Brain Neuroplasticity and Computer-Aided Rehabilitation in ADHD

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Abstract
This article includes a discussion on the brain’s ability to work around damage caused by injury or other insult, a discussion on different types of brain damage, and a discussion on the various ways for healing, or at least softening, the effects of brain damage. It also discusses motor, sensory, and autonomic function; the psychiatric aspects of traumatic brain injury; schizophrenia; and cerebrovascular disorder. It includes an extended discussion on the role MRI and PET examination in discovering what really goes in the formation and development of the brain in developmental disorders, including ADHD.
Current Empirical Understanding of Central Nervous System Neuroplasty

Plasticity is a term meaning ability to change, to modify as needed to meet some new situation or repair damage from some insult to a system. What does the term plasticity mean with regard to repairing damage that a person was born with? The information regarding the ability of the brain to repair itself is gathering at an astounding rate as the newer imaging methods make the study of the living brain a daily occurrence. Magnetic Resonance Imaging and Positron Emission Tomography are both techniques that allow researchers to study the brain while it is functioning. This allows the researchers to see what parts of the normal brain respond to given stimuli and to compare how a damaged brain responds to the same stimuli. This new work is expanding the boundaries of the definitions of plasticity. We have moved from a belief that the adult brain especially was not able to compensate for damage done to a cautious optimism that the brain has a great deal more in the way of resources to rebuild and heal than previously believed.

Much of this new attitude toward CNS plasticity comes as the result of imaging techniques that allow doctors and researchers to watch the brain functioning. Previously all studies were done post-mortem or with techniques that allowed only still images. Functional Magnetic Resonance Imaging and Positron Emission Tomography are both techniques that allow for working images. When different parts of the brain are actively involved in a given operation there is a difference in the amount of blood going to that distinct part of the brain and these differences allow activity to be tracked.

Can the information gathered about how the human brain works to begin with and then repairs itself after injury be applied to helping people born with some developmental dysfunction such as Attention-Deficit Hyperactivity Disorder popularly known as ADHD? Children and adults with this disorder display inabilities to pay attention to the task at hand, appropriately monitor their responses to stimulus and in a range of functions called executive functions such as planning and organization. Building and ordering these functions is what such people need and the hope for the future is that our new technologies can both give us better understanding of causes and provide new, more effective ways to treat ADHD. Besides the new imaging technologies, we also have our societies’ love affair with personal computers. The focus of this research will be to test the idea that the personal computer and the programs that can be designed for it can be a strong positive tool to help ADHD clients.

In Chapter One, Cognitive Neurorehabilitation, discusses plasticity or the ability of the brain to work around damage caused by injury or other insult. The discussion centers on re-growth of various aspects of the neuron and its discrete parts. The discussion also looks at some of the neurotransmitters that have been discovered to stimulate nerve growth and re-function.

In the Jul/Aug 2003 issue of The Journal of Head Trauma Rehabilitation, in an article titled “Concepts of CNS plasticity in the Context of Brain Damage and Repair,” by Donald G. Stein and Stuart W. Hoffman, the focus is most particularly on traumatic head injury and its aftermaths. Among the ideas they explore are those of specific localization and complete equipotentiality. There is also information concerning new drugs that can limit the damage done when the brain is injured. Part of the problem when the brain is injured is that the original injury creates further problems. Damaged and dying cells give off chemicals that create a toxic environment and cause cell damage and death to spread beyond the original insult. Stopping this spread and creating an environment where damaged cells can heal is part of the new technology. They discuss the need for re-evaluating these concepts in light of better data and current experimentation. There is much discussion of many studies of animals and humans that refine and redefine understanding of what can occur after injury to the brain, whether that injury is controlled and deliberately inflicted, as in the laboratory, or actual traumatic, accidental injury. Part of the information they deal with has to do with injuries created in fetal monkeys which were then returned.
to the womb to come to term. The authors say that not only was there a complete sparing of cognitive function, but there was also a radical re-organization of the cortical mantle, and there were cells of certain types where they weren’t normally found. Further, studies concerning various brain injuries in younger children seemed to bear out the concepts of the equipotentiality theory which says that the various parts of the brain can take over or create function to make up for loss or injury. While nothing is mentioned of the congenital issues that seem to be at the basis of ADHD, many behaviors described as the result of injuries or aging also apply to this disorder.

In the American Scientist, article, “Brain Plasticity and Recovery from Stroke,” Nina P. Azari, and Rudiger J. Seitz begin by outlining what happens when a stroke damages the brain. They make the argument that conditions such as loss of speech or paralysis can occur because the part of the brain that controlled those things has been damaged or destroyed. They explain the whole process thus:

The brain is able to perform all of these tasks (and much more) at the same time because it is not merely a homogeneous blob of cells. It is made of separate parts—neural networks—that are specifically dedicated to doing each task independently. Such division of labor has obvious benefits and it is performed so seamlessly that we never need to think about it—until something goes wrong.

When a particular neural network is damaged, as often happens in a stroke, the system fails and function is lost because no other neurons in the brain “know” how to do the task formerly performed by the damaged network. Thus, the result may be paralysis or the loss of speech or the inability to comprehend speech or any one of a number of actions we take for granted until we can’t perform them anymore. Curiously, however, many people who have suffered a stroke regain some or most of the

lost function after a brief recovery period, sometimes in a matter of weeks. (Italics added) (427)

The situation that has puzzled doctors and researchers for years is the recovery that so many stroke victims make even in the face of what seem like devastating losses. The writers discuss two kinds of plasticity. The physical ability of the brain to heal—more than was believed previously, and the ability to re-learn what has been lost—also more than previously believed.

Utilizing PET scanning, the researchers studied a group of 21 stroke patients with motor cortex lesions and who had all suffered severe paralysis to one hand. 12 of the patients had recovered function within about four weeks. The PET scans suggested that instead of the pyramidal tract, the recovered patients’ brains were using some manner of compensatory track from the supplementary motor area to the spinal cord. This different track was accompanied by abnormally enhanced connections between the thalamus and the cerebellum. With other stroke patients, they observed examples of plasticity where the compensation involved parts of the brain not usually associated with movement. The PET images indicated that when asked to move fingers of the affected hand, the brain activity of blindfolded patients showed engagement of the visual cortex—something that does not normally occur in movement of the hand or fingers. It appeared that an alternative network outside of those areas normally associated with movement had been recruited.

These writers also make a good case for the improving body of information that is becoming available through the use of functional imaging methods. As these techniques are more and more used for visualizing various kinds of injury involving the brain, those involved with neurorehabilitation should find information that will assist in treating other brain malfunction issues such as ADHD.

The textbook Brain Damage, Brain Repair, Edited by James W. Fawcett, Anne E. Rosser, and Stephen B. Dunnett, is a deeply detailed work. From Chapter One through Chapter Six,
many kinds of brain damage are discussed. There
doesn’t to seem to be concomitant explanation
of the symptoms that would be noted with each
disease or disorder, however, most of the subjects
discussed are widely known. The chapters discuss
“Death and Survival in the Nervous System,” is an
in depth discussion of how and why neuronal cells
die and how some of them can survive. The subjects
include necrosis, apoptosis, control of apoptosis,
cell death caused calcium and free radical damage,
trophic factor withdrawal and cell death caused by
DNA damage. Chapter Two discusses axotomy
and mechanical damage. Chapter Three discusses
metabolic damage to the CNS. This chapter’s
focus is on how insult such as stroke can precipitate
a whole cycle of reactions that cause cell death due
to chemical changes around the damage. Chapter
Four has as its focus neuronal damage and death
due to inflammation and demyelination. Chapter
Five goes into brain and neuronal damage that
can be caused by infection. Chapter Six discusses
neurodegenerative disease.

Chapters Seven through Ten begin discussing
various ways, both natural and man-made avenues
for healing or at least softening the effects of brain
damage. These chapters are titled or focused as,
“Neuroprotection,” “Steroids,” “Trophic Factors,”
and “Control of Inflammation.”

Chapter Eleven discusses the relative ease
with which the Peripheral Nervous System, even
in mammals, heals and regenerates. The chapter
makes it clear that even this nerve regeneration
is not without its problems but it does occur
more readily than in the CNS. Chapter Twelve
goes into a detailed explanation of current best
understanding of why the CNS is so difficult to
obtain healing and regeneration in.

The next three chapters include information in
the areas of, “Anatomical Plasticity,” “Biochemical
Plasticity,” and “Remyelination.”

Chapter Seventeen involves discussion of
Motor, Sensory, and Autonomic Function.” The
primary idea here is to note how these functions are
assessed in various disorders and disease process
like MS, Parkinson’s disease, and Huntington’s
disease. Many evaluation tools are included in the
chapter.

Chapter Eighteen does approximately the same
service in evaluation of “Cognition.” Again the
focus is on familiar diseases and their effects and
processes. Various forms of dementia especially
are discussed. and discussion of approximately
Twenty different tests and measures for cognitive
function, are looked at, and there is consideration
of determining test validity.

Chapter Nineteen is titled, “Psychiatric
Assessment,” and discusses the psychiatric
aspects of traumatic brain injury, schizophrenias,
cerebrovascular disorder, and then the main
discussion focuses around the various aspects of
Huntington’s Disease.

“Deep Brain Stimulation: Challenges to
Integrating Stimulation Technology With Human
Neurobiology, Neuroplasticity and Neural repair,”
by Andres Lozano, MD, PhD. FRSC in the Journal
of Rehabilitation Research and Development; Nov/Dec 2001
is a “guest editorial” that discusses
aspects of medical treatment for Parkinson’s and
other disorders that, in places, almost sounds like
science fiction. He never actually mentions treating
disorders like ADHD with deep brain stimulation
but the implication is there. Lozano discusses the
fact that surgical intervention in Parkinson’s is not
a new idea, that it was the treatment used in the
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He says:

Patients who were treated operatively back
in the 1940’s were generally awake, and
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a somewhat nonspecific manner until
something interesting happened. Either the
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effect was produced to signal the stopping
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He goes on to explain how it was that modern
medicine came to find out what caused Parkinson’s.
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levodopa in the treatment of Parkinson’s. And,
Lozano says, now medicine is back to surgery
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and for other disorders that they are just now experimenting with. The treatment involves putting electrodes into parts of the brain and sending titrated electrical impulses in to help stop spasms and other symptoms of Parkinson’s and other disorders. He gives the example of a child with a genetic disorder that made his limbs and trunk twist in random movements. The child did not respond to drugs and got to where he couldn’t walk at all although there was nothing wrong with his cognitive functioning and images of his brain showed nothing out of the ordinary. The situation finally responded to DBS. Specifically to something called a bilateral pallidal procedure and the child was able to go back to school and to all his usual activities including riding his bicycle.

Lozano is careful to make it understood that in many ways researchers and neurosurgeons don’t know exactly how these methods work. He says they know for sure that they have neurostimulators in a certain part of the brain but exactly how many and what kinds of neurons are being affected is still not clear. Lozano closes out his guest editorial by speculating on where and how both DBS and various drugs that researchers suspect are released as the result of the stimulation, can be used in treating any number of disorders from depression to eating disorders to chronic pain. It seems obvious that deep brain stimulation opens very new possibilities for encouraging plasticity in the CNS. The application in such things as ADHD is not clear, but the concept that this treatment may have a place in its care/healing, is tantalizing.

M.S.C. Thomas, in an article, “Limits on Plasticity,” in the Journal of Cognition & Development, Thomas evaluates and recaps much of the most current literature on the plasticity of the central nervous system. He reviews four books, Handbook of Developmental Cognitive Neuroscience Nelson and Luciana (Eds.) (2001); Developmental Neuropsychology: A Clinical Approach, Anderson, Northam, Hendy & Wrennall, (2001); Developmental Disorders of the Frontostriatal System: Neuropsychological, Neuropsychiatric, and Evolutionary Perspectives, Bradshaw (2001); and Neural Plasticity: The effects of Environment on the Development of the Cerebral Cortex, Huttenlocher (2002). Generally, the author’s over-all view would seem to be that the most useful information is to be found between the two extremes of “pre-determined by built in blueprint” and “unlimited plasticity.” He discusses the two prevailing theories of when, where and how the brain and associated functions develop and poses the idea that “truth” is probably somewhere between.

In the section labeled, “Assessing Limits to Plasticity Via Recovery From Early Brain Damage,” Thomas is discussing various views of “Early Plasticity” which indicates that damage done when a person is a child should heal more completely with less residual incapacity. In the literature being reviewed, this doesn’t seem to hold true and Thomas says:

Indeed, children with generalized cerebral insult (e.g., from traumatic brain injury) exhibit both slower recovery and poorer outcome than do adults suffer similar insults. This is quite inconsistent with the notions of greater early plasticity. From the “early vulnerability” perspective, short-term recovery favors the mature brain. Across time, a child who has seemed initially to recover well from the insult may start to increasingly lag behind age-matched peers and fail to show the expected emergence of new cognitive skills. The child thus appears to “grow into” his or her cognitive deficit as the brain matures. (104)

There is also an extended discussion of the role MRI and PET examination is playing in discovering what really goes in the formation and development of the brain in developmental disorders including ADHD. This information should make it possible to better intervene either pharmacologically or cognitively the problem is, that in his working to not seem to take a strong position, Thomas rather leaves the reader where he found him/her.

Michael Zappitelli, Teresa Pinto and Natalie Grizenko offer a exhaustive review of literature
titled “Pre-, Peri-, and Postnatal Trauma in Subjects with Attention Deficit Hyperactive Disorder.” They begin by establishing that although the etiology of ADHD is not well understood, the fact that ADHD has genetic components is documented by family studies, twin studies, and adoption studies. Further, their review paper discusses the possible role of environmental stressors such as pregnancy and delivery complications which it has been suggested may also increase the risk for ADHD.

The authors write, “It is believed that pre-, and perinatal trauma may have a direct effect on the fetal brain during a crucial period of development....ADHD, increasingly discussed in terms of its origins in neurochemical alterations, can be examined as a neurological outcome of insult suffered early in life.”(542)

According to Zappitelli et al. in utero toxins has been a major focus for research, especially the areas of “cigarette smoking and alcohol exposure.” (543) In one study quoted in this article, the comment is made that “the accepted neurochemical hypothesis behind the pathophysiology of ADHD is a dysfunction of the dopamine system in the prefrontal cortex.”(543) The writers go on to quote further, “Animal studies have shown that pups prenatally exposed to nicotine showed decreased striatal dopaminergic receptor binding sites.” (543) There are many other studies cited to bolster the contention that maternal smoking can lead to fetal hypoxia—blood carboxyhemoglobin is elevated in pregnant women who smoke, possibly leading to decreased oxygen delivery to the fetus. They go to discuss how mothers drinking alcohol during pregnancy might create later problems with learning and behavior problems and those results are inconclusive. The only thing researchers know for sure is that excessive alcohol use will cause fetal alcohol syndrome. Other studies have considered other, non-substance factors that might contribute to ADHD. Hartsough and Lambert, in a study of 301 children with hyperactivity and 191 unaffected children, the there seemed to be correlation with young maternal age, poor maternal health during pregnancy, eclampsia, and parity pregnancy. Millberger and others add maternal bleeding and complications of maternal accidents to the list of possible causes. Other studies have concluded that hypoxia, for any reason, is likely a factor in ADHD.

Suggestions for future studies include following women through their pregnancies, together with the use of medical records and data gatherers and analysts with sufficient medical knowledge to record and interpret data accurately. In retrospective analysis, data collectors would be “blind” to the status of ADHD subjects.

There is one related body of information that is conspicuous by its absence. That would be any relationship between ADHD or other learning/behavior problems and second hand smoke or, for that matter, any research might there be about the effects alcohol or smoking may have on the genetic integrity of sperm from a baby’s father.

From the Rogers Medical Intelligence Solutions, an on-line continuing education service, comes the article/lesson set titled, “Advances in the Treatment of Adult ADHD—Landmark Findings in Non-stimulant Therapy,” Margaret Weiss and Robert Bailey Eds. Comes information in the continuing search for finer definition of what goes on in the brain when one has ADHD. Although the focus of this particular article is adult ADHD, some of the electrophysiological studies mentioned were actually done on children. In the mentioned studies, children with ADHD were found to have lower amplitudes in the areas of the brain believed to be analogous for attention and memory. MRIs have shown that the prefrontal lobe and right caudate nucleus is smaller in patients with ADHD. In adults who were diagnosed with ADHD as children, PET scans have revealed decreased activity in frontal cortical activity and abnormal regional and global glucose metabolism during the performance of a task involving executive function. PET scans have also shown decreased dopamine transmission in the left and medial portions of the prefrontal cortex.

Chapter Two of *Cognitive Neurorehabilitation* is a fairly in-depth discussion of results in transplanting fetal cells to damaged brain areas in the treatment of deliberately caused lesions in laboratory animals. The discussion also includes a comparison of the relative effectiveness between fetal cells and genetically engineered cells. There are further comparisons between the results in young and aged animals. The various studies cited indicate that re-enervation, re-establishment of chemical function and growth in neurons are all observed whether the lesions are chemically or surgically induced.

Weizmann Institute; Scientists reveal key part of nerve regeneration mechanism. (2004) *Biotech Week*, Feb 11, Atlanta. 622. A further discussion of this subject is found in an article in the on-line magazine *Biotech Week*, written by the magazine’s staff, where the protein complexes importin alpha and importin beta are described along with their functions in the repair and healing of nerves outside the CSN.

Chapter Twenty-Two of *Brain Damage, Brain Repair* is titled, “Axon Regeneration in the CNS.” There is a detailed discussion of the reasons why re-growth in the CNS is difficult, such as the interference that occurs from the chemicals created by dying cells and the mechanism the body uses to “clean up the mess.” The following chapters are also dealing with various presently experimental methods to encourage re-growth in the central nervous system. Chapter Twenty-three is “Primary Neuronal Transplant,” Twenty-four is “Glial Transplant,” Twenty-five deals with “Stem Cells,” Twenty-six is concerned with “Gene Therapy.” This concludes the main part of the book. There are nine Appendices that give detailed, concise information on nine different brain diseases or disorders.

Normally, injured nerve fibers, known as axons, can’t regenerate. Axons conduct impulses away from the body of the nerve cell, forming connections with other nerve cells or with muscles. One reason why axons can’t regenerate has been known for about 15 years: several proteins in the myelin, and insulating sheath wrapped around the axons, strongly suppress growth.(127)

The article explains reasons why CNS axons don’t re-grow and what neuroscience and biology research are doing to re-grow nerves when there has been damage of some kind. Using combinations of technology to not only interfere with the proteins that stop re-growth but to also make growth happen more quickly is what scientists are after.

This is one of two articles reproduced in two sections because the information applied both places.

“Deep Brain Stimulation: Challenges to Integrating Stimulation Technology With Human Neurobiology, Neuroplasticity and neural repair,” by Andres Lozano, MD, PhD. FRSC in the *Journal of Rehabilitation Research and Development; Nov/Dec 2001* is a “guest editorial” that discusses aspects of medical treatment for Parkinson’s and other disorders that almost sound like science fiction. He never actually mentions treating disorders like ADHD with deep brain stimulation but the implication is there. Lozano discusses the fact that surgical intervention in Parkinson’s is not a new idea, that it was the treatment used in the 1940’s and 1950’s.

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Patients who were treated operatively back in the 1940’s were generally awake, and written reports suggest that neurosurgeons used to just cut into different parts of the brain in what would now be considered a somewhat nonspecific manner until something interesting happened. Either the patient’s symptoms improved or an adverse effect was produced to signal the stopping point of the procedure.(x)
He goes on to explain how it was that modern medicine came to find out what caused Parkinson’s. He also discusses how medicine moved to using levodopa in the treatment of Parkinson’s. And, Lozano says, now medicine is back to surgery as the most up-to-date treatment for Parkinson’s and for other disorders that they are just now experimenting with. The treatment involves putting electrodes into parts of the brain and sending titrated electrical impulses in to help stop spasms and other symptoms of Parkinson’s and other disorders. He gives the example of a child with a genetic disorder that made his limbs and trunk twist in random movements. The child did not respond to drugs and got to where he couldn’t walk at all although there was nothing wrong with his cognitive functioning and images of his brain showed nothing out of the ordinary. The situation finally responded to DBS. Specifically to something called a bilateral pallidal procedure and the child was able to go back to his usual activities including riding his bicycle.

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In an article from the United Kingdom, titled, “Neurological Rehabilitation: A Science Struggling to Come of Age,” found in *Physiotherapy Research International*, Valerie Pomeroy and Raymond Tallis discuss the general state of the physical therapy aspect of rehabilitation. It seems appropriate to place their work here because of their recognition of the need to better understand how what is done externally with the body by way of retraining—in their case stroke patients—will either support neuronal healing, regeneration and return to function or it will hinder it. The authors quote a number of studies that would probably hold out a measure of hope except there were such weaknesses in study design time after time that it is almost impossible for the results to be accepted on an equal footing with other scientific research. Their basic premise is now that we know the CNS is basically “soft wired” mutable and much more accommodating to injury than was previously thought, how do physical therapists re-configure their practice to take advantage of this amazing information. These people are asking themselves and their profession what plasticity means to them. They are asking if deep brain stimulation is a tool that they can use in their part of patient care. Physical therapists are looking at the new imaging techniques and asking is this a tool for us? At this point, they are trying it all as far as they can get research dollars to take them. The comment is made that there is no comparison between what is spent on developing medications and what is spent on researching more effective methods for physical therapy. There is application even to ADHD, perhaps. So little is actually known about what will permanently, positively affect ADHD and maybe something the physical therapists learn and apply will be part of that answer.

In an article, “Can Brains Help Policymakers Improve Their Education Systems? Scientists Say They Can,” written for the Organization for Economic Cooperation and Development the anonymous author says neuroscientists are beginning to argue that loss of neurons after 40 can be offset by stimulating the brain regularly. It is believed that, as with muscles, targeted exercise can help. This plasticity or the capacity for lifelong learning is an exciting finding. At a meeting in June of 2000, the OECD’s program on Learning Science and Brain Research was launched with the aim of getting neuroscientists and policymakers talking to each other.

What the neuroscientists have to offer is the information they have been gathering over the last 10 years. Technology, such as fMRI, which
uses radio waves to measure active brain areas, and Positron Emission Tomography, PET, which tracks brain energy metabolism with the help of high-powered computing is the thing of today and the future. Rather than having to work on cadavers or injured people, neuroscientists can watch the blood circulating through living, healthy brain tissues. They can record “the firing of neurons and circuitry of synapses.” Using these technologies allows researchers to find and measure process like spatial orientation.

Bruno Della-Chiesa, organizer of the 2000 conference, says that Bruce McCandliss of the Sacler Institute in New York, presented researcher findings from the study of dyslexia that are considered amazing. McCandliss says they have not only pinpointed a tiny section of the brain that causes dyslexia, but they think they have a way to correct it. He uses a method that “jogs” the brain and reactivates neuron links. There was, according to the article, to be another conference in Spain in February of 2001. The focus was to be on using the new technology on a range of problems that confront many youth.

Dennis Garlick, University of Sydney, in Psychological Review offers an article titled “Understanding the Nature of the General Factor of Intelligence: The Role of the Individual Differences in Neural Plasticity as an Explanatory Mechanism,” that gives some explanation of how intelligent behavior is mediated through the neurons and their early innate plasticity. He further explores the role of that plasticity in the development of intelligence. It is explained that researchers have developed a concept that postulates two forms of intelligence. Fluid intelligence is a form which begins development at birth and continues to about age 16. The other form is labeled crystallized intelligence and is intelligence applied to learning and can continue to develop over the life span. It is believed that these two forms of intelligence, indeed all mental functioning depend on plasticity in neuronal functioning.

Garlick writes:

The properties of neurons have been firmly established through recent procedures such as electrophysiological recording of single neurons and the patch clamp technique. In fact the precise characteristics of neurons have been specified both mathematically and in computer simulations. These studies have shown that neurons represent a relatively simple gating mechanism whereby inputs are summed, and if these inputs exceed a certain threshold, an action potential is produced that is propagated to all of the neuron’s attendant connections. The critical issue than is how a system consisting of such units may produce meaningful or intelligent behavior. Given that intelligent responding at the neural level must ultimately consist of the ability to arbitrarily map inputs to outputs, some mechanism is required to allow this mapping.(120)

Garlick goes on to explain that the answer to being able to respond to the stimuli coming in lies in changing the connections between the neurons. He says that by changing connections, the pattern of activation in the network can be changed. As it is explained:

A neuron cannot decide to receive inputs from only one neuron and not others to which it is connected. Inputs to the dendritic tree result in changes in the electro potentials across the membrane that obeys simple laws of conductance. Nor can the neuron choose to send an action potential to only one axonal branch and not another….neural activity is not able to shape its pathway through the neural network actively. Rather, the neuron is a rather simple processing unit that operates independently of other neurons and whose firing is determined by changing the connections between it self and other neurons. (121)

The question is then raised as to how the brain develops its connections. In studies of brain damage, it is revealed that the cerebral cortex is the area of the brain responsible for higher intellectual process and is also a newer part of
the brain, most developed in humans. When this part of the adult brain is examined histologically it is possible to see that neurons in the adult cortex form idiosyncratic connections with other neurons. They don’t connect with those right beside themselves. The researchers say this, “…this indicates that the cerebral cortex has evolved to produce very complex connections between the neurons, in contrast to earlier evolved brain areas, which possess simpler and more uniform neural circuits.” The writer goes on to say that these complex connections will mold or restrict the way activation would take place through the system would allow or create the complex patterns between input and output and this would affect intellectual behavior.

In images of axons and dendritic trees from a newborn and from an adult, it can be seen that neuron connections in the newborn are mostly undifferentiated. As the child grows and develops connections become more complex and more idiosyncratic until the time of maturity at 16 when fluid intelligence stops developing.

There is a discussion of the possible part genetics might play in causing neurons to behave in ways to create intelligent patterns of reaction. This theory is discarded because there are simply not enough genes to individually control each and every neuronal connection. The theory is also discarded because new development, such as the cerebral cortex couldn’t have happened. It is of necessity that the neural system respond to stimuli from the environment so that growth and change can take place. If neural function was controlled by genetics, how would we have learned to read and write, for example, when this is something our ancient ancestors did not do—did not need to do. Garlick further suggests that the fact the neural system is self-regulating and responsive to environment allows it to respond to damage. The neurons will change the connections they make. The cortical system such as the primary visual cortex has greatest plasticity up to about the age of 5, whereas the brain areas responsible for such abilities as language and fluid attention hold plasticity until about 16. An explanation for the individual differences in intelligence and for plasticity in the case of injury is offered as exactly that—individual differences.

The European Journal of Neuroscience has an article from Inna Belyantseva and Gary R. Lewin, “Stability and Plasticity of Primary Afferent Projections Following Nerve Regeneration and Central Degeneration.” This is an extremely detailed and technical article that discusses experimentation in promoting growth of different nerves. The discussion concerns how spinal cord nerves can be encouraged to sprout and fill places in the neuronal system that have been deliberately damaged. Working with rats, the researchers used a number of techniques including crushing parts of nerves and chemically damaging others to see what kind of compensatory growth would occur in certain afferent nerves. In order to more closely understand what they were seeing, these researchers tended to work continuously with the same animal so that individual differences in how the body handled insult would not cloud the results. The summary for this article states:

In summary, the present study provides new evidence that the ability of sensory neurons to regenerate centrally in response to denervation and injury is remarkably heterogeneous. This heterogeneity in sprouting is manifested not only in the distances that new processes can grow but also in the types of denervated neuropil that can be newly innervated. It is clear from neurophysiological studies that, following nerve lesion, substantial rearrangements of afferent terminals may take place within normal central territory. Our data suggest that these rearrangements may differ depending on which subpopulation of sensory neuron is studied. A somewhat surprising outcome of the present study was that inducing a regenerative mode in sensory neurons appears to confer only a small sprouting advantage….In contrast, it appears that central differentiation is a sufficient stimulus to induce considerable sprouting of peptidergic afferents. (467)
There are no particular comments as to how this all applies to the possibilities for useful plasticity in injured humans but it does make it seem possible that, with certain assists, there is the possibility for spinal cord regeneration.

“Neural Plasticity and Exaptation,” from *American Psychologist* by John R. Skoyles, offers some interesting ideas concerning Neuroplasticity. An evolutionary theorist by the name of Stephan Jay Gould proposed the concept, “… that human psychology links not to past evolutionary adaptations but to the co-opting of previously evolved functions to do new things—exaptation.” Gould also accredited our expanded brain to exaptation: “The human brain, is *par excellence*, the chief exemplar of exaptation,” (55) and, “exaptations of the brain of the brain must greatly exceed adaptation by orders of magnitude.” (57) Examples of such exaptations are, Gould suggested, language, religion, the fine arts, writing and reading.

Buss et al. (1998) criticized Gould’s ideas. He said that there was no demonstrated special design for the ‘hypothesized function or for co-opted functionality or any “distinct original adaptational functionality.”’ The author of this article comments that Gould is not a neuroscientist. Skoyles suggests that “…neural plasticity—strongly links the brain, exaptation, and human psychology.” He goes on to explain that neural plasticity is an important adaptation, that plasticity concerns the ability of neural circuitry, if properly trained, to learn almost any function. Neuro-researchers contend this because it has been found that in people who are blind, neural circuits process hearing and Braille reading. Also, there are circuits that should have no ability to process visual stimulation, that do exactly that when retinal inputs are surgically directed to them. Studies have shown that in people who make great demands on their left hand—such as pianists—the circuits in the right primary motor cortex cover a larger area than in people who don’t make such demands. “Neural plasticity,” Skoyles says, “would seem prima facie to be an important *adaptation* of the brain. At least for the human brain, it is also an important exaptation.” He says that other researchers have shown that this expansion happened in the parietal, temporal and prefrontal association cerebral cortex areas, not the primary or older areas so the human brain gained many neuronal areas that were open to acquire non-innate skills such as using tools and communication. Then, these areas were strengthened in these specialized uses by transmission of information across generations and humans were able to put together the beginnings of, “material and symbolic culture.” He goes on to say that the flexibility created by this neuroplasticity allowed a being that was originally fitted for living and functioning in hunter-gather bands, to do mathematics, read and program computers.

In the article, “Induction of Plasticity in the Human Motor Cortex by Paired Associative Stimulation,” written for *Brain*, Katja Stefan, Erwin Kunesch, Leonardo G. Cohen, Reiner Benecke, and Joseph Classen, discuss their experimentation with inducing plasticity in the human motor cortex by uses of electrical stimulations administered from separate points on the body. Their experiments caused changes that lasted for 30-60 minutes or more and caused an increase in the amplitude of the motor evoked potentials in resting abductor pollicis brevis muscle as well as a prolongation of the silent period measured in the pre-contracted APB following transcranial magnetic stimulation. It is proposed that the methods used in stimulating the motor cortex in these experiments could be used to help repair damage and the resultant motor disabilities. There was no speculation offered as to the possible effectiveness of similar stimulation to deal with other forms of brain dysfunction.

**Neuropharmacological Interventions in Neuroprotection and Rehabilitation in Traumatic Brain Injury, Congenital Central Nervous System Conditions including ADHD and Psychostimulant Medications.**

Chapter Five of *Cognitive Neurorehabilitation* opens a discussion of relatively new research using the female reproductive hormone, progesterone. The brains of females and males, of many species,
humans included, have differences that scientists have studied for years. Such factors as brain mass, the shape of various brain structures, the number of neurons in the posterior cerebral cortex and other features show marked, measurable differences. For example, female rodent brains exhibit more dendritic branching than the brains of males and there is also a fluctuation connected to the oestrus cycle. The researchers for this chapter have found evidence that suggests even such unrelated medical conditions as breast cancer surgery and brain damage can be affected more positively by where in the cycle the patient is when sex hormone therapy is applied.

Chapter Seven of *Cognitive Neurorehabilitation* discusses actual drug interventions on behalf of brain injury/stoke patients with the desired end result of protecting the central nervous system from “cascading” symptoms after injury and medications to assist in recovery of function. It is noted that most of the information highlighted in the chapter comes from animal studies and that work has really just started with efforts for human brain trauma patients. The chapter does not specify applicability to ADHD.

Chapter Eight of *Cognitive Neurorehabilitation* further discusses the role of medication in the treatment of brain injury with a focus on developing symptoms of destructive behaviors. The descriptions of the various behaviors under the general label of “destructive” could easily be applied also to many of the behaviors seen in ADHD. The similarities open the possibilities of pharmacological interventions in the treatment of this disorder. Chapter Eight also discusses the role of adapting environment, especially with regard to background noise and other extraneous stimulation, in the treatment of certain manifestations of destructive behaviors. This concept bears consideration for ADHD also.

Brown University puts out something called the *Child and Adolescent Newsletter*. Vol. 20, Issue No. 2 of February, 2004 contains an article recapping the deliberations and conclusions of child mental professionals from six countries. The conference was sponsored by Johnson and Johnson, manufacturer of Risperdal (risperidone) and Concerta (methylphenidate), both drugs commonly used in the treatment of ADHD and disruptive behavior disorders. Consensus statements included, “Do not be satisfied with a single diagnosis: keep assessing to uncover likely co morbidities; accurate diagnosis is essential to improve prognosis.” Another statement says, “… say researchers, psycho stimulants are commonly prescribed with twice-daily dosing, whereas thrice-daily dosing, or the use of long-acting agents, providing daily coverage is generally more desirable.” There were three recommended treatments and nine key findings included in the article.

From *Pediatrics* Vol. 113 April, 2004 comes two studies that are both related to a project of the National Institute of Mental Health. The two reports, National Institute of Mental Health Multimodal Treatment Study of ADHD Follow-up: 24 Month Outcomes of Treatment Strategies for Attention Deficit/Hyperactivity Disorders; and National Institute of Mental Health Multimodal Treatment Studies of ADHD Follow-up: Changes in Effectiveness and Growth After the End of Treatment; are actually reporting on slightly different aspects of how their research design was impacting the lives of the study subjects at specified times after the end of the actual treatment program. The subject group was comprised of approximately 550 children. 579 originally entered the study and 540 were still participating at the time of the first follow-up ten months after the end of treatment. The participants were randomly assigned to four groups. One group, designated CC was the control group and received no treatment. Another group, designated Beh, received only behavioral modification therapy. Group three, labeled Comb, received both medication with any one of a variety of the medications used in treating ADHD and behavioral rehabilitation therapy; and the last group was labeled MedMgt. and received only medication with the same range of familiar medications. Generally speaking, the results showed significant, original positive response in both the MedMgt groups and the
Comb groups. After 14 and 24 months there was more diminishment of positive effects for these two groups and none to speak of for the other two groups but, the original improvement for the other two groups was significantly lower. Between the two groups that showed improvement, the Comb. Group showed the greatest amount of improvement overall and maintained that superiority at both 14 and 24 months after treatment ended although there was measurable diminishment of positive effects with time. The other issue this study was intended to deal with was inhibition of growth while on prescribed medications such as methylphenidate. The result reported for this aspect of the study says, “In the MYA follow-up, exploratory naturalistic analyses suggest that consistent use of stimulant medication was associated maintenance of effectiveness but continued mild growth suppression.”

“A Cognitive Remediation Program for Adults with Attention Deficit Hyperactivity Disorder,” in the *Australian and New Zealand Journal of Psychiatry* 2002; 36:610-616 offers a most interesting sidelight on the subject of medication effects. This information may only apply to adults with ADHD but it is worthy of comment that in the over-all reporting of features affecting outcomes, Caroline Stevenson, et al, note that whether a subject was medicated or not, did not seem to impact how well the rest of the intervention worked.

The *American Journal of Public Health; Feb. 2002* offers a study by Andrew S. Roland, David M. Umbach, Lil Stallone, A. Jack Aftel, E. Michael Bohling and Dale P. Sandler entitled, Prevalence of Medication Treatment for Attention Deficit—Hyperactivity Disorder Among Elementary School Children in Johnston County, North Carolina.” The stated reason for this study was to find out what the prevalence of children in the public school system was who had not only received diagnoses for ADHD, but to find out how many of them were actually being treated for the condition. The test population was children grades one through five in the public schools only. Private schools and home-schooled children were excluded because there was likely to be a profound difference in their learning environment. Also, children who were in self-contained classrooms or who had special education designations such as such as autism or sever health disabilities such as traumatic brain injury were excluded. After the discussion of findings, the researchers offer this commentary:

If the prevalence of ADHD diagnosis or ADHD medication treatment among elementary school children in the United States is similar to the estimates reported here, educators and public health officials may have substantially underestimated the public health impact of ADHD. (234)

These researchers go on to say that this problem is likely to be far more prevalent than the survey shows because while older children are probably still ADHD, the use of medications, especially stimulant medications falls off “sharply” among teenagers. The authors also comment on some of their demographics which are bourn out in other studies. Boys are three times as likely as girls to receive diagnoses of ADHD. African-American children were only slightly less likely to be diagnosed as ADHD and Hispanic children were much less likely to receive such a diagnosis.

Chapter Twenty discusses “Pharmacological Management,” and the drug management is pretty much for the same for the disorders as are pretty much the focus of the whole book, MS, Parkinson’s, Huntington’s and other traumatic and progressive brain problems. There is discussion of the various dysfunctions that can result from the brain being damaged such bladder problems, spasticity, sensory malfunctions and bowel disturbances. Obviously, all this discussion is focused around drug therapies for the different problems.

“A Comparison of the Newer Treatment Options for ADHD,” in the *Formulary January 2003 Vol. 38*, by Lisa Edwards PharmD., offers a close examination of the latest in the classes of drugs known as psycho stimulants which are used in the treatment of ADHD. The various drugs in this group are methylphenidate, mixed amphetamine salts, dextroamphetamine and
pemoline. Pemoline and its various brand names, Cylert, from Abbott, and various generics, are no longer recommended due to its association with life-threatening hepatic failure. Tricyclic antidepressants such as guanfacine, clonidine and buropion have also been used in the treatment of ADHD but there are safety concerns that limit their use in children. Edwards says that one of the major complaints with the stimulants has been the need for frequent dosing. She goes on to say, that recently, the pharmaceutical companies have brought out long acting versions of the medications they have produced for years. These new forms of medications are marketed under the names Concerta®, Metadate®, Ritalin LA® and Adderall XR®. Various clinical trials for each of these medications are outlined. The major considerations with the stimulants are appetite suppression, possible inhibition of growth and possible sleep disturbances. Medication administration needs to be focused to cover school hours without interfering with evening meals and bedtime.

Edwards also addresses the issue of the 30% of children, adolescents and adults who either do not respond to, or are intolerant of, the stimulant therapies. She offers a discussion of a drug called atomoxetine or, Strattera as it is known on the market. This drug acts as blocker of presynaptic norepinepherin transporters in the brain. Previously other non-stimulants such as the TCAs were used but the increased risks of such side-effects of cardiac arrhythmias have limited their use in pre-pubertal children.

David A. Kube, Mario C. Petersen and Fredrick B. Palmer authored a study titled, “Attention Deficit Hyperactive Disorder: Comorbidity and Medication Use,” from the journal Clinical Pediatrics in which 353 children referred to the University of Tennessee Health Science Center, Boling Center for Developmental Disabilities between December 1, 1996 through June 1,1998 werestudiedinaretrospective review. Subjects were referred for concerns of possible developmental problems. The inclusion criteria were the referral, age greater than 2 and no previously diagnosed mental retardation, developmental delay, autism or cerebral palsy. 189 children met these criteria. Each child was examined by a developmental pediatrician, had a complete medical history, developmental history, family and social history, physical examination and lab work if necessary. There was information from the clinical interview, school reports including questionnaires for teachers and also for parents and observation at the clinic. Where appropriate, children were also seen by a range of other specialists. If the children were on medication for treatment of ADHD, that was recorded. The study was intended to answer a few questions. Those previously diagnosed as ADHD were re-evaluated to test the idea that “stimulant medications are overused.” While their study did indeed find children who had been mis-diagnosed, what they actually found was that a percentage of the children finally diagnosed as ADHD were not on any kind of medication or treatment at all.

“National Trends in the Treatment of Attention Deficit Hyperactivity Disorder,” by Mark Olfson, Marc J. Gameroff, Steven C. Marcus and Peter S. Jensen, (2003) in The American Journal of Psychiatry is a brief overview of what was the most current information in the treatment of ADHD in June of 2003. The studies compared the information from a survey done in 1987 and a follow-up, identical survey done in 1997. There are figures from households in all socioeconomic levels, from the pharmaceutical industries, physician-based surveys, and state-wide surveys of Medicaid, showing that treatment of and for ADHD, has increased. There is this statement regarding medications:

The National Medical Expenditure Survey and the Medical Expenditure Panel survey ask for the conditions associated with each prescribed medicine bought or otherwise obtained. We focused on the prescribed medications associated with the treatment of ADHD. Psychotropic medications were the classified as stimulants, anti-depressants, clonidine, and other psychotropic medications, including antipsychotics, mood stabilizers, anxiolytics and hypnotics. (1072)
The authors also note that there seemed to be a trend of decreasing involvement of psychologists and other behavioral health professionals with ADHD as the medication use increased.

In a report from the Surgeon General’s Office, under pharmacological treatment, the statement is made that stimulants have been the treatment for childhood behavioral disorders since the 1930’s. It goes on to say that stimulant medications are effective for 75-90% of children with ADHD. At the time the report was written, most of the usage was still in the shorter-acting forms of these various drugs because it is said that the drugs metabolized and leave the body quickly so medication routines are times around the child’s school schedule. Although stimulants improve classroom performance and behavior for ADHD children, they do not appear to achieve long-term changes that persist outside of the medications.

The following medications are suggested as possible means to medicinally enhance the healing/rehabilitation of memory-specific areas of the brain. Drugs suggested are: hypothalamic and pituitary neuropeptides, cholinergic agonists, catecholaminergic agonists, nontropics and vasoactive agents. It is also suggested that minimizing the use of medications that can potentially interfere with cognition is also helpful. There is no discussion of the use of such medications outside of the issues of acquired brain injury.

In the Jul/Aug 2003 issue of The Journal of Head Trauma Rehabilitation, in an article titled “Concepts of CNS plasticity in the Context of Brain Damage and Repair,” by Donald G. Stein and Stuart W. Hoffman, the focus is most particularly on traumatic head injury and its aftermaths. Among the ideas they explore are those of specific localization and complete equipotentiality. There is also information concerning new drugs that can limit the damage done when the brain is injured. Part of the problem when the brain is injured is that the original injury creates further problems. Damaged and dying cells give off chemicals that create a toxic environment and cause cell damage and death to spread beyond the original insult. Stopping this spread and creating an environment where damaged cells can heal is part of the new technology which includes the experimental use of progesterone as a neuroprotector.

In the “National Institute of Mental Health Multimodal Treatment Study of ADHD Follow-up: Changes in Effectiveness and Growth After then End of Treatment,” the MTA Cooperative Group reports on how well members of their subject groups did in a couple of areas that have been of concern to parents and providers who deal with ADHD children. One area is that of carry-over of positive effects of either medication or various forms of behavior modification. Using the figures from their sample groups it was determined, as has been noted in many other studies of effects of stimulant medications that there is no perceivable carry over effect as far as control of ADHD symptoms once stimulant medications are discontinued.

There was also, in group members who decided to stay with medication after the study was over, a noticeable increase in the symptoms of both ADHD and ODD indicating a decrease in the effectiveness of the medication, perhaps attributable to the body accommodating to the medication. The other issue of concern with regard to medications such as methylphenidate is the interference with growth that has been noted in many studies. First of all, it is important to note that a number of researchers have in one way or another discounted the idea of suppressed growth with the use of stimulant medications. For example, Satterfield et al offered the explanation that although growth might be suppressed to begin with, that there would be a growth rebound even if the medication was continued and there was no “summer holiday” provided. Another group of researchers, Spencer et al, hypothesized that the ADHD itself, and not medication factors is what caused the perceived growth issues. This was one of the questions the MTA group hoped to find a definitive answer for with their much larger sampling. It was observed that there was indeed something causing growth inhibition in the groups that were on medication the longest and it seemed to be an effect from the use of methylphenidate. As to the idea that there might be growth-inhibiting factors within the ADHD
spectrum itself, since there was quite pronounced growth in subjects who had no medication, this particular hypothesis doesn’t seem to hold. There was also interest in how well the effects of behavioral modification treatment would hold up once actual treatment was over and while there was also some erosion here, it was found not to be as much as with the cessation of medication. In order to really understand the long-term effects of continuous medication, track growth/slow growth, and to track the effects of other treatments offered in the Multimodal Testing, the is currently a MTA follow-up that is following these subjects into adolescence and in to adulthood.

Rogers Medical Intelligence Solutions an online continuing education service for medical providers offers “Advances in the Treatment of Adult ADHD—Landmark Findings In Non-stimulant Therapy,” edited by Margaret Weiss, MD, and Robert Bailey MD. This lesson package offers information about the effects of ADHD on an adult population. The effects for adults are not only the same inattention, dysfunctional impulse control etc., but the picture is further darkened by increased likelihood of drug and alcohol abuse, cigarette use, with increased difficulty of quitting and, more likely hood of traffic and driving problems.

Then the writ-up offers a hopeful review of the role of a drug called atomoxetine. First, the traditional drugs of choice for dealing with ADHD, the stimulants such as methylphenidate are discussed. Their actions as dopamine and norepinephrine re-uptake inhibitors are mentioned. The major concerns, once the ADHD person becomes an adult is the potential for abuse and for the ADHD patient to sell the medication because it is one of the class of drugs known on the “street” as uppers. Studies done both on subject populations and by various methods of medical imaging describe a very narrow range of action for atomoxetine which seems to be exactly what ADHD sufferers need. There have been some side effects noted that are more pronounced in adults than in children, such as, insomnia, gastrointestinal effects and genitourinary symptoms. Over all, however atomoxetine is probably going to be a better choice for many ADHD patients, especially for adults for whom substance abuse may potentially be an issue.

**Diagnostic Techniques in Neurorehabilitation including: PET, MRI, and Neuropsychological testing (including: Stroop Color Word Test, and Continuous Performance Tests) applicable to ADHD.**

Chapter Three of **Cognitive Neurorehabilitation** is involved with a discussion of the role of neuroimaging in identifying, specifically not only areas of the brain tasks are mediated through—information that researchers have had on many levels for a long time—but what areas can accommodate new tasks as required when the organism has been brain-injured. The ability to study living creatures as they perform various tasks designed to activate different sections of the brain give researchers vital, new information. Since the advent of these new imaging capabilities:

In recent years, neuroscientists have increasingly moved from the strict localization approach to brain function and have begun to think of both sensorimotor and cognitive processing as the product of activity in functional networks. This imaging also displays how the functions are carried out. (McIntosh and Gonzalez-Lima, 1994; Bressler,1995; Vaadia et al., 1995). This systems-level approach has allowed researchers to examine interactions among brain areas during specific types of cognitive or motor function and how these interactions change as behavior changes. (Grady & Shitij, pg.47)

Although the authors do not specifically mention ADHD, they do comment in summation that,

Whether as a result of injury, disease, degeneration, **congenital condition** (italics added) or decline, compensation originates in a deficit—a mismatch between skills, expectations and demands. Through various mechanisms of substitution, remediation, accommodation or assimilation, compensation involves closing one
or more gaps between skills, expectations and demands. (Grady & Shitij, p. 69)

Chapter Twenty of *Cognitive Neurorehabilitation* offers a discussion of tests and methods for accurately as possible defining the areas of the brain that have been affected by stroke or injury. The author is careful to explain that:

Many of the component cognitive functions that have been ascribed to the executive control system, such as inhibitory control or working memory are not easily operationalized and their measurement almost always involves some dependence on other cognitive abilities such as visual recognition or reading. Clinical tests that show deficits in patients with frontal lobe lesions typically require multiple component process and lack performance measures that are specific to individual cognitive processes. (316)

There are a number of tests for executive function named and they are many of the same tests used in determining the performance abilities of children diagnosed with ADHD. These tests which include, Wisconsin Card Sorting Test, Tower of Hanoi, Trail Making B and the Six Elements tests have shown some sensitivity to frontal involvement and include the need for problem-solving mental flexibility and or set/shifting. Working memory can be evaluated with such tests as Consonany Trigrams Test, self-ordered pointing measures and delayed response alternation measures. Inhibition of pre-potent responding can be assessed with the Stroop Test and Go-No-Go measures. Though prospective memory is not frequently tested there are tests to check on capacity to remember to initiate intended actions. It is also noted here that to get a good picture of what is going on with a given patient it is necessary to use multiple test methods.

In an article entitled, “Examining Brain Connectivity in ADHD,” from *Psychiatric Times Jan. 2004, 41*, researchers, Sanjiv, K. M.D. and Thaden, E. discuss the valuable role of magnetic resonance imaging (MRI) in learning more about what takes pace in the brains of children and adolescents with ADHD. There a number of advantages of MRI research with children: no ionizing radiation, gives a tool for doing longitudinal studies; could allow researchers to study the effects of psychotropic drugs on brain structure; and could in the future help develop new tools for diagnosis and for studying what the effect of drugs might be on disorders such as ADHD. Having more effective tools to deal with ADHD is important because the disorder not only causes difficulties in school, but creates the possibility of even worse problems such as increased risk of driving accidents in late adolescence and adulthood. The particular focus of this study was to measure and evaluate differences in the connective “white matter” of the brain. New evidence suggests that abnormalities in white matter development may contribute to ADHD.

M.S.C. Thomas, in an article, “Limits on Plasticity,” in the *Journal of Cognition & Development*, Thomas evaluates and recaps much of the most current literature on the plasticity of the central nervous system. He reviews four books, *Handbook of Developmental Cognitive Neuroscience* Nelson and Luciana (Eds.) (2001); *Developmental Neuropsychology: A Clinical Approach*, Anderson, Northam, Hendy & Wrennall, (2001); *Developmental Disorders of the Frontostriatal System: Neuropsychological, Neuropsychiatric, and Evolutionary Perspectives*, Bradshaw (2001); and *Neural Plasticity: The effects of Environment on the Development of the Cerebral Cortex*, Huttenlocher (2002). Generally, the author’s over-all view would seem to be that the most useful information is to be found between the two extremes of “pre-determined by built in blueprint” and “unlimited plasticity.” He discusses the two prevailing theories of when, where and how the brain and associated functions develop and poses the idea that “truth” is probably somewhere between.

In the section labeled, “Assessing Limits to Plasticity Via Recovery From Early Brain Damage, Thomas is discussing various views of “Early Plasticity” which indicates that damage done when a person is a child should heal more
completely with less residual incapacity. In the literature being reviewed, this doesn’t seem to hold true and Thomas says:

Indeed, children with generalized cerebral insult (e.g., from traumatic brain injury) exhibit both slower recovery and poorer outcome than do adults suffer similar insults. This is quite inconsistent with the notions of greater early plasticity. From the “early vulnerability” perspective, short-term recovery favors the mature brain. Across time, a child who has seemed initially to recover well from the insult may start to increasingly lag behind age-matched peers and fail to show the expected emergence of new cognitive skills. The child thus appears to “grow into” his or her cognitive deficit as the brain matures. (104)

There is also an extended discussion of the role MRI and PET examination is playing in discovering what really goes in the formation and development of the brain in developmental disorders including ADHD. This information should make it possible to better intervene either pharmacologically or cognitively. The problem is, that in his working to not seem to take a strong position, Thomas rather leaves the reader where he found him/her.

In the Journal of Emotional and Behavioral Disorders, Edith E. Nolan at el. offer the results of testing with various test instruments for reliability in identifying children with ADHD and often associated behavioral disorders such as Oppositional Defiant Disorder. The purpose was to test the reliability of such things as the Symptom Inventory Test. The conclusions that the researchers came to were that the youngest children, the preschool through age five were more likely to be ADHD-C or combined disorder whereas the most common finding in the adolescent age group was ADHD-I or inattention disorder. Besides finding a high degree of reliability in the various tests instruments, researchers also verified a perception that girls are under-reported and under-treated for ADHD and other behavioral disorders. The test groups followed the expected approximately three boys to one girl ratio, but the findings strongly suggest that when girls are identified and referred, they frequently display more intense symptoms. There are fairly complete statistical data to back up the researchers claims.

From the Journal of Abnormal Child Psychology, Vol. 29, December 2001, comes the report of a study done by Russell A. Barkley et al, that discusses the results of various measures of executive function, temporal discounting and sense of time of adolescents with ADHD and with ODD. It was stated that this study was unique in that it was aimed at children who were older when they were first referred to a clinic for behavioral and performance issues rather than being a follow-up on children who had been in the mental health system since they were young. Besides testing to rule out seriously diminished IQ, all subjects were asked not to take any stimulant medications they might be on. Tests used included KBIT Composite IQ to obtain a minimum baseline intelligence rating; Conners Continuous Performance Test, to test Vigilance and Response Inhibition; To check for Verbal Working Memory the Digit Span Reversed (Wechsler Intelligence Scale for Children, 3rd Ed. WISC-III Wechsler, 1994) was employed. To evaluate nonverbal working memory, the Simon Game was used. Verbal fluency was tested through the use of the Controlled Oral Word Association (F-A-S) test. Other areas tested were Ideational fluency by use of the Object Usage Test, Non-verbal Fluency, with the Form Fluency Test, Temporal Discounting was checked by use of the Reward Discounting Task in two ranges $100 dollars with time variables and $1000 dollars with time variables; and the last areas of testing related to Sense of Time and Time Reproduction. Only one of these testing methods had any connection with computers and no special significance was assigned to this nor was it postulated that there would be any great difference in performance due to the work being done by computer.

Richard W. Root II and Robert J, Resnick have co-written an article titled, “An Update on the Diagnosis and Treatment of Attention
Deficit-Hyperactivity Disorder in Children,” for the Professional Psychology: Research and Practice (2003) Vol. 34 journal. As part of their article, they have included the following guidelines in the diagnosis of ADHD:

1. Child should have a complete physical to rule out possible medical problems both as cause for the behaviors of concern and to make sure the child has no conditions that might interfere with care.

2. The assessment should establish that the child has significant inattention, impulsivity or over activity, that is age inappropriate and not accounted for by some other etiology.

3. There should be information gathered from parents, the child, teachers, and these interviews may be structured or unstructured.

4. There should be a complete review of school and health records, including report cards, achievement tests, psychoeducational tests and medical and psychological treatment records.

5. There should be a battery of psychological tests that might include any or all of the following: Continuous Performance Test, Freedom From Distractibility Index of the Wechsler Intelligence Scale for Children—III, Porteus Mazes, the Rey-Osterrieth Complex Figure Test, the Trail Making Test (A and B), the matching Familiar Figures Test, the Wisconsin Selective Reminding Test, the Wisconsin Card Sorting Test, the Controlled Oral Word Association Test, the Stroop Word-Color Association Test and the Hand Movements Test.

It is also suggested that it is helpful to observe interactions between the parents and child either informally or as part of some task assigned for them to do together to assess for co-morbid oppositional defiant or conduct disorder.

Clinical Pediatrics is an on-line, ProQuest Psychology Journal. James Nahlik offers information specifically designed to obtain accurate diagnoses of ADHD in adolescents. The basis of Nahlik’s concern is that most instruments for assessing for ADHD are aimed at younger children. One of the criteria from the DSM-IV requires symptoms to be present before age 7. Nahlik, however, points out: Nevertheless, certain sub-groups have less marked symptoms in childhood and are easily missed. These include the following three sub-groups: individuals (mainly girls) who tend to exhibit fewer hyperactive symptoms—the more obvious symptoms for teachers and parents to pick up on; individuals who exhibit mental rather than physical restlessness; children with a higher than normal average intelligence quotient (IQ).

Nahlik goes on to suggest that diagnosing this population correctly is important because when these people are not recognized and treated, they are likely to under-achieve at school which can lead to poor employment prospects, there are more than normal difficulties in relationships and adolescents with ADHD at much higher risk for behaviors such as dangerous driving, careless sexual activities, substance abuse and criminality all of which can have a negative impact on their futures. Also, in order to obtain reasonable accommodation from high schools or colleges, an accurate diagnosis is required.

Michael J. Murphy of Indiana State University, in the article “Computer Technology for Office-based Psychological Practice: Applications and Factors Affecting Adoption,” from Psychotherapy: Theory, Research, Practice, Training, Vol. 40 (2003) discusses many aspects of the use of computer technology by the private psychological practitioner and those who are part of managed care organizations. For the most part, this article does not address the treatment aspects of computers in the office although there is an extended discussion.
of the use of the computers and their various softwares as diagnostic tools. As he opens the discussion of computers as assessment and diagnostic tools Murphy makes this statement, “Next to billing packages, psychological testing is the best established and most frequently used computer application specifically developed for psychology.” (14) He goes on to say computer scoring and evaluation is available for all the major testing instruments such as Rorschach, Minnesota Multiphasic Personality Inventory, the Wechsler Adult Intelligence Scale and the Wechsler Memory Scale-III. Murphy also offers the opinion the current applications, because they are text based, are not taking the best advantage of the ability computers have to present “graphic displays of stimuli and complex scenarios.” He has found that one application that comes into this category is the continuous performance test (CPTs) that is available for use in the assessment of attention disorders. Computer programs for assessment interviewing is another set of applications that are available, however in a study by Salib and Murphy (2003) none of the independent practitioners surveyed use the computer-based interviews.

Under the heading, “Technology Use in Treatment,” Murphy reviews literature that has been developed as far as computers and their various capabilities such as the Internet in treatment. Although, many researchers seem to feel that there are great possibilities for both in-office use and what they are calling “telehealth” individual practitioners are not involved to any noticeable extent. The people who feel there are great possibilities have many reasons. One researcher, Budman (2000) says, “…applications can be tailored to individual needs and are cost effective, convenient, standardized, and foster greater disclosure.”

There is information to show that the internet is a widely used source of information concerning health issues, a poll by Harris in 2000 found that depression was the single most frequently searched health topic and that four of the top ten health topics searched had a mental health component. Many other aspects of computers-as-therapy-aid are discussed with the comments that therapists and clients alike don’t seem interested because much of what is available is also available in self-help books and watches with alarms so that people have the option of going low-tech, low-price.

In the overall review at the end of the article, the author states that computers and software are used mostly for the business aspects of the counselor’s office, not for the assessment or treatment of clients. Murphy writes, “The relative advantages of receiving services from a psychologist across the country over a face-to-face interaction with a local therapist do not seem compelling to patients or clinicians.

In her dissertation titled, “Cognitive Rehabilitation: A Method for Improving Sustained and Selective Attention in Adolescents With Attention Deficits,” Glinda Bullock designed a research mechanism to test for the effectiveness of computer-mediated cognitive rehabilitation for young people who had attention deficits issues due to ADD. The testing was done with four male middle-school students who were all diagnosed with ADD and who were all being treated with psychostimulant medications (Ritalin). She used a pretest-posttest design. The subjects were tested before the intervention to check on levels of attentional functioning and then were tested after six weeks of a hierarchical attention training program. This program included three weeks of sustained attention training and three weeks of selective attention training. Bullock reports that there was some improvement for all four subjects in sustained and selective attention on at least two out of three measures. “However, she writes, “only selective attention results were significant.” Bullock states that these results give reason to believe that cognitive rehabilitation could be effective in treating ADD and that further studies using groups, subjects and controls, are warranted.

The following assessment instruments are often used to evaluate how limited memory is after brain injury. In the article, “Functional Treatment Approaches to Memory Impairment Following Brain Injury,” in Topics in Language Disorders, (1997) Vol. 18 45-58, Judith Hutchinson and Thomas P. Marquardt, offer an extensive look
at what memory dysfunctions after brain injury might or might not be. They offer a number of tests as possible ways to evaluate the extent of loss of memory. The authors do state that such instruments are, “limited, difficult to standardize and sometimes, controversial.” The testing mediums offered for memory are, the Rivermead Behavioral Memory Test, which is a battery of test that attempt to simulate real life memory situations; the Present Functioning Questionnaire; Prospective Memory Process Training Memory Questionnaire; Multimodal Inventory of Cognitive Status; Cognitive Failures Questionnaire; Everyday Memory Questionnaire; Brief Cognitive Rating Scale and the Instrumental Activities of Daily Living Scale. There is no mention of how any of these tests might aid in evaluating congenital situations such as ADHD. There is also no indication that any of these tests are or could be computerized. Besides the testing mechanisms, there is also some discussion of how MRI and PET imaging help to identify more closely the parts of the brain associated with different aspects of memory.

In the article, “Activation of the Visual Cortex in Motivated Attention,” Margaret Bradley et al. studied the effects of emotional involvement with visual cortex engagement. The study design used students in a psychology class and images in both color and grayscale. The images came from seven categories designed to provoke emotional response. The imaging technique used was functional magnetic resonance imaging. The study is very involved, deeply statistical and probably of interest to those whose focus is on emotional response however it wouldn’t seem to have much applicability to the subject of ADHD or of how best to approach this disorder.

The Rehabilitation of Attention using Computer Assisted Cognitive Rehabilitation Programs including: Selective, Sustained, and Divided Attention.

Although this article discusses the use of computers mostly in passing, apparently, some of the Pay Attention© materials Kerns, K.A., Eso, K., Thomson, J., (1999) were using when they did the study “Investigation of a Direct Intervention for Improving Attention in Young Children with ADHD” were administered by computer and it may be that the materials they were using would be generally adaptable to use on computers especially if it seems that computers add some extra measure of acceptability for young children, i.e. they feel very grown up working with the computers so that they are attending better at the same time their attention issues are being addressed.

In Chapter Nineteen of Cognitive Neurorehabilitation the book’s editors provide brief evaluations of eleven different studies that used some manner of computerized attempts at re-training of attention in stroke or otherwise brain-damaged adults. Although the studies each showed something in the way of possibilities, across the spectrum, the major difficulty was that there seemed to be no generalizability to a multitude of situations or general life situations. Each study had weaknesses as to methods of testing or methods of reporting. Because of these problems, it is not possible to actually decide whether or not computer-aided training has a real place in the rehabilitation of brain injury or stroke patients and since none of these studies were aimed at congenital, cognitive disorders such as ADHD, there is no way to know if the measures used have transferability. There is also no way to know if it is the use of computers that is not functional or if it is the programs being used—the programs are not interesting enough to engage attention enough for there to be a lasting effect.

Bill Lynch, a PhD in private practice in Redwood City, California offers this article titled, “A Historical Review of Computer-assisted Cognitive Retraining. The article appeared in the Journal of Head Trauma Rehabilitation. Lynch says that researchers and therapists began considering the possibility of using computers in cognitive retraining about 40 years ago.

Places like NYU Medical Center, Hawaii State Hospital, and the VA Medical Center in Palo Alto became known for their programs involving computers even before electronic video games and
home computers were common. The rehabilitation programs in these places approached the treatment of traumatic brain injuries with an emphasis on the impaired thinking, memory and information possessing.

His purpose was to give a general overview of what was happening in the field of computer-assisted neurorehabilitation. His evaluation is that programs which work the best combine the information it is desired that the client learn with practical applications and fun.

It is also his perception that programs aimed at compensatory approaches provided better outcomes than then did those applying restorative programs. He offers a number of suggestions in the compensatory category. First of all there is a wide array computer-based assistive technology such as, NeuroPage which is a programmed pager that will provide either tonal or text reminders for prospective memory tasks. Lynch says that Wilson and colleagues have published research on the NeuroPage which indicates improved ADLs and good patient compliance in 80% of a 143 subject study. NeuroPage is one of the many of what Lynch calls “reminding systems.” He suggests that such things as answering machines, digital watches with data storage, microcassettes digital palm sized dictation devices and PDAs are all computer-based helpers that can create greater independence for brain-impaired people, no matter what the diagnosis.

Lynch offers for consideration an outline for future research in this field. He says research should address these issues:

1. How does treatment with this software compare with existing treatment approaches with regard to effectiveness and cost? 2. What brain conditions are more likely to respond favorably to this software? 3. What is the optimal time after onset to begin treatment with this software? 4. What is the optimal treatment regimen or schedule for using this software?

Lynch includes a list of softwares to assist with everything from driver screening and training, to programs that help with math and executive function by creating “real-world” simulations to use math and planning abilities.

It would seem that the compensatory approach could be of benefit to ADHD clients because their deficits do not result from abilities they once had and understood, being taken away.

In the discussion of a program that an interdisciplinary team is working on, D.L. Mickey, et al., of Neuropsychological Associates, of Madison WI, describes a battery of computer-aided retraining formats for retraining victims of traumatic brain damage. Their article, “Brain Injury and Cognitive Retraining: The Role of Computer Assisted Learning and Virtual Reality” explains the work they are doing to harness the computer as therapeutic tool. The focus is on traumatic injury but the information itself should be transferable.

Their Adaptable Learning Environment for Rehabilitation Training, acronym, ALERT, begins by defining the cognitive domains to be addressed:

The design of this learning environment addresses a variety of cognitive domains including arousal and orientation, attention and concentration, memory visual and spatial perception, language and verbal skills, executive functioning (e.g., reasoning, planning, organization, problem solving), life skills (e.g., time telling budgeting following directions), and social skills. Cognitive tasks are activities specific to assessing the skills contained within a broader cognitive domain (e.g., attention, memory, executive functioning) and are designed to enhance the learner’s skill level in that particular sub-domain.

The authors go on to describe the program as adaptable to age through game-like activities which use a multiple level system to provide challenge and growth. They write that once the participant reaches a certain “predetermined level of competency in a particular skill, he or she will then engage in a series of simulation tasks.
designed to enhance the functional use of the skill and increase the ecological validity of the intervention. This is accomplished through the use of virtual environments.” The discussion that follows, although aimed at brain injury issues, also seems to include many of the same cognitive weaknesses which are recognizably part and parcel of ADHD. It would seem that the same kinds of interventions could be constructively applied to ADHD across the age spectrum just as well as for brain damage. Part of the ALERT program includes Virtual Reality interactive settings. The image shown in the article is that of a kitchen that “talks back” so to speak. With interactive objects—a phone that rings, a sink that fills with water, a pot that boils and a coffee pot that works, as the text puts it, Once started these processes… continue until the user takes action. All those things can be happening at once “thereby creating a need for prioritized attention. Meanwhile, the user’s responses and response times are recorded and performance scores calculated to be used to update the user model and guide the course of treatment.

Plans for these programs include expanding the life-skill scenarios and virtual environments to include many vocational settings and vocational and social problem-solving scenarios in order to support vocational rehabilitation. It does seem that there would be ways to adapt this whole idea to working with ADHD. In the Conclusion to the article, it is noted that ALERT was to be made available over the Internet and on CD-ROM. Release was scheduled for Spring 1998. There was also supposed to be a web site: http://www.earthlab.com/alert/

Margaret M. Bradley at el., in a study for the National Institute of Mental Health, titled “Activation of the Visual Cortex in Motivated Attention,” published in Behavioral Neuroscience worked with neuroimaging, specifically fMRI to measure where and how in the brain motivated attention was focused. No particular disease processes where discussed, as the actual focus of the study was emotional arousal and focused attention, but it is possible that this information could be useful in designing computer programs to assist with rehabilitating attention in persons with ADHD.

From Cyber Psychology and Behavior, Vol. 5, November (2002) is an article titled, “The Effect of Virtual Reality Cognitive Training for Attention Enhancement,” from a Korean research team,Cho Baek-Hwan et al., concerns the use of Virtual Reality to assist in training and enhancing attention in children with ADHD. Baek-Hwan Cho et al. begin their discussion with a definition or description of the five basic categories of attention which are: focused attention, sustained attention, selective attention, alternating attention and divided attention. This group developed their own materials to be used for this study. Since much of a child’s time is spent in the classroom, the first project was a virtual classroom, or a virtual environment, VE. The VR cognitive training tools were designed to follow the patterns set up in ADHD assessment instruments such as Continuous Performance Task, Test of Variables of Attention or Wisconsin Card Sorting, but are meant to be used in training rather than assessment. The comment is also made that the VR programs have the added feature of levels that allow the subjects to track their own progress.

The researchers report a number of factors that might make evaluation of their system difficult, i.e. the subjects, while they displayed many of the same behavior tendencies as people with ADHD, were a population from a reformatory setting and none of them had an actual diagnosis of ADHD. The research group also feels that their programming needs work because the group that used just a regular desk top computer for the training reported the effort to be tedious and uncomfortable. The positive side, however is that the people using the Head Mounted Display and a Head Tracker not only showed good results over all but also more willingly worked with the training program. There is some detailed information as to how the tests worked and what the elements were.

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research mechanism to test for the effectiveness of computer-mediated cognitive rehabilitation for young people who had attention deficits issues due to ADD. The testing was done with four male middle-school students who were all diagnosed with ADD and who were all being treated with psychostimulant medications (Ritalin). She used a pretest-posttest design. The subjects were tested before the intervention to check on levels of attentional functioning and then were tested after six weeks of a hierarchical attention training program. This program included three weeks of sustained attention training and three weeks of selective attention training. (Italics added) Bullock reports that there was some improvement for all four subjects in sustained and selective attention on at least two out of three measures. “However, she writes, “only selective attention results were significant.” (Italics added) Bullock states that these results give reason to believe that cognitive rehabilitation could be effective in treating ADD and that further studies using groups, subjects and controls, are warranted.

Incredible Horizons: New Brain Research, does offer some basic information on brain plasticity and developing attention, but this particular document is basically one long commercial for a series of products put out by Advanced Brain Technologies/Unique Logic and Technologies. The products are a collection and combination of software programs and dietary supplements.

In, “Current Directions in Computer-assisted Cognitive Rehabilitation,” from the journal, Neurorehabilitation Samuel T. Gontkovsky, et al. discuss the state of computer-based neurocognitive rehabilitation. They view cognitive deficits in a pretty general way although most of their examples have to do with brain injury patients. They discuss various studies that have been done with computer programs. The researchers say that as the empirical evidence continues to increase, “direct comparisons of findings across investigations remains problematic due to multiple methodological issues to similar to those encountered when attempting to compare traditional methods of cognitive rehabilitation.” (196) and the general view is that computers get about the same efficacy for patient improvement as traditional therapy. While at first glimpse, that may not seem wonderful, these researchers see those results in areas such as attention deficits as very promising because programs can be provided for use on home computers, once training is completed, and people can be working with the information at home. Even if such treatment needs to be combined with more traditional interventions, it is suggested that working at home could be very cost effective in itself and in reducing the number of therapist hours required per patient. Even if computer-based treatments were not used to “replace” traditional therapy it would make sense to use them for re-enforcement of treatment. As in many other articles, the possibilities for use with ADHD certainly exist but are not directly addressed.

Norman W. Park and Janet L. Engles contribute their article, “Effectiveness of Attention Rehabilitation after an Acquired Brain Injury: Meta-Analysis,” published in Neuroscience. They discuss the importance of returning brain-injured subjects to there former level of attention-related function. The writers state most accurately that the level to which attention is negatively affected is a strong predictor of a patient’s likely ability to return to work. The authors outline the usual methods of re-training attention which usually includes completing a series of exercises or drills. The rehabilitation client responds to visual or auditory stimuli within a frame work of rules. In the Attention Process Training Program there is a series of graded exercises that begin with simply pressing a buzzer when they hear the number 3, through increasingly complex tasks. There is feedback at each level. When the training tasks are completed, there is testing and treatment is considered successful when improvement is shown on the tests of cognitive function. The Attention Process Training program has sections for sustained, selective, alternating and divided attention. This approach was developed because one current theory says the specific divisions of attention need specific training or re-training. Nothing was mentioned as to whether any of this particular program is computerized.
According to these writers, another, less studied approach to rehabilitation is to train or re-train attention by having clients perform specific tasks of “functional significance.”

One example of something considered a functionally significant task was driving. Kewman et al. (1985) looked at driving as a complex skill that requires critical paying attention and flexibility to shift focus from one activity to another. An experimental group completed a series of exercises that were developed around divided attention. The tasks were performed driving an electric-powered vehicle and used a group of brain-injured subjects and a group of regular subjects. This paper says that the brain-injured subjects were not trained using the specific exercises and offers no results of this experiment.

This paper goes to say one purpose is to evaluate other studies of cognitive, attention-focused rehabilitation studies specifically those studies that attempted to “directly retrain attention.”

In the “Discussion” section of this paper, the writers make these comments:

One objective of this meta-analysis was to evaluate quantitatively, for the first time, the efficacy of rehabilitation programs that attempt to directly retrain attention. Several lines of evidence showed that these methods produced only small, statistically non-significant improvements in performance in all general measures of cognitive function and in all specific measures of attention when improvement was determined using pre-post with control effect size estimates. We also examined individual studies that reported an improvement in cognitive functioning. Of the 12 direct-retraining studies with a control condition, 6 reported no statistically significant improvement in performance after training. In the remaining 6 studies, the pattern of improvement was specific in each case and, in most cases, could be attributed to specific skills acquired during training. (Italics added) Thus, support for the hypothesis that direct retraining can restore or strengthen damaged attentional function was not found in the reviewed studies. (205)

The writers do state that there may have been significant improvement for individuals however, grouped data prevented examination of such cases.

The second stated purpose of the meta-analysis was:

…to identify methodological factors that may contribute to the variability in training efficacy across studies. Effect sizes derived from studies without a control group were consistently much larger than those from studies with a control group…These findings strongly suggest that the larger effect sizes in the pre-post only studies are attributable to the effects of practice on the outcome measures and not to other associated factors” (205)

Although, these reviewers are critical of how much of the looked at research was conducted, they offer an interesting comment for future consideration:

Perhaps most important, however, the consistency and magnitude of practice effects, observed even after a single exposure to test material, demonstrate that people with acquired brain injuries can quickly learn a broad range of skills. This finding suggests that treatment aimed at helping people learn or relearn skills after an acquired brain injury will probably be effective, particularly if the skill being learned has a substantial attentional component. (Italics and emphasis added) (206)

In the closing remarks there are some comments that might be pertinent to working with ADHD attention deficit issues and that might also be particularly suitable for computer-aided training. They are discussing breaking complex skills down into simpler components. By practicing these components and giving feedback as practice goes along performance can more easily be evaluated.
A little earlier in the discussion they also used the term “neuropsychological scaffolding.” This is, perhaps, another concept that could be applied to computer-assisting ADHD subjects.

Although this letter is found on the website for a company that provides Captain’s Log® as a product, it seems worth noting. As is so often the case, the subjects who took part in the study at Shasta College were all brain injured so it must be inferred that they would be re-learning not first time acquiring the discussed capabilities. The letter writer, who is affiliated with the college’s High Tech Center, explains that each student is carefully evaluated for abilities and disabilities prior to beginning the use of Captain’s Log®. An individual care plan is devised with the computer program as its main component. The writer, Bobby Roberts, says:

In just a short period of time (in some cases as little as nine weeks) we are seeing great improvement in these students’ abilities in memory, in reading and in all of the other basic cognitive areas covered by Captain’s Log®. Most exciting of all, we are seeing these skills generalize into daily living and improve the students’ quality of life. The individuals showing the most improvement and the biggest generalization are those who spent a minimum of one hour, three times a week working with Captain’s Log®. It seems to be very important that they start at an appropriate level in each category and follow their individual plan….

“An Analysis of Computerized Cognitive Training and Neurofeedback in the Treatment of ADHD,” is a review that comes from the same site and is commentary by Joseph A. Sandford PhD., on a study conducted by Drs. Aubrey Fine and Larry Goldman, at the Center for the Study of Special Populations, California State Polytechnic University, Pomona, California.

The research sample was 67 subjects between the ages of 8-11, 85% of whom were males. Each volunteer had been professionally diagnosed with ADHD by either a physician or a psychologist. They were randomly assigned to Cognitive Training, Neurofeedback or No Treatment. A pre-post design was used and the test examiners were blind to group designation. This author states that the experimental findings were analyzed based on a “3X2 ANOVA factorial design ….Thus, this design provided experimental controls for possible practice, learning and placebo effects.

The description/definition of Captain’s Log® says it consists of cognitive training exercises that utilize the capacity of the computer to provide immediate non-judgmental feedback for self-regulation, individualized instruction, reinforcement of response inhibition, challenging tasks which require sustained attention, engaging and game-like stimuli and small, chunk-like building block exercises. A number of familiar non-computerized tests were administered to the test subjects and the Cognitive Training—the group treated with Captain’s Log® scored generally and significantly higher in most measurements. There is further discussion with regard to the feedback portion of the testing and the commentator finishes with the observation that no treatment at all of children with ADHD during the summer led to a pervasive worsening of their emotional and behavioral problems. He commented it wasn’t clear what they did, but it seemed that a lack of regular tasks demanding the various disciplines to be found, say, in school was not good for ADHD children. All of these comments and observations will be included in the next section as well as they cover all the aspects of ADHD discussed there.

The Rehabilitation of Executive Function Using Computer Assisted Cognitive Rehabilitation Programs including Response Inhibition (self-regulation); Problem-solving and Self-monitoring; Working Memory; Planning and Organization.

In the dissertation done by Dona M. Belluci, “The Effectiveness of Computer-Assisted Cognitive Rehabilitation for Patients With
Chronic Mental Illness” many of the symptoms described for schizophrenia, are also, to one extent or another also present in people with ADHD. Seeing these similarities, it seems there would be a logic to trying some of the same computer-assisted rehabilitations with the ADHD population.

Chapter Twenty-one of *Cognitive Neurorehabilitation* there is a discussion of the need for and the progress in theories and methods for helping people with memory deficits. The discussion is, again, focused around people who have known proper memory function and have lost some of that function due to injury or illness. In recent time there have been three major approaches to memory rehabilitation—environmental adaptations, new learning and the use of new technology. New technology involves a number of possibilities. “Smart” houses that are being designed to increase the possibility of independent living for confused elderly people are likely adaptable to other groups who suffer cognitive impairment. These special homes are a mix of high technology and adapted everyday appliances or items. Examples are telephones with pre-programmed numbers and a picture on the phone button cues the user which person in their world is connected to which button. Video phone links connect the client with a care center or primary helper. Control systems for water temperatures can be installed to protect from showers or bashes being too hot or cold.

Another form of technology is the NeuroPage. It is a pager which can be used to remind memory-impaired people to do certain things as they go along through their day. Whether the prompt is, “take your medications,” or “It’s time to feed the dog,” with the assistance being mediated from outside, the person isn’t trying to use and impaired memory to remember passive memory aids such as using a day runner. There is something called the Interactive Task Guidance System which can be used to provide step-by-step instructions for doing whatever daily task the guidance is required for. The ITGS uses computers to provide cues to daily tasks such as cooking.

“A Cognitive Remediation Program for Adults With Attention Deficit Hyperactivity Disorder,” in the *Australian and New Zealand Journal of Psychiatry* 2002; 36:610-616 Caroline Stevenson, Stephanie Whitmont, Laurel Bornholt, David Livesey, and Richard J. Stevenson, offer the results of a cognitive intervention on behalf of adults who have been diagnosed as being ADHD. The purposefully designed intervention reports nothing about the use of computers but because of the success reported is worth noting and worth considering as a possible model to adapt for children and to possibly adapt to use with computers.

The study reported here used a three-prong approach to reduce the impact of cognitive impairments: (i) retraining cognitive functions; (ii) teaching internal and external compensatory strategies; and (iii) restructuring the physical environment to maximize functioning. Many experts in the field of adult ADHD use and recommend such an approach, albeit without systematic evaluation of these interventions.

The Cognitive Remediation Program (CRP) was designed for a small group format and included eight weekly, therapist-led group sessions; support people who acted as coaches and there was a workbook for the participants. The point of group sessions was to teach strategies to improve function in the areas of motivation, concentration, listening, impulsivity, organization, anger management and self-esteem. To evaluate the co-effects of intervention and medication, both medicated and non-medicated participants were included. To stabilize this variable, participants were asked to not change their medication status until the two-month follow-up point. The outcome measurements used to determine the success of the intervention were, *DSM-III-R ADHD checklist*, *Adult Organizational Scale*, *Davidson and Lang Self-Esteem Measure*, and the *State-Trait Anger Expression Inventory*. These measurements were administered pre-treatment, immediately post-treatment, and at 2 months and 12 months post-treatment. The results for maintaining the gains of this particular intervention are encouraging.
In the article, “Functional Treatment Approaches to Memory Impairment Following Brain Injury,” from *Topics in Language Disorders, (1997) Vol. 18, 45-58*, Judith Hutchinson and Thomas P. Marquardt discuss many methods for dealing with memory impairment. They discuss MRI and PET imaging to help with closer diagnosis. They discuss the possible role of medication in assisting with cognitive/memory rehabilitation. They discuss the many possible test instruments to evaluate the extent of memory damage. The next section of their article deals with what they refer to as peripheral factors such as vision or hearing aids, and making sure that nutrition and hydration are optimal, adjustment of medications as may be needed, making sure patient is getting enough sleep, is relaxed enough and not in pain as much as possible.

They then go on to discuss practical, environmental adjustments that can be made to assist with memory. These aids include labeled, fixed receptacles for glasses, keys, dentures etc., signs on cabinets and drawers and reminder cues for activities or medication schedules. There are further comments about family/caregiver training to help these people better understand what is going on with the patient and to train the people around the patient in the use of cues and environmental adjustments to make things easier for everybody.

This article also includes an extended discussion of the importance of developing patient awareness of disability and the extent of disability as the foundation on which to build/rebuild memory function. The authors quote Crossen et al. (1989) in these levels of awareness:

1. Intellectual awareness is the ability to understand and verbalize deficit knowledge.
2. Compensatory awareness is the slightly more advanced ability to identify errors and correct them.
3. Anticipatory awareness is the demonstrated ability to prepare for and prevent potential problems resulting from cognitive impairments.

The memory-impaired patient must be assessed for current level of awareness and presented with educational and counseling support appropriate to that level of awareness in order that awareness be gradually increased. Group therapy approaches are particularly effective in providing peer feedback and improving insight into deficits. Video feedback is also frequently employed for awareness training, including treatment to facilitate communication in context, message repair and cohesiveness of narrative. (Erlich & Spies, 1985)

Hutchinson and Marquardt go on to say: Many popular approaches to memory improvement, including those designed for the non-brain-injured population are based on assumption that repetitive use, practice, and placing of increased demands on the cognitive system will result in neurological adaptation and recovery. General “stimulation” approaches have been found to have minimal and only generalized effects on overall cognitive function. However, narrowly focused direct retraining of cognitive processes through hierarchically arranged treatment (the process approach described by Bracy (1986) and Solberg and Mateer [1987]) has been shown to be effective in the rehabilitation of some types of linguistic and cognitive impairments. Process-specific training has been used most effectively in attention training and probably least effectively in memory training. {Emphasis/italics added}The crucial role of attention in memory function—in encoding, rehearsal, consolidation, in retrieval processes—indicates the utility of providing attention-process training as part of a memory rehabilitation program. However, repetitive practice in memorization and frequent
demands to remember material, although still frequently observed in rehabilitation settings, have not been shown to be useful in memory improvement and, in fact, are likely to be detrimental to the therapy process (Prigatano, et al. 1984).

The authors go on to offer suggestions in the way of strategies to be used in a rehabilitation setting. There are personal compensatory training techniques which focus on increasing conscious attention, rehearsal techniques and operating on specific content to enhance its encoding and subsequent retrieval. Rehearsal training is the process of repetition of information in working memory in order to enhance its consolidation into long term memory. They go further to explain that this process is to some extent automatic and unconscious in normal function but the automaticity of processing is impaired in brain injury. Rehearsal training is based on the idea that brain-injured patients need explicit, conscious rehearsal of information.

There is also a discussion of visual imagery, domain-specific training, the TRACES protocol and external compensatory aid training as ways to work around or re-train memory deficits. There are no specific suggestions for use outside the area of dealing with people who had adequate memory skills and lost them due to injury however it would seem that there would be a certain aspect of transferability. There is also no mention of the use of computers except as the power behind the NeuroPage. This article is seven years old and there may have been changes that would now include the deliberate use of computers at some point. This article, in its focus on memory seems to, by implication, suggest possible treatment avenues for all executive functions and for conditions such as ADHD.

Although this letter is found on the website for a company that provides Captain’s Log® as a product, it seems worth noting. As is so often the case, the subjects who took part in the study at Shasta College were all brain injured so it must be inferred that they would be re-learning not first time acquiring the discussed capabilities. The letter writer, who is affiliated with the college’s High Tech Center, explains that each student is carefully evaluated for abilities and disabilities prior to beginning the use of Captain’s Log®. An individual care plan is devised with the computer program as its main component. The writer, Bobby Roberts, says:

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Working memory, say these researchers, underlies several cognitive abilities including logical reasoning and problem-solving. In ADHD impairment of WM is of central importance and it is suggested that it is in part an impaired frontal lobe. The study was set and designed to investigate whether it would be possible to improve WM capacity with training. They go on to say that in previous attempts to do the same thing, the training did not involve graduated difficulty levels so that while there grew to be faster reaction times, there was no reported increase in WM capacity. There has been some reported success in teaching rehearsal strategies to children with learning disabilities and there have been studies where subjects have learned strategies to retain large numbers of digits. These strategies did not, however prove to generalize to otherWM or reasoning tasks.

The study was made unique by designing special computer programs, that included a staircase method of increased demand, with the idea of pushing the subject to close to capacity. Training with these programs was 20 minutes per day, 4-6 days per week for at least 5 weeks. In the pre-test, post-test part of the study, a battery of tests used for evaluation of WM capacity and prefrontal functioning was used. Among others were included Raven’s Colored Progressive Matrices, and Stroop’s test which children with ADHD are known to have problems with. There were seven children in the test group and seven in the control group. To use with the control group there was a specially designed “placebo” program that lacked the interactive difficulty level and was administered less than 10 minutes per day. Also, the study was a double-blind design where parents, children and the psychologist who administered pre and post training testing did not know which version of the programs the children had practiced. There is a detailed description of the actual test measures and how they changed as difficulty increased. This same test measure was used in a second experiment in which four healthy males between 22-29, with no psychotic, or neurological history participated in the training.

The general findings were that during training, performance gradually improved on all trained tasks with an increased amount of information kept in WM and decreased reaction times. The writers also report that on the cognitive testing performed before and after training, all subjects improved on all tasks. They go on to say, “The present study showed that intensive and adaptive, computerized WM training gradually increased the amount of information that the subjects could keep in WM. The improved performance occurred over weeks of training, and is in this respect similar to the slow acquisition of a perceptual skill or a motor skill.”

In the article Executive Functions, Self Regulation, and Learned Optimism in Pediatric Rehabilitation: A Review and Implications for Intervention,” in Pediatric Rehabilitation (2002 Mark Ylvisaker and Timothy Feeney, review much of the current literature on executive functions.
and make recommendations for treating children with executive function deficits. Most of their discussion has to do with brain injury but they state that they believe what they have found is transferable to children with congenital learning dysfunctions such ADHD. In various studies, researchers found that different kinds of damage or conditions will produce variations on the general theme of Executive functions. Different deficits cause different parts of the executive function picture to be distorted. For example children with traumatic brain injury configure solving the executive function puzzle differently than children whose brain damage was caused by meningitis. The authors go on to say that ADHD children present a third, separate picture in that, reduced behavioral inhibition is the core deficit which causes a, “secondary interference of four additional executive functions (working memory; self-regulation of affect, and arousal; internalization of speech and reconstitution or behavioral analysis and synthesis.” (52)

Ylvisaker and Feeney also discuss strategies for working successfully with the child population which has suffered some sort of brain injury. Their opinion is that executive functions must be worked with as a whole if there is to be a successful outcome for the client. Further, they suggest strategies based on real-life, day-to-day issues the clients face as opposed to laboratory testing-type activities. Their emphasis was student-based co-planning, and execution led by specially trained teachers or parents. There was nothing mentioned about the use of computers but there doesn’t seem to be any reason why their “Goal-Plan-Do-Review” format couldn’t be adapted to function with a computer program as long as the cooperative nature of the concept wasn’t lost or turned over to the computer. As far as that goes, if an adolescent really had a problem with authority figures, he/she might take guidance and direction better from a computer figure of some sort.

In another part of this study, the authors review the work of Anderson et al and quote this passage: “The magnitude and intractability of the defects incurred by injury at an early age suggest that there might be limited neuronal plasticity in the sectors of the prefrontal circuitry which contribute to emotional modulation and the linkage of emotion and decision making.”(59)

There is also an extensive checklist to be used in assessing interventions proposed for use in the treatment of impaired children.

Some of the material found in the Hutchinson/ Marquardt article cited in a previous section might also apply to working with cognitive defects. Many of the same tests, might in some manner function for assessing weaknesses and strengths in ADHD, but nothing is said about how researchers would go about testing for functions that probably work poorly at best. Nothing is said about how to teach what a person never had. It may be that the Present Functioning Questionnaire and the Multimodal Inventory of Cognitive Status might be of assistance in ADHA, especially with adults who may have managed to compensate for weaknesses.

This same information appears in section VI as it is applicable to both discussions as we discussed at the beginning of the project. I hope this particular set of information proves accessible and useful to your project as it—or something like it—seems so logical and workable.

In the discussion of a program, that an interdisciplinary team is working on, D.L. Mickey, et al., of Neuropsychological Associates, of Madison WI, describes a program of computer-aided retraining for victims of traumatic brain damage. Their article, “Brain Injury and Cognitive Retraining: The Role of Computer Assisted Learning and Virtual Reality” explains the work they are doing to harness the computer as therapeutic tool. The focus is on traumatic injury but the information itself should be transferable.

Their Adaptable Learning Environment for Rehabilitation Training, acronym ALERT, begins by defining the cognitive domains to be addressed:

The design of this learning environment addresses a variety of cognitive domains including arousal and orientation, attention and concentration, memory visual and spatial perception, language and verbal
skills, executive functioning (e.g., reasoning, planning, organization, problem solving), life skills (e.g., time telling, budgeting following directions), and social skills. Cognitive tasks are activities specific to assessing the skills contained within a broader cognitive domain (e.g., attention, memory, executive functioning) and are designed to enhance the learner’s skill level in that particular sub-domain. (2)

The authors go on to describe the program as adaptable to age through game-like activities which use a multiple level system to provide challenge and growth. They write that once the participant reaches a certain “predetermined level of competency in a particular skill, he or she will then engage in a series of simulation tasks designed to enhance the functional use of the skill and increase the ecological validity of the intervention. This is accomplished through the use of virtual environments.” The discussion that follows, although aimed at brain injury issues, also seems to include many of the same cognitive weaknesses which are recognizably part and parcel of ADHD. It would seem that the same kinds of interventions could be constructively applied to ADHD across the age spectrum just as well as for brain damage. Part of the ALERT program includes Virtual Reality interactive settings. The image shown in the article is that of a kitchen that “talks back” so to speak. With interactive objects—a phone that rings, a sink that fills with water, a pot that boils and a coffee pot that works, as the text puts it, Once started these processes… continue until the user takes action. All those things can be happening at once “thereby creating a need for prioritized attention. Meanwhile, the user’s responses and response times are recorded and performance scores calculated to be used to update the user model and guide the course of treatment.

Plans for these programs include expanding the life-skill scenarios and virtual environments to include many vocational settings and vocational and social problem-solving scenarios in order to support vocational rehabilitation. It does seem that there would be ways to adapt this whole idea to working with ADHD. In the Conclusion to the article, it is noted that ALERT was to be made available over the Internet and on CD-ROM. Release was scheduled for Spring 1998. There was also supposed to be a web site: http://www.earthlab.com/alert/

Review of Computer Assisted Cognitive Rehabilitation as a Treatment Modality:

A. Empirical Support, B. Limitations, and C. Future Directions.

A. Empirical Support:

In a review of literature entitled, in Education and Treatment of Children. 25:2 Chunshen Xu, Robert Reid and Allen Steckelberg of the University of Nebraska undertake to draw some conclusions regarding using computerized testing and training for ADHD children. While it seems they are convinced, perhaps on a personal level, that computers should be a valuable tool for treating and training ADHD children, the actual results of their review of the literature are inconclusive at best. They offer the explanation for this vagueness as being in some cases, poor design, some cases lack of real control and some cases poorly collected information.

In the study, “The Effect of Virtual Reality Cognitive Training for Attention Enhancement,” Cho et al., offer these conclusions in support of using computer-mediated Virtual Reality as an Attention Enhancement tool.

In this research, our main goal was to validate the use of VR in cognitive training for attention enhancement. Therefore we developed a cognitive training program in VE as part of the prototype of the Attention Enhancement System.

Compared to the non-VR group and the control group, the VR group increased their correct rate and decreased their perceptual sensitivity (d’) and response bias (B)
significantly which means that cognitive training in VE with HMD and head tracker is effective in sustaining one’s attention, and making one consider sufficiently and distinguish target stimuli more sensitively. These results prove that VE cognitive training, which is as application of exposure therapy, is more effective in improving the attention span of children and adolescents with behavioral problems and helping learn to focus on some tasks. We can also say that immersive VR may be appropriate for attention enhancement. (Italics added.)

As part of his article, “Historical Review of Computer-assisted Cognitive Retraining,” Bill Lynch reviews the software and personal hardware available at this moment—2002—when this article was published. He offers the statement: “There are two trends evident in the way in which computers are used in cognitive rehabilitation treatment in recent years: one involves the content of software, and the other involves the use of computers or electronic devices as cognitive aids or prostheses.” (451). There follows an extensive discussion of what is currently available, with approximate prices as far as software programs are concerned, and also a discussion of the prostheses. There are no prices given in this part of the discussion.

Park/Ingles offer much comment on the current state of treatment for attention deficits. They are willing to hypothesis that specific-skills training/retraining has hope to offer but lacks much in well designed, well controlled studies where information gained can be scientifically accepted and built on.

S. T. Gontkovsky et al. provide empirical support for the use of computers in cognitive rehabilitation by reviewing the work of a number of research groups. They offer the example of Finlayson et al. who demonstrated significant improvement in “new learning, problem solving, mental flexibility, and psychomotor functioning following completion of a program of microcomputer exercises which was individually designed and systematically implemented for an adult female who had sustained a severe closed head injury.” Gontkovsky goes on to say that reports indicated generalization of the gains made when independent neuropsychological testing was done.

In, “Applications of Computer-based Neuropsychological Assessment,” Philip Schatz and Jeffery Browndyke, published in the *Journal of Head Trauma Rehabilitation* of September 2002, present an overview of where computer-based assessment is and what would make a better future for this technology and for the neuropsychological profession.

These writers begin by looking at how computers are presently used in professional practice. They are of course, used for scheduling, billing, and the word processing that goes with narratives of care and histories. Computers are also being used to some extent for neuropsychological assessment and that is the primary focus of their article. At present, there have been traditional paper-and-pencil tests computerized. Tests such as, the Peabody Picture Vocabulary Test, the Raven’s Colored Progressive Matrices test, and the various versions of the Wechler’s Adult Intelligence Scale up until very recently when the WAIS-III pretty much returned to it’s written format.

The authors also discuss the Halstead-Reitan Neuropsychological Test Battery which was “originally developed to predict the presence and localization of brain damage”. (396) They write that although a lot of attention has been shown to this battery as far as computerization values are concerned, it hasn’t really proven more effective than clinician interpretation. Something called the Category Test, a subset of the Halstead-Reitan Battery was first computerized in 1975. It had problems and was eventually re-computerized in the 1980s. Improved microcomputer technology “allowed for full automation of the Category Test with the exception of the verbal instructions and prompts necessary for test completion. This version of the Category Test demonstrated an acceptable level of equivalence with the original version of the Category Test.”

The writers go on to say that many assessment tests have been computerized and suggest accessing work by Bartram and Baayliss or Kane and Kay.
for more in depth material on what is actually currently available. These authors, Schatz and Browndyke, include in their presentation the APA guidelines for including the computer in clinical practice. They then move into the real discussion that is the purpose of the article which is, how valuable and or practical computer-based assessment is in the clinical setting, its limitations and future possibilities. They offer these features of computer-based formats for consideration in practice:

Computer-based assessment has inherent features that are absent in traditional forms, such as timing of response latencies, automated analysis of response patterns, transfer of results to a database for further analysis, or the ease with which normative date can be collected or compared with existing normative databases. In addition, computer-based assessment measures are better able to provide precise control over the presentation of test stimuli, thereby potentially increasing test reliability. (397)

They go on to offer other advantages to computer-based assessment.

**B. Limitations:**

In this same study, of “Technology Applications for Children with ADHD: Assessing the Empirical Support,” it is stated that the most serious limitations at this time are that there are very few well-controlled studies—“a handful”—and these studies had very narrow focuses.

The majority of studies were quasi-experimental at best or were very limited case studies. The main methodological concerns lie in three areas: (1) the lack of rigorous experimental studies, (2) subject selection procedures, and (3) outcome measures. For some studies confounding variables make it uncertain to what extent the positive results reported in these studies are due to other factors and how much, if any can be attributed to the computer-based training. For example, in many studies students also received behavior modification... or changes in the academic environment.... Subject selection is also problematic. Current best practice in ADHD diagnosis requires a multi-stage, multi-informant assessment procedure....Few studies met this requirement. In some studies is uncertain whether an ADHD diagnosis was warranted because of lack of description of diagnostic criteria..., over reliance on report data..., or the identification process had not been completed....The situation is further complicated by the fact that, over the time span covered by this review, the diagnostic criteria for ADHD have changed three times.

Considerations that are not addressed in the Cho et al. study, “Virtual Reality as an Attention Enhancement Tool” are sustainability of effect, and there were no comments or suggestions that the observed effects on attention could be related solely to the novelty of the method.

Parks/Ingles also address the problems of study design and terminology. They comment on the number of claims for progress that are based on anecdotal material from individuals. More rigid study design standards are called for as are larger samples and, these researchers particularly, suggest going outside of the “usual” subject groups which very frequently are composed entirely of patients with acquired brain injury in order to (1) better define attention and its deficits, and, (2) in order to see if the same methods of skill-specific training are effective for attention deficits created by different causes. To work almost exclusively with a single cause/client group severely limits generalizability.

In the Gontkovsky study cited in the “Empirical” section, the limitations of the results from the head trauma subject are what are seen so frequently—they are anecdotal. Can these results be replicated in other research settings? Can this “individually designed” program be used by a general head
trauma population? Does this program, which is not really described, offer any possibilities to other neurologically impaired populations such as ADHD?

In, “Applications of Computer-based Neuropsychological Assessment,” Philip Schatz and Jeffery Browndyke, published in the *Journal of Head Trauma Rehabilitation* of September 2002, present an overview of where computer-based assessment is and what would make a better future for this technology. As part of their presentation, they look at an array of the criticisms of the technology. The APA is concerned with the failure of some test developers’ to meet established testing standards. Poorly designed human-computer interfaces have been another concern. There have been those who suggested that the computer presents such a dramatically different presentation that computer-based and traditional administration can never be equal. It is suggested that factors not found in the traditional paper-based testing might be disruptive and need to be identified and studied to evaluate the validity of this concern. Another possible limitation is inaccurate timing in some softwares where the synchronization between the processor and the monitor has a delay or error in timing that can create a problem with consistency. The authors say that other researchers have developed software that have solved this problem and offer near millisecond accuracy.

Another limitation in the use of computers is the very automatic nature of operation that do not allow the examiner to interrupt or stop the assessment which can interfere with flexibility in the evaluation. The current paradigms do not allow for collecting spontaneous verbal responses. There are researchers who have issues with trying to take even a laptop to a bedside evaluation or to try to use with physically incapable people.

In a report titled, “Development and Initial Testing of a multimedia Program for Computer-assisted Cognitive Therapy.” Published in *American Journal of Psychotherapy*, Jesse H. Wright, Andrew S. Wright, Paul Salmon, Aaron T. Beck et al., bring up the objection to computerized rehabilitation that comes from a study by Stuart and LaRue, “who found that severely depressed people had difficulty using a computer program that attempted to simulate patient-therapist communication.”

Another area of concern is patient acceptance of multimedia programs as part of their therapy. There is a concern that patients will perceive that therapists “don’t want to work with them.” There was also difficulty in making the communication between human and machine work.

C. Future Directions:

In general it would appear that the greatest need in this area and the most useful activity would be many well-constructed, well-controlled, carefully conducted studies of a great enough number of properly diagnosed ADHD children, adolescents, and adults to provide results that can be considered definitive.

The authors of “Technology Applications for Children with ADHD: Assessing the Empirical Support,” suggest the following, “unanswered questions,” as guides for future research:

(1)How should computers, and, other forms of instruction, be integrated to maximize effectiveness of computer-based instruction? (2) How can teachers and learners use technology most efficiently to produce optimal results? (3) How can teachers select appropriate software and hardware for students with ADHD? (4) What are the short-term and long-term effects of such software or hardware on maintaining student attention and academics? (5) How can computer programs be designed to train students with ADHD in behavioral and social skills?

In the article “Issues in Diagnosis of Attention Deficit/Hyperactivity Disorder in Adolescents,” Nahlik repeats the concept that the young child-based bias of most testing instruments is probably the single most important issue to be addressed on behalf of the ADHD adolescent who has not been diagnosed earlier. A suggested area for intense future research is in testing measures based on
computer use that will not rely so heavily on parent/teacher/subject reporting and so would be more objective.

Bill Lynch, in the article, ”Historical Review of Computer-assisted Cognitive Retraining,” in Journal of Head Trauma Rehabilitation, offers for consideration an outline for future research in this field. He says research should address these issues:

(1) How does treatment with this software compare with existing treatment approaches with regard to effectiveness and cost? (2) What brain conditions are more likely to respond favorably to this software? (3) What is the optimal time after onset to begin treatment with this software? (4) What is the optimal treatment regimen or schedule for using this software? (454)

From Cyber Psychology and Behavior, Vol. 5, November (2002) is an article titled, “The Effect of Virtual Reality Cognitive Training for Attention Enhancement,” from a Korean research team, concerns the use of Virtual Reality to assist in training and enhancing attention in children with ADHD. Baek-Hwan Cho et al, after reporting the results of their research, make the following suggestions for bettering the job that was done. The first comment was to use a subject group with actual diagnoses of ADHD. The next change they will make will be to conduct the cognitive trainings over a greater period of time to improve some of their dependence measurements. They have developed specific routines for alternating attention and divided attention but there were problems with the subjects understanding and completing what was expected so these programs are still being worked on.

As have other researchers, Gontkovsky et al. comment on the need for more studies and more stringent studies. They say:

Additional empirical research clearly is needed to address the aforementioned numerous shortcomings. Investigations involving larger samples of patients, a wider variety of diagnostic groups (e.g. patients with dementia secondary to Alzheimer’s disease or Parkinson’s disease), and less impaired participants are necessary before firm conclusions can be made with respect to the viability of computer-based cognitive rehabilitation.

This group also suggests more investigation of the possibilities of enhancing cognitive performance for non-impaired subjects and to do rigorous studies there. There is the implied suggestion for another direction for future study. The comment is, “However, the authors contend that given the equivalent findings between the two modes of intervention, (computer-based or traditional face-to-face) computer-based cognitive rehabilitation potentially would be more economical and more convenient (if conducted independently in the home) than more traditional forms of intervention.”

Suggestions for further investigation from the Park/Ingles study include further empirical research into the efficacy of specific-skills training as a method of cognitive rehabilitation. The perception is that specific-skills training will help improve performance substantially.

Another suggested direction for study is to better determine a definition of attention. Parks/Ingles are candid that a lack of consensus as to what constitutes attention and attention deficits may have interfered with identifying relevant studies due to a difference in terminology. As far as the focus of this paper, any and all of this should be framed in the concepts of computer-aided therapy for those with ADHD.

In, “Applications of Computer-based Neuropsychological Assessment,” Philip Schatz and Jeffery Browndyke, published in the Journal of Head Trauma Rehabilitation of September 2002, present an overview of where computer-based assessment is and what would make a better future for this technology. The authors recognize that issues of confidentiality must be addressed and that would be part of their focus. On the other hand, the possibilities in being able to quickly share
test results and getting other opinions on patient condition is the pay-off for solving that problem. Developing ecologically valuable programs, such as, Schultheis’ Neurocognitive Driving Test is where computer-aid cognitive assistance is headed. The writers say, “With the emergence of three-dimensional virtual reality technology, the assessment of driving ability is a clear example of an emergent technology. They also mention that the developer of the program has an article in the same journal.

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