

**2<sup>nd</sup> Session**

**CONSEQUENCES  
AND REHABILITATION**

**Monday, May 7, 2001**

**ORAL PRESENTATIONS**





## CEREBRAL RE-ORGANIZATION AFTER TRAUMATIC BRAIN INJURY: A FUNCTIONAL MRI STUDY OF WORKING MEMORY IMPAIRMENT

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### Objectives:

1. Examine cerebral re-organization of cognitive functioning after TBI.
2. Determine the specific form of cerebral organization of working memory ability after TBI.

Cerebral re-organization of cognitive function has been hypothesized to occur in persons with TBI. However, how the brain re-organizes after TBI has not been clearly demonstrated in humans. Working memory (WM) is especially vulnerable to disruption following TBI. Unlike healthy individuals, little is known about the functional cerebral organization of WM after TBI. The present study examined patterns of brain activation while performing a WM task in moderate to severe TBI and healthy controls. Method - Subjects consisted 9 moderate-severe TBI and 7 healthy controls. Functional magnetic resonance imaging was performed on a 1.5 Tesla GE scanner to assess brain activation during a WM task (i.e., modified Paced Auditory Serial Addition Test). MRI data were analyzed with Statistical Parametric Mapping (SPM) software, using stringent alpha thresholds (.001). A random effects procedure identified significantly activated regions in each group, and differences between groups. Indices of activation, laterality, and dispersion were also calculated. Results-- TBI subjects made significantly more errors than controls. Cerebral activation in both groups was found in similar regions of the frontal, parietal, and temporal lobes, resembling activation patterns found in previous neuroimaging studies of WM in healthy persons. However, compared to the healthy controls, the TBI group displayed an activation pattern that was more regionally dispersed and more lateralized to the right hemisphere. Differences in lateralization were particularly evident in the frontal lobes. Conclusions - These results show that processing WM after TBI is associated with alterations in functional cerebral activity. Models of cerebral re-organization will be discussed.



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## CAN TRAUMATIC BRAIN INJURY CAUSE PSYCHIATRIC DISORDERS?

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3. **Jenny Wong**, B.A. (H), Baycrest Centre for Geriatric Care, North York, Ontario, Canada

### Objectives:

1. To provide the audience with a comprehensive review of the existing data addressing the question of whether TBI causes Major Psychiatric Disorders (such as Major Depression).
2. To consider the mechanisms by which TBI may cause these disorders.
3. To highlight the need to develop interventions to minimize the impact of these disorders in TBI, and to promote further research in this area.

Traumatic brain injury (TBI) may cause psychaitric illness. These illnesses may contribute to further suffering, impairment and handicap. This article reviews the available literature evidence, based on a set of causation criteria, to establish whether TBI does in fact cause Psychiatric Disorders. The evidence is convincing for a strong association between TBI, and mood and anxiety disorders. For example, Major Depression occurs in over 40% of all persons who have suffered a TBI, a rate which is over 7-fold higher than individuals who have not had a TBI. Substance abuse, and schizophrenia, are not strongly associated with TBI, and there is little research into the rates of personality disorders after TBI. Evidence for a biologic gradient is lacking, but may not be relevant to TBI. Evidence for the correct temporal sequence is present. Preliminary evidence suggests a biologic rationale for TBI causing psychiatric illness. Further, and methodologically improved research is supported by these results, especially into the treatment of these disorders. From a clinical point of view, these results suggest the need for careful monitoring for emergence of these disorders, and further suggests the need to try to prevent their occurrence. From a medical-legal point of view, these results have important implicaitons for compensation, and access to rehabilitation, post-TBI.



### THE HAMILTON DEPRESSION RATING SCALE IN A HEAD-INJURED POPULATION: A THREE-FACTOR SOLUTION

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2. **Glenn Curtiss**, PhD, Defense and Veterans Head Injury Program, James A. Haley VA Medical Center, Tampa, FL, USA
3. **Deborah L. Warden**, MD, Defense and Veterans Head Injury Program, Walter Reed U.S. Army Medical Center, Washington DC, USA
4. **Elaine S. Date**, MD, Defense and Veterans Head Injury Program, VA Palo Alto Health Care System, Palo Alto, CA, USA

#### Objectives:

1. Determine the factor structure for the Hamilton Depression Rating Scale in a depressed, brain injured population.
2. Compare this results quantitatively and qualitatively to previously published factor analytic studies.
3. Discuss the problems that may have contributed to the apparent differences in published studies.

