# MEMORY DISORDERS FOLLOWING TRAUMATIC BRAIN INJURY: ALL MAY NOT BE AS IT SEEMS

I have the distinct honour of coming to Ottawa to give people having the last session of the day. First of all, I didn't expect so many people here. It's very exhilarating to see how many people have come to this meeting. The talk I am about to give will be geared towards professionals working in the field. It is going to be somewhat academic in nature, and there will be some technical terminology that I'll use, but I'll try my best to define it as I go.

In addition, the presentation won't be quite exactly what was advertised in the brochure. I wanted to spend more time talking about how memory functioning breaks down rather than propose a "cure-all" for the problem. Over the course of the last several years, a number of people in the field have presented soled clinical data with regard to the rehabilitation of those with acquired disorders of memory. What seems to be missing, however, are presentations which characterize in adequate detail how the process of learning and remembering, memory functioning, might actually break down.

With that in mind. I decided it would not be the best use of time to come to Ottawa to give people several hours of ways to improve "memory"; take those ways back to your family or rehabilitation center; and, hopefully, employ them with "astounding" results. Presuming to be able to do this would be, I believe, a great disservice. I propose that it would be better, perhaps, to try to spend the time "walking" you through related neuropsychological concepts involving cognitive information processing, in order to show you where, along the way, that learning and remembering of new information can break down. Additionally, I'll give you some examples demonstrating the above notion and, then, quite possibly, lead you to discover that many who have trouble remembering don't have a true disorder of memory, but, rather, something else.

When trying to improve memory functioning, head injury rehabilitation professionals frequently encounter problems when trying to apply successfully their techniques. Often, the patient is declared to have a problem more serious than previously believed or that he or she is not trying hard enough. Sometimes, the therapist will assume the responsibility for problems and will redouble his or her efforts in an attempt to improve performance.

Goldstein and Levin, in the recently published book, Neuropsychological Rehabilitation, put the issue quite precisely: “from a remediation standpoint, it is critical to conduct a detailed process analysis to determine where performance is breaking down, and then to design programs which focus on the level of impairment.” This is especially true with the head injured given the likelihood of a multiplicity of cognitive problems which may culminate in a core or functional memory disorder.

Even with careful consideration of these factors, however, a more thoughtful analysis of failed efforts with regard to the remediation of memory rehabilitation, might lead one to discover that these failures are related to issues the nature of which, might be characterized more accurately as philosophical and methodological. To simplify somewhat, we, in our zeal to deliver rehabilitation services, tend to jump readily into the technology of mastering a problem, to fix it; we see a symptom, we treat the symptom. Human cognition is an astoundingly complex enterprise; and until rehabilitation techniques within this domain become exact and replicable, we must proceed thoughtfully and deliberately with regard to what we do in order to conserve limited patient, family, professional, and economic resources.

## NEED FOR CAREFUL ASSESSMENT

In order to rehabilitate that which can be rehabilitated, one must first recognize several problems that may get in the way. The first of these is the tendency to view the head injured population as monolithic, homogeneous; individual differences become muddied. When trying to predict severity of cognitive disability, responsiveness to treatment, and/or outcome individual patients are often categorized inappropriately using group data such as the Rancho Scale, time in coma, or length of post-traumatic amnesia. In head injury, the diagnostic discriminability between and/or among groups is frequently no more informative than saying a patient is a “lot” head injured or a “little” head injured. Given the range of potential injury as well as the fact that two people who suffer the same injury can have very different outcomes only emphasizes the need for careful delineation of individual differences.

Second, there is also a similar tendency to view homogeneously the disorders of memory seen in head injured patients. To say that a head injured person has a memory problem may describe the symptom but says nothing about clarifying the cognitive aetiology nor does it help us to derive an intervention approach, assuming one is warranted. Drawing on research from other patient populations may not serve the rehabilitation professional either. The type of disorder seen, for example, in alcoholic Korsakoffs patients or in dementia of the Alzheimer’s type, are not good analogies and would not, necessarily, help one to gain a fuller understanding of the memory disorder following traumatic brain injury.

Third, the subjective experience, on the part of the patient, his/ her family, and rehabilitation staff, of a memory problem, must be distinguished from the objective measurement of memory functioning. Often, patients, or those working with them, describe memory problems in “all or nothing” terms. In reality, memory disorders usually fall along a continuum of efficiency ranging from intact, to functional, to globally amnesic. People who often have the experience of a failure of memory can be shown to have ability that is, for the most part, quite functional and, in many cases, intact.

Fourth, the need for careful observation of behaviour and definition of terms used to describe that behaviour cannot be overemphasized. There are at least twenty terms (and, quite likely, more) that are associated with the description of memory functioning. As a quick exercise, try to define “short-term” memory. How long is “short-term”? Is it five seconds? Five minutes? Five hours? Patients, family members, and the various professional disciplines all use a variety of methodologies and language to investigate and characterize similar phenomena related to the function of memory. This welter of terms and definitions, even for the same concept or

phenomenon, often contributes to a cognitive “Tower of Babel” in which all speak and none communicate. For example, a patient may be asked what he had for breakfast earlier that day and, in response, may give a very good answer: “Yeah, I had two eggs, scrambled, toast, and coffee.” Unless, however, the questioner has direct knowledge of that person’s breakfast, there is no way to know for sure of the veracity of the response. One cannot draw any conclusions with regard to the patient’s memory functioning based on this “assessment”. Further, many memory tests in common use do not truly measure memory. Efforts at assessing and/or rehabilitating memory may be confounded by unrecognized cognitive and/or methodological factors which may: enhance “memory” functioning; worsen it; or have nothing at all to do with it despite claims to the contrary!

Fifth, the desire on the part of all of us for quick and easy solutions to the very complicated problems of cognitive dysfunction. Our desire to make things better may lead us to adopt approaches to treatment that are faddish or have been developed without a careful enough consideration to all the factors that may be contributing to a memory disorder. Examples of this notion abound as all one has to do is to look at the latest in mnemonic strategies, megavitamins, memory enhancing drugs, or computer programs which tantalize us with the promise of across the board improvement for patients with “memory” problems. To have someone sit at a computer working for hours on the latest software which purports to improve memory may make us feel as though something is being accomplished, but whether that truly is happening is an empirical question which demands to be tested in some objective way.

## IMPORTANT MEMORY CONCEPTS

As noted earlier, to explore memory functioning one must confront terms and definitions which, on the surface, may appear to be more daunting than the disability itself! This state, however, reflects more the breadth and complexity of the area than anything else. Despite this, one can gain a working understanding by becoming familiar with only a few fundamental concepts and terms. Additionally, it is important to note that the aspects of memory about which I’m to discuss, are dissociable, one from the other, in some respects, modular. One may work and other(s) not. While our old memories are the core of who we are, when rehabilitating everyday functioning, one is usually concerned with an individual’s ability to learn new information. A pictorial overview might be helpful to clarify the concepts. Imagine a line going from left to right. In the middle of the line is the point of the traumatic brain injury. Everything to the left represents old information that which the individual learned before, retrograde information. Information to be learned from the point of the injury onwards is termed anterograde. The distance from the point of the injury to that time when the patient begins to learn and remember new information relatively reliably represents what is termed post-traumatic amnesia (PTA).

POST - TRAUMATIC AMNESIA Injury

<P.T.A.>

<Retrograde—><—Anterograde->

What can be confusing is that the definitions we refer to point in time when information was learned, not necessarily when the event(s) occurred. For example, a person with a retrograde amnesia for the day of as well as the time before his accident, might be emerging from PTA and be told the details of his injury by a family member. Recalling this information subsequently might appear to be retrieving retrograde information. This material is “new”, however, even though the events occurred before; as such, it would be considered new learning or anterograde information.

## RETROGRADE AMNESIA

Retrograde amnesia is common after TBI. People will forget what happened a year ago, two years ago but may remember something from childhood. People can forget things they did at work but remember strange and detailed events from home. Retrograde amnesias can be patchy, with areas of remembering and forgetting, it can be shrinking, diminishing in its breadth as one heals.

## ANTEROGRADE LEARNING

As I mentioned earlier, however, this talk is concerned primarily with anterograde learning and remembering as it serves as the foundation for cognitive, behavioural, and in many aspects, physical rehabilitation. With regard to anterograde learning, it is the type of information to be learned which determines the particular memory system which will subserve the learning process. It is not the sensory system by which information comes in.

## PROCEDURAL LEARNING

A major distinction in the kind of information one may learn involves that between “knowing how” vs. “knowing that”. With regard to the first, procedural learning, we are interested in how someone goes about doing something. Examples include such things as driving a car or swinging a golf club. Even though someone may read, learn, and tell back all the steps involved in driving, that does not mean that the first time behind a wheel one will be an accomplished driver (nor, unfortunately for some, even after many years). How do you go about teaching a child to tie his shoes? You may tell him the steps but, in the end, it is still a matter of learning the procedure and practising it over and over. The same, quite obviously, is true for learning to perform a transfer or to use a wheelchair safely. The knowledge base of facilitation techniques for enhancing procedural learning has grown rapidly.

## DECLARATIVE INFORMATION

The other aspect of learning mentioned above, “knowing that”, involves what, is termed declarative information, fact-based, what we often regard as “knowledge”. Declarative information can be verbal (work-bases) or nonverbal (e.g., pictorially-bases) in nature. Again, information is learned according to the type of material it is rather than by the sensory system one employs to learn it. It does not matter whether one hears a list of words to be learned, sees it, or feels sandpaper letters. Verbal information is learned by one’s verbal memory system. Nonverbal information which cannot easily be verbalized, such a rhythmic pattern or a work of abstract art, is remembered (or not) by the nonverbal memory system.

## ANALYSIS OF MEMORY FUNCTIONING: DIAGNOSING THE PROBLEM

We have spent a substantial amount of time discussing terminology and definitions. As I mentioned earlier, an additional fundamental consideration necessarily involves methodology or how one goes about determining whether an individual has a disorder of memory or whether it is something else. Simply because a test says it measures memory does not necessarily mean that the results you get will give you any additional insight into memory functioning in and of itself. What if, for example, I was to test your memory by giving you a list of ten words to be learned, choosing to read them to you at 4:00 AM while you slept? If I asked you to give back as many of the words as you could from the list at 9:00 AM, I imagine the odds would be great that you’d have no

"recollection". Based on this methodology, of course, I would declare that you have a disorder of memory! Sound ridiculous? Perhaps, but analogous situations occur all the time when patients are tested for memory functioning.

The other side of the methodological "coin" (and just as much of a clinical disservice) is manifested when patients are characterized as demonstrating functional "memory" because they are able to display the acquisition and retention of isolated pieces of information.

## ATTENTION AND MEMORY

When people talk about disorders of memory following head injury what they are in fact almost always describing are the secondary effects of an acquired attention deficit disorder. Attentional functioning is the foundation upon which all other aspects of higher order cognition rely. I'm sure all of you have had the experience of being awakened in the middle of the night by a phone call. Can you remember "coming up" to a higher stages of alertness, step by step, feeling at first confused and disoriented as you try to sort out the gross stimuli coming your way. It is only after several long moments that you are able to determine what is going on and then what to do about it. Obviously, your attention was not completely shut down during sleep as you were able to attend to the ring of the phone and rouse yourself ultimately to act. But, for a moment, try to imagine spending all your time in that never-never land of diminished, confused, and disoriented state of attentional functioning. This is the experience of many severely head injured people who spend almost all of their time trying to stay awake.

## PRIMARY AND SECONDARY MEMORY

Arousal, as I've described here, is only one aspect of the attentional domain or, what is technically termed, primary or working memory. As long ago as the 19th century, the concept of primary memory was articulated by the American philosopher and psychologist, William James: "Primary memory refers to the information that forms the focus of current attention and occupies the stream of thought." By way of comparison, secondary memory has come to represent what has usually been thought of as long-term memory. Here, we are concerned with the actual structures in brain that are involved with the consolidation of new information into memory store. The literature is quite clear: when secondary memory for declarative information is ablated, that person is unable to learn and remember new information of a particular (non-verbal or verbal) kind.

Given this, it is indeed fortunate that it is most often the impairment of higher order aspects of primary memory which lead to the functional disorders of memory experienced following head injury. This happens because such impairments directly interfere with attending to and/or initially processing (that is, holding briefly in mind) information to be learned. A computer serves as a good metaphor to help explain this concept. First of all, the computer must be switched on (arousal); the operator must select the operation or program to run. Ultimately, the efficiency of the computer is a function of the interaction of the computer's pre-determined, information capacity and the speed by which that information is processed. Unless that information is recorded somehow to a permanent medium (secondary memory), such as a disk or tape, once that machine is shut off, the information goes with it. This metaphor also helps to explain the dissociation between the two cognitive constructs. It demonstrates that the one system can be quite intact, perhaps memory, our magnetic disk, while the other, attention, involving one or more of its many aspects can be significantly diminished.

## AETIOLOGY OF ATTENTION DEFICIT DISORDERS IN HEAD INJURY

The attention deficit disorders observed following head injury may have as their basis one or more of the following aetiologies:

1. ***Pre-injury:*** This includes such things as developmental anomalies, e.g., hyperactivity, or previous head injuries.
2. ***Acquired primary disorders of attention:*** This comes about from the actual damage to brain sustained in the injury. It may occur as a result of the direct physical forces involved in the traumatic injury, for example, the tearing of fibres in the brain stem during rapid deceleration/acceleration of the brain, or the secondary medical problems which arise later such as brain-swelling (edema) which, in turn, damages fibres in the brain stem through compression.
3. ***Medications:*** Many medicines which are administered to head injured patients have sedative main or side effects. Anti-seizure drugs (e.g., Dilantin, Phenobarbital), neuroleptics which are used to "control" agitation (e.g., Haldol, Thorazine), and anti-spasticity drugs (e.g., Lioresal) all have deleterious effects on arousal and attention. With higher level patients, anti-anxiety medications (e.g., Xanax) and anti-depressants (e.g., Elavil) may all diminish already impaired functioning. Of course, one must be cognizant of the cost-benefit trade-off. Some symptoms, e.g., severe spasticity, may be so debilitating at a particular point in time, that the patient and the treatment team will have to tolerate the sedative side effects until the primary problem diminished. In other cases, less sedating, often equally effective drugs may be substituted. Tegretol may be given to a patient for seizure prophylaxis rather than Dilantin or Phenobarbital for precisely this reason.
4. ***Physical disability:*** Attentional problems can be exacerbated by any of a number of consequences arising from physical problems. Pain, for example, can be a nasty thing with which to contend. I doubt if anyone could maintain a high level of attentional functioning for any length of time if they had to spend most of their day hurting. Illness, too, including, for example, frequent infections, can sap one's endurance, contributing to the overall diminishment of attentional functioning.
5. ***Emotional adjustment issues:*** Following head injury, as is the case with any traumatic disruption in our lives, the adjustment issues with which we are confronted can be severe and debilitating. Anxious concerns, powerful feelings of inadequacy, loss of control, and loneliness are all factors with which the head injured person can become preoccupied, significantly disrupting, for example, his ability even to focus and/or sustain his attention. Combined with a physiologically-based attentional disorder, this factor can devastate one's ability to function effectively on a cognitive as well as an emotional basis.

## SPECIFIC DISORDERS OF PARTICULAR ASPECTS OF ATTENTION

Disorders of attentional functioning form a major class of those cognitive impairments which can devastate a head injured person's ability to learn and remember. As I tried to demonstrate by using the metaphor of a computer, attentional functioning is a complex interlacing of particular abilities that, under normal conditions, processes information automatically, usually without our direct governance. I'd like to explore in some greater detail how problems with particular aspects of attention can diminish the amount of information available to us for learning. First, I'd like to offer a partial outline of the phenomenology of attentional functioning (R. F. Cohen, Ph.D., 1987). Try not to let the terminology be intimidating. First, I'll define and explain it and, second, it does follow our computer metaphor!

## AROUSAL AND ATTENTIONAL ABILITIES: A PARTIAL PHENOMENOLOGICAL TAXONOMY

1. Arousal
    a. tonic
    b. phasic

2. Responsive selective attention
3. Sustained attention
4. Attentional capacity
    a. span
    b. the ability to maintain immediate access to sub span amounts of information while engaging in competing, distracting task
5. Speed of information processing

## EACH ASPECT OF ATTENTION IS DISSOCIABLE, ONE FROM THE OTHER.

Let me explain the terms I've presented above and how they might impact on one's ability to process information within this domain.

1. ***Arousal:*** This is pretty straightforward. If one is under aroused, then no matter how much information comes this way, it will not, for the most part, be attended to. Coma represents the most impaired manifestation of this aspect of attention. (The distinctions above, tonic and phasic represent, each in turn, our general state with regard to our preparedness to respond and our ability to temporarily heighten that state in response to some type of warning stimulus.)
2. ***Responsive Selective Attention:*** We are, relatively automatically, usually able to establish and maintain a focus of attention on a stimulus that is of relatively greater importance to us—whether that stimulus is a speaker, our child crying, or our bladder! When we are tired, however, or if there are many competing stimuli, this task can become quite difficult and, on occasion, overwhelming. For many head injured patients, damage to brain results in their being in a state in which they are almost always distracted. Information is lost because they cannot maintain their focus from moment-to-moment.

    Many other patients suffer an impairment of another aspect of selectivity that is their ability to deploy their attention uniformly in space. Not quite a terse definition, but it does get at what I'm about to explain. The brain creates a number of illusions for us. In particular, we experience the world outside of us as a seamless, 360 degree arc. In reality, the brain attends to information coming in from both left as well as right hemi space. That is, two 180 degree arcs organized and processed simultaneously to create this grand illusion. Again, following head injury, patients may suffer what is termed a neglect or hemi-inattention in which one side of space (usually the left) is not attended to although it is seen. This seems very strange but it goes to point out the automaticity by which we usually operate and how disruptive it is when that breaks down. Obviously, a hemi-inattention can lead to an individual's missing significant amounts of information such as objects placed on one side of the room or the text on the left side of the page. Patients may sometimes display a hemi-inattention to the degree that they will not attend to the left side of their meal tray and it may appear that they are dissatisfied with the hospital's gourmet delights.

3. ***Sustained Attention:*** Once we have established a focus of attention and are generally able to maintain it from moment-to-moment, we must, in order to process information efficiently and in adequate amounts, sustain that focus over time, the proto-typical representation of this ability is the radar operator sitting at his scope; as time goes on, his efficiency wanes. This notion, parenthetically, is quite different from endurance, which is a physical parameter. Again, to draw a comparison with the normal, unimpaired population, we have all experienced a decline in our ability to sustain our attention on a task over time or if we are tired or distracted. This is typical and the decrements are predictable. With adequate refreshment, our ability returns and we are able to go on for another significant period. For people with

impairments, however, the time available to them to work on a task can sometimes be shortened dramatically. A patient may, for example, fall asleep in the middle of a task on which he has been working for only a few minutes. One can readily imagine the impact that this disability would have in situations requiring substantial amounts of learning such as in the acquisition of a set of new vocational skills or complex ambulation techniques.

4. ***Attentional Capacity:*** The notion of attentional capacity is also straightforward. In general, it involves, again, the efficiency with which we begin the early stages of information processing. If, in the moment, we are able to hold on to more information, we can get our work done, learning new information, for example, more quickly.

   The first aspect of capacity that I'll discuss involves span. I'll ask you to do away with any previously acquired definitions such as "how long one can remain at a task" (which we have now defined as *sustained attention*) and learn a new one which is more in keeping with the latest research. *Span*, then, is *the number of bits of information one can hold consciously in mind at a given moment.* To illustrate and, at the risk of mixing metaphors, I'll leave high-tech and move into the culinary realm. If we are trying to cook up a large amount of mashed potatoes, the efficiency of our efforts will be determined by the size of the pot available to us for boiling the potatoes. If our recipe calls for 14 potatoes and our pot can hold seven, then we'll be finished after boiling up only two batches. If, on the other hand, we only have a pot that can accommodate four, our efficiency will be halved. Further, let's say we have the latest labour-saving kitchen tool, "The Potato Dispenser", which unloads potatoes by an unalterable amount which in our san case, is 7 at a time. With our four-potato pot, we are going to be losing a lot of potatoes. Our ultimate goal, mashed potatoes for fourteen, is going to have to be a little light.

   In the real world of head injury, it is almost inevitable that patients suffer impairments of span. The only questions are usually to what degree and will it get better. The net effect of a span disorder is, of course, that there is less information available for learning and remembering. Unlike impairments in the aspects of attention discussed earlier, however, impairment of span is often not as evident for what it is, *even if detected.* At the functional level, patients may be described as "forgetful" or "passive-aggressive" and "unmotivated" (because they did not follow through on an instruction or "weren't listening"). Speech therapists will often diagnose an auditory comprehension problem "at the sentence level" which, functionally, is accurate. In the end, however, an accurate, differential diagnosis is required in order for the patient, his family, and rehabilitation professionals to deal adequately and appropriately with the problem.

   A disorder of span can be *generalized* so that the individual is just plain less able to hold in mind adequate amounts of information coming his way regardless of its nature. On the other hand, a span disorder can be *material specific*, for example, only for nonverbal information such as the events happening simultaneously in a neighbourhood street, but not for verbal information. Or, with verbal information, one might be relatively less able to hold in mind strings of digits spoken by an information operator than sentences of increasing length and complexity. The difference could very well be attributable to the inherent interrelatedness of the sentences; they serve as a meaningful framework with which one can tie together the works. In any event, for patients with span disorders, usually, as verbal information becomes lengthier or more grammatically complex, their ability to attend accurately to all of it becomes significantly less effective. Depending on the type of material to which one must attend, the functional impact may be relatively minimal.

To illustrate this, I offer a research study conducted by Saffrin and Mann. They presented for repetition, a series of increasingly lengthy and complex sentences. The first, *"The people filed calmly into the ancient cathedral"* was given back as "People *went* calmly into the old cathedral". Here, words were changed and others omitted but the meaning of the sentence was preserved. With a more grammatically complex sentence, however, things become functionally problematic. Another sentence in the series read *"The boy the dog chased went home."* It was given back as "The boy chased the dog home." The patient's span problem radically altered the structure and, hence, the meaning, of this passively constructed sentence. It was given back in the active voice as it is a higher frequency construction in English. Patients themselves, as well as their family members, are often not aware of their deficit and act in accordance with what they believe has been presented to them. Staff, too often neglect this "invisible" cognitive problem as they speak to patients at their usual rate of delivery and any grammatical construction they can muster.

A second aspect of attentional capacity involves one's ability to *hold on to a small amount of information, engage in a competing, distracting task for a few moments, and then return to that small amount of information with which you were "working" before.*

On occasion, we all experience the effects of a disruption in this ability. You are standing in a hallway conversing with a friend; as you go along, you are developing and holding on to a gist of what is being said. In the middle of your conversation, another friend comes along and interrupts with an urgent question. You respond to this question, distracting yourself from your previous conversation for about 12-15 seconds. Your friend thanks you for your attention to her question and leaves. You turn back to re-engage the original conversation and you have "forgotten" what you were talking about. But did you really "forget" or were you unable to *maintain access to that small amount of information in the moment?* Your friend reminds you of your discussion and you experience a flash of recognition, suddenly realizing that you do remember, and you go on from where you left off.

This ability sounds an awful lot like memory; certainly it must be what is typically thought of as "short-term memory". It seems to fall right in the border zone between attention and memory. But, remember our discussion from before. Definitions and categorization of cognitive functions are critical factors both for understanding as well as engaging in rehabilitative efforts. For our purposes, I believe it is helpful to follow Cohen's taxonomy not only because this ability fits my conceptualization of how to go about defining aspects of attention (a statement of faith for now), but, unlike true disorders of memory, impairment.

Impairments of the ability just described are almost universal following head injury. The effects on memory functioning can range from mildly disruptive to devastating. For those with significant problems, one's life can become a maddeningly discontinuous experience. The slightest, purposeful, attentional diversion can cause a person to lose or confuse that which was being held in the stream of consciousness. Although deficits are typically more severe early on, its effects may become chronic and can become the major contributor to a secondary disorder of memory.

5. ***Speed of Information Processing:*** The speed by which we can process information may, indirectly, determine what we notice and how much will go unnoticed—the limitation is the rate of controlled processing. Following head injury, one of the most commonly made observations involves how long it seems to take for a head injured person to work with a task involving cognitive control. With a diminished rate of processing, we again are dealing with the notion of that much less information available to the individual for learning and remembering.

In summary, attention deficit disorders following head injury are almost always inevitable, may involve one or more aspects of attention, often get better, and should be suspected whenever there is any report of a problem with learning and remembering of new information. Simply put, the head injured just has less attention to pay than the healthy individual.

## ORGANIZATIONAL PROBLEMS AND MEMORY DISORDERS

The way we go about organizing information we wish to learn or our retrieval of that information already in memory store, can impact significantly on the way an individual's memory functioning is characterized. Information that is confused and disordered on recall, if it can be recalled at all, may be unrecognizable and lacking in functional utility. If, for example, one is to remember a series of seven steps in following a recipe, those steps must be followed completely and in the proper order for the task to be completed successfully.

Higher order organization, reasoning, and problem-solving abilities are related to frontal lobe functioning bilaterally. As is the case with many of our other abilities, nonverbal functioning is more closely related to the right hemisphere while our more verbally mediated abilities are principally associated with the left. Because of their location, the frontal lobes are especially vulnerable to injury in typical motor vehicle accidents, that is, where the head impacts on the windshield, and the brain inside collides with the skull. At the behavioural level, not only are the consequences of frontal lobe damage deleterious to the acquisition of new information, but can be extraordinarily disruptive with regard to activities of daily living.

## IMPAIRMENTS OF ORGANIZATION REASONING, AND PROBLEM-SOLVING:

(That is, those abilities involved in the way we go about managing our behaviour and the processing of information) can include:

1. confusion
2. disorientation
3. disinhibition
4. problems in reasoning; perseveration (inability to inhibit customary modes of responding)
5. errors in sequencing chained behaviours
6. suspiciousness
7. inability to use demonstrated knowledge to modify behaviour "the curious dissociation between knowing and doing" (Teuber)
8. inability to engage in the making of comparisons and contrasts (cannot benefit from analogical reasoning or through the use of metaphors)

At the risk of displaying an organizational deficit myself I will yet leap into another metaphor that I hope will be helpful in gaining a better understanding of the role that organization can play in storing and retrieving information! Imagine, if you will, a filing system (*memory store*) that is alphabetically-based. You have some information to be filed (information to be learned) about automobiles. As you go to file it, you are distracted and, instead of filing it under "A", you use a categorization system and place your folder under" V" for *vehicles*. Later on, someone asks you to retrieve (information to be *remembered*) the folder you filed this morning. You return to your file cabinet and what comes to mind are *transportation* and "A"; so, you look under "A" and *airplane* seems a reasonable selection. Coming back with the folder, the person for whom you retrieved it tells you no, they wanted "automobile" as the folder subject; you may still be unable to find it unless you recall the organizational system under which it was filed.

If this metaphor represents the learning and remembering process, can we truly say that what has been described was, in fact, a disorder of *memory*, in and of itself? I would propose not. Rather, the information (the folder) to be learned (filed) was buried in memory store (the file cabinet) but, because of organizational impairments, that information, *which is still in memory store;* may be, for all intents and purposes, unavailable.

## THE INTERACTION BETWEEN ACQUIRED ATTENTION DEFICIT DISORDERS AND ORGANIZATIONAL DEFICITS IN LEARNING AND REMEMBERING: FUNCTIONAL CONSEQUENCES

As has been emphasized during this presentation, head injury survivors may suffer what appear to be disorders of memory when, in fact, other cognitive systems may be implicated. There are many ways in the neuropsychology laboratory to test memory. One of the most ecologically valid—a procedure similar in nature to what happens out in the real world—involves testing one's ability to learn and remember a short story. The reason I believe that this test qualifies as an ecologically valid instrument is that it parallels so closely a fundamental day-by-day activity; hearing and learning from others such things as events, instructions, communications, and all the other discourse which fill our day.

It is the methodology, though, that is the critical element which helps us to understand more completely the learning and remembering process of the breakdown of that process. As I've described before, because of the various cognitive systems involved, testing memory directly can lead to results that may, or, at least should be, uninterpretable. A methodology of testing memory should give us insight with regard to some of these systems so that we may do a better job making sense of the findings. With this in mind, I'll describe the methodology employed in our lab.

A subject is read a short, highly interrelated story, one paragraph long, at a normal rate of presentation. S/he is then asked for his/her recall *immediately after hearing it.* The next 45 minutes are filled with other, more *nonverbally* mediated (in order to avoid confounding the results) activities. Then, without forewarning and without re-exposing the subject to the original material, s/he is asked for his/her recall.

The analysis of the subject's report both immediately after hearing the story as well as after the filled, 45 minute delay involves making several critical comparisons. The first of these is between the *original story* and the *immediate recall*. This affords us a look at the impact *attentional problems* may have had on *how much* of the story was available to the subject for learning and how much was "lost" or not attended to.

Additionally, we study how the story was *sequenced*, how it was organized to see the effect of any verbally-related *organizational problems.*

Next, and this provides us with a measure of the nature of the subject's memory, we compare the *delayed recall* with the immediate, not with the story itself. The reason for this should now be clear. The immediate recall represents what the subject had available for learning; the delayed recall represents what, of that material, got into memory store and was actually able to be remembered. If the immediate recall, in comparison to the original, is sparse in its detail and, if that detail is badly organized and confused, as long as the delayed recall adequately re-represents the immediate production, an individual can be said to have demonstrated core memory functioning.

## DISORDERS OF CORE MEMORY

All of the preceding has been in the service of helping to explain several of the aspects of recognition, the impairments of which typically underlie functional or secondary disorders of the memory following traumatic brain injury. Differentially diagnosing a disorder of memory as a consequence of an impairment of another aspect of cognition is central to the rehabilitation process.

Given the definition of a fixed disorder of memory, i.e., when the structures in brain subserving the consolidation of new information (of whatever kind) into memory store are damaged or ablated, the reason, then, is quite simple. Disorders of memory arising from impairments of other aspects of cognition usually can be fixed; disorders of memory, in and of itself cannot. Actual disorders of memory may range from mild to profound but, it is, in the end, what it is. From an information processing point of view, it is what's left when you have accounted for the role that attentional and organizational (along with other cognitive) deficits play in an observed memory disorder.

## PROCEDURAL LEARNING

At the beginning of this presentation, we discussed procedural learning, the memory system involved in "knowing how" to do something. Learning such things as tying shoes, swinging a golf club and, importantly, what are called heuristics, or "rules of thumb", that we use to go about solving problems. People who have severe secondary (functional) or even disorders of core memory for new, declarative information that is either verbal or nonverbal in nature, may still learn how to engage in new activities that may help them, as well as those who provide them care, enjoy a better quality of life.

As has been stated, after one has diagnosed and accounted for the attentional and organizational components of a memory disorder, what is left may be said to involve one's memory in and of itself. Procedural learning, however, is, in all but the most profoundly impaired, spared to one degree or another. In those head injury survivors for whom learning anything new seems an impossibility, procedural learning techniques can be harnessed by rehabilitation workers or family members to enable these people to learn, often without the awareness that learning has occurred! The literature is replete with individual case studies reporting on such phenomena. Such researchers as Larry Squire, involving his work with alcoholic Korsakoffs patients, Elizabeth Warrington in England and Dan Schachter here, in Canada, with the head injured.

In my own clinical experience, I have worked with many severely amnesic patients who were clearly unable to demonstrate any type of new verbal or nonverbal learning including, for example, the names and faces of staff people they saw 20 times a day over a period of months. They were however, able to demonstrate the learning of routines and behavioural sequences, of which they were unaware and often, to the chagrin of the staff, were maladaptive in nature! Of course, what can be learned can be unlearned and new, more adaptive learning can take its place. In any event, the promise of exploiting procedural learning techniques for the rehabilitation of the head injured is increasingly being fulfilled.

## IMPROVING MEMORY FUNCTIONING FOLLOWING HEAD INJURY

This was, nominally at least, to have been the focus of this presentation. We have certainly, it must seem, strayed far from that original focus. Rather, I should like to propose that by addressing so very directly the underlying cognitive functions that play such a central role in memory functioning, as well as some ways by which we can more carefully study that functioning, we have achieved, at least, the first step in any process that tries to improve something, finding out what the problem truly is. All too often, the head injury survivor's precious rehabilitation

endowment is diminished by well-intentioned caregivers employing strategies that, in hindsight, prove to be futile. This happens because the problem allegedly being addressed may only be the superficial manifestation, or symptom, of underlying, unrecognized impairments of one or more aspects of cognition. Had they been properly diagnosed, they might have responded to appropriate intervention(s) and within a reasonable period of time. As our knowledge of the brain-behaviour relationships involved in memory functions expands, we should be far less likely, and less willing, to apply strategies and techniques throughout the practice of rehabilitation that are wasteful, misguided, and, worst of all, ineffective.

There is no magic, single answer to the rehabilitation of a memory disorder following traumatic brain injury. As I have emphasized, the precursor to the development of intervention programs must be the accurate identification of the underlying cognitive problem(s) which are to be fixed; and following that, by defining carefully how one will know if the problem is getting better, staying the same, or worsening. Once these steps have been accomplished, the interventions should be more easily derived. As the conclusion to this presentation, I should like to offer a partial catalogue of factors, techniques, and strategies which have been associated with improvement in memory functioning following traumatic brain injury:

1. ***Healing:*** The brain heals, over time, and cognitive functioning may improve spontaneously.
2. ***Treating Attention Deficit Disorders:***
   a) Remove, wherever possible, drugs with sedative main-or side-effects. For example, commonly used medicines for seizure prophylaxis are inherently more sedating. Substituting one that is less so, may significantly improve cognitive functioning.
   b) Employ stimulant medications to directly address the attention deficit; occasionally, patients may become somewhat more disinhibited or energetic (initiating greater amounts of behaviour) as a result but efforts should be made to guide and direct that behaviour.
   c) Cognitive retraining strategies may be helpful. These have been especially so in rehabilitating patients with a hemi-inattention. Although George Prigatano has employed these methods successfully, other researchers have been less enthusiastic.
   d) Compensations for attentional deficits such as speaking in short, grammatically simple phrases and sentences may help people attend to more information coming their way. Checking to make sure that someone has actually attended to vital information can be critical. The use of voice activated micro-recorders can capture lengthy and/ or important instructions or discourse and make a permanent record which can be reviewed and studied as often as one desires.
3. ***Cognitive Retraining of Other Aspects of Cognition:***
   a) Strategies to improve the way information is interrelated may improve learning and or retrieval (organization) may include:
      - outlining information to be learned
      - developing “key points” about information to be learned
      - employing what are known as schemata or scripts, that is, using prior knowledge bases to integrate and interrelate new information to be learned. For example, a hockey fan may be taught to employ his knowledge of the structure of the game in which to embed an everyday schedule of activities
   b) Mnemonics, or memory strategies such as the “peg” method or using a mental image of a house to learn and remember lists, have, themselves, been used for thousands of years. Their utility with this population is questionable. There are problems teaching such techniques to many and, they may be limited in their ability to be generalized.

c) Computers can be used to administer repetitious programs and/or exercises. One caveat about so called cognitive rehabilitation software. Its authors are prone to the same problems with regard to the misidentification of areas of cognition that have been addressed throughout this presentation. Individuals purchasing such software should be sure that the programs are valid representations of the cognitive area(s) they purport to "rehabilitate". Frequently, "memory" retraining programs do not adequately address underlying attentional factors which may deleteriously affect performance.

4. ***Imagery Techniques:*** Again, a technique that is well over a thousand years old. For individuals known or suspected of having a deficit in memory functioning for verbally-based material, developing mental "pictures" of verbal information to be learned has, for some amnesiacs, proven to be helpful.
5. ***External Memory Aids (Prosthetics):*** For many individuals with severe organizational problems, who may be characterized as people who "forget to remember" or, survivors with identifiable disorders of memory itself external memory prosthetics may permit a level of functionality:
   - notebooks
   - the use of micro-computers (e.g., Apple's Macintosh) and programming which allows microcomputers to function as mnemonic prosthetics, such as that resource developed by Dr. Douglas Chute in Philadelphia
   - alarm watches or clocks may cue an individual to perform specific actions at given times; organized "frames" may be needed to guide the sequence or action to be taken (an example of this is the "Executive Board" which is a lap board with pockets containing cards on which are printed tasks to be carried out at cued times)
6. ***Procedural Learning****:* As described earlier, procedural learning techniques may be powerful aids which can be enlisted to help those who suffer from disorders of core memory. Many of the techniques enumerated above may have to be taught to individuals utilizing procedural learning. It is important to note that, just as it is with the neurologically intact population, learning how to do a new task may take great amounts of practice spread out over time. Do not be discouraged!
7. ***Counselling:*** As has been emphasized, accurate diagnosis of the problem is the first, and perhaps most important, step in dealing with one's experience of a memory disorder. In some cases, individuals, for whatever reason including misdiagnosis, come to believe that they suffer a memory disorder that is of greater proportions than that which a careful analysis might determine. Obviously, the first step is a re-evaluation of their functioning. If the individual has believed for a long time that their condition is severely impaired, counselling is indicated to help them deal with issues of self-esteem and with the stress of renewed and, quite possible, higher expectations. Conversely, counselling may also be helpful to family members, if not the head injury victim him/ herself, who are dealing with issues related to denial of disability.

I wish to thank the Ontario Brain Injury Association for providing me the opportunity to address their annual meeting. I hope that this huge amount of information has been, at the very least, digestible. More importantly, however, I hope it will be illuminating and helpful.

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