The factor structure of the Hamilton Depression Rating Scale (HAM-D; Hamilton, 1960) has been examined by numerous investigators, but the stability of its factors is still widely debated. In addition, the use of the HAM-D total score as the best measure for assessing severity of depression has been questioned (Gibbons, Clark, & Kupfer, 1993). While the HAM-D has generally been found useful across diverse populations and diagnostic criteria, Cleary & Guy (1977) have suggested that its factor structure may be specific to the population from which it is derived. The HAM-D has been utilized with head injured individuals (e.g., Jorge, Robinson & Arndt, 1993), but its factor structure in this population has not been established. We analyzed data from the 17-item version of the HAM-D for 161 depressed, head injured individuals using a principal components factor analysis with orthogonal rotation. As with many previous studies, the resultant six-factor solution was not well defined beyond the third factor. A three-factor solution produced a clinically meaningful structure; we defined these factors as Anxiety/Somatic Concerns, Depression and Sleep Disturbance. This factor structure was then compared to other, previously published findings using Cattell's salient similarity index. Where it was not possible to conduct quantitative analyses, qualitative comparisons were made. The results suggest that anxiety or anxiety with a somatic component, depression and sleep disturbances are widespread, if not universal, factors for the HAM-D. Problems of homogeneity of samples, range of scores and multidimensionality are discussed.



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## PSYCHOPATHOLOGY AND UNAWARENESS OF COGNITIVE IMPAIRMENTS AND BEHAVIORAL LIMITATIONS IN TRAUMATIC BRAIN-INJURED PATIENTS

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3. **P. De Collasson**, Psychologist, Clinical Manager, ADEP-MAS, Garches, France
4. **P. Azouvi**, MD, PhD, Neurologist, Professeur des Universités, Praticien Hospitalier, Hôpital Raymond Poincaré, Garches, France

### Objectives:

1. Looking for the psychopathological elements specific to traumatic brain-injured patients who underestimate their cognitive impairments and behavioral limitations

The complexity of unawareness of cognitive impairments and behavioral limitations was explored using a psychopathological approach. The data from semi-structured interviews with 15 traumatic brain-injured patients and their families, at least six months after the accident, were compared with data supplied by PCRS, Awareness Interview, and NRS-R. Out of the 15 patients studied, 9 were anosognosic according to the PCRS, six were not. There was a partial awareness of impairments in all the anosognosic patients. Psychic phenomena specific to patients with anosognosia were found. Some of these were specific to brain injury, such as the lack of representation of brain-injury, or the difficulty to integrate the brain-injury into one's psychic space. Others were not specific to brain injury such as non-compliance, mourning process difficulties, personality characteristics, defense mechanisms, the attitude of the family. Several psychic phenomena coexisted in the same patient. Denial was rarely found. In 55% of the patients diagnosed as having impaired awareness according to PCRS, there was a clear awareness of impairments during the interview. This study draws the conclusion that it is illusory to separate that which refers to personality and that which are cognitive impairments due to brain lesions in the unawareness of disability. The post-traumatic subjective experience could be what links these two aspects. The coexistence of psychic phenomena specific and non specific to being brain-injured adds complexity to the approach of unawareness of cognitive impairments and behavioural limitations and makes future clinical and theoretical definition indispensable.

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## DIVIDED ATTENTION AFTER SEVERE DIFFUSE TRAUMATIC BRAIN INJURY

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4. *M. Rousseaux*, MD, PhD, CHRU, Lille, France

### Objectives:

1. Assess divided attention after a severe TBI.
2. Study the relationships between divided attention, speed of processing and mental effort.

**Background.** Survivors from a severe traumatic brain injury (TBI) often complain of a difficulty in doing two things simultaneously. However, experimental data on divided attention have given conflicting results (1, 2).

**Subjects and methods.** 42 severe TBI patients at the subacute or chronic stage performed two tasks under single- and dual- tasks conditions: (a) random generation; (b) a go-no go task. Moreover, two additional dual-task conditions were given, in which subjects were alternatively asked to focus preferentially on each one of the two simultaneous tasks. Patients were compared to matched controls.

**Results.** A disproportionate increase of reaction time in the go-no go task under dual-task condition was found in the TBI group, as compared to controls. However, patients were able to modify, at least in part, their pattern of performance in dual-task conditions, according to the specific instructions concerning the task to emphasize.

**Discussion.** These results confirm previous findings (2, 3) on a divided attention deficit of severe TBI patients. However, they also suggest that patients have a relatively preserved ability to allocate their attentional resources according to task requirements. These data will be discussed within the van Zomeren and Brouwer (1) model of attention.

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## LEXICAL IMPAIRMENT IN TRAUMATIC BRAIN INJURED PATIENTS: SELECTIVE DAMAGE OF VERBS AND NOUNS

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3. **Giuseppina Zonca**, Aphasia Terapist, Istituto Scientifico di Riabilitazione, Fondazione Salvatore Maugeri, Montescano, Pavia, Italy
4. **Gabriella Fizzotti**, MP, Dirigente I livello, Istituto Scientifico di Riabilitazione, Fondazione Salvatore Maugeri, Montescano, Pavia, Italy

### Objectives:

1. Impairment for nouns and verbs in traumatic brain injured patients.
2. Comparison with the rate observed in vascular patients.
3. Follow-up study of a single case.

In a previous study we compared the naming impairment for Nouns and Verbs in a large sample of focal brain damaged pts (Raggi et al., 2000). The results confirmed the existence and relative frequency of dissociated naming impairments of verbs and nouns. Selective impairment of verbs was more frequent and emerged in the large majority of the agrammatic pts. Dissociation was less frequent in fluent aphasic pts, but both the naming of verbs and of nouns may be selectively impaired.

Aim of the study was to compare the performance of vascular pts with that of TBI pts. A second aim of the study was the description of the treatment given to a TBI patient with selective impairment of verb retrieval.

A naming task for verbs and nouns was administered to 48 vascular and 10 traumatic pts. The pts were shown drawings of objects in order to stimulate the naming of nouns, while the naming of verbs was elicited by the use of drawings of actions. For each noun and verb the major lexical (i.e. word frequency and age of acquisition) and semantic variables (i.e. familiarity and imageability of the underlying concept) were considered. Verbs were distinguished by major functional classes (transitive, intransitive and ergative verbs). The results from the naming task were analyzed both as a group study and as a multiple single case study to evaluate the variability in naming verbs and nouns between individual pts and the effect of lexical semantic variables on individual performance. Type and severity of aphasia were measured by means of the Italian version of the Aachen Aphasia Test (AAT; Luzzatti et al., 1996)

While vascular pts were distributed across all standard aphasic groups (all together 26 Fluent + 15 non Fluent + 7 non classifiable pts along the fluent/non-fluent dimension) all traumatic pts had a fluent language disorder. Therefore we compared the performance of the 10 fluent traumatic pts with that of 26 fluent vascular patients. We found that in traumatic patients nouns are less impaired than verbs (46% vs 58%)



whereas in vascular patients the opposite pattern of impairment (N 49 vs. V 37) emerged. The single case logistic regression analysis showed a dissociation impairment of verbs and nouns in 21 vascular pts and in 5 traumatic pts. While 18 vascular and 2 traumatic pts were less impaired on verbs, the opposite pattern of performance was found in 3 vascular and 3 traumatic pts. The results lend support to the hypothesis of an independent mental organization of nouns and verbs, but at the same time. In the second part of our presentation we'll discuss the treatment of a patient (M.C.) who was re-educated for his lexical deficits from 30<sup>th</sup> October 1997 to 30<sup>th</sup> October 1999. The implication to a selective impairment of verb retrieval will be discussed in light of the results obtained.

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## FACE RECOGNITION IMPAIRMENTS AFTER BRAIN INJURY: CONTROLLED EVALUATION OF THREE REHABILITATION PROCEDURES

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3. *Tim Valentine*, Professor, Dept of Psychology, Goldsmiths College, London University, UK
4. *Sue Letson*, Dept of Psychology, Goldsmiths College, London University, UK

### Objectives:

1. Development of theoretically-based procedures for facilitating face recognition after brain injury.
2. Evaluation of three face recognition rehabilitation techniques in a controlled within and between-subjects design.

Difficulties in learning to recognise unfamiliar faces are common after acquired brain injury (ABI) through effects on diverse aspects of cognitive functioning. We report here an attempt at remediation based on a cognitive analysis of the processes involved in face recognition. 21 patients with single incident ABI, aged 18 to 63, and 6+ months post-injury (GROUP A), were trained on four different sets of 10 previously unfamiliar faces using the following procedures: unelaborated exposure (control condition); semantic association (linking each face with biographical information); presenting caricatured versions of the faces during the training phase; and part recognition (focusing on distinctive features of each face). Each procedure was repeated over six learning trials; the control condition was conducted first and the three experimental procedures were counterbalanced for order. 12 further patients (GROUP B) were trained on all four sets of faces under unelaborated exposure. Recognition was tested following each procedure, using sequential presentation of 20 faces (10 trained, 10 distractors).

The GROUP x CONDITION interaction was significant, reflecting superior recognition following the three experimental procedures than the control procedure. Within GROUP A, performance was worst after unelaborated exposure and best after the part recognition procedure. GROUP B showed no differences between face sets. Thus, the three experimental procedures were associated with benefits which were not attributable to intrinsic differences in memorability between the face sets.

These data suggest that difficulties with face recognition following ABI of differing aetiology and location are amenable to interventions derived from contemporary cognitive neuropsychological models.



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## REHABILITATION PROGRAM FOR PATIENTS WITH PENETRANT HEAD INJURIES IN CROATIA

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2. *Davor Janculjak*
3. *Bosko Barac*
4. *Mirjana Vladetic*

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Objectives:

1. We made a post-hoc analysis of the rehabilitation program for patients with penetrant head injuries in Croatia.

We followed-up a cohort of 39 patients (37 males and 2 females, mean age 29 +/- 9 years) who were hospitalily treated for penetrant head injuries during the Croatian Defense War (1991-5). A team of psychiatrists, psychologists, neurologists and speech therapists had provided a full rehabilitation program for 23 patients. Mean duration of their stationary rehabilitation was 133 days (range 21 to 720 days). After the comprehensive physical rehabilitation most of the patients retained a severe neurological deficit (13 had hemiparesis and 2 had tripareisis), which impaired their activities of daily living and working ability. Verbal communication was impaired in 12 of our patients, and that deficit remained after the speech therapy. Neurological follow-up included repeated EEG recordings. First recordings showed brain activity changes in 8 patients, while later performed EEG showed that changes disappeared in 3 of those patients and appeared in 2 new cases. Despite of early prophylactic use of anticonvulsants, the late-onset epilepsy occurred in 12 of our patients. Psychological evaluation showed mild mental changes after trauma in 4 patients, a severe mental disorder related to trauma in 13 patients, and a posttraumatic stress neuroticism in 3 of our patients.



### C.U.O.K - THE COMPUTERISED SYSTEM FOR TBI REHABILITATION SETTINGS

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3. *Ofer Keren*, MD, Loewenstein Rehabilitation Hospital, Ra'anana, Sackler Faculty of Medicine, Tel-Aviv University, Israel
4. *Zeev Groswasser*, MD, Loewenstein Rehabilitation Hospital, Ra'anana, Sackler Faculty of Medicine, Tel-Aviv University, Israel

Objectives:

1. To present the advantages of an integrative computerised Data base for handling rehabilitation set-ups.

The C.U.O.K software was developed for handling data in a rehabilitation environment and is based on Microsoft Access 97Æ

The system includes more than 1800 individual data bases for each patient presented in 82 charts. Apart from handling admissions and discharges, the system enables to monitor various aspects of patient's progress during rehabilitation. Once the patient is admitted to the hospital the demographic data serves to identify the patients and most of the other variables can be added to the patients file by pointing on the necessary item. Free text can be added at various points but this comes to use mostly in the discharge remarks.

The system has several built-in modules which enable to record the state and progress of patients in the medical as well as in the paramedical (physiotherapy, occupational therapy, psychology etc.) fields. As all parties involved in the treatment are linked a better time table for each patient can be created. Thus enabling to optimise the use of available manpower. Several progress, discharge and evaluation of outcome questionnaires like FIM, FAM, DRS, MMSE, CIQ are already included in the system. The systems can provide accurate admission, interim and discharge reports at a minimum cost of time. Data can be easily transferred to authorised parties taking care of patients post discharge.

It is believed that such systems will enable rehabilitation to cope with current economic pressures on rehabilitation services.



## DISABILITY RATING SCALE AND GLASGOW OUTCOME SCALE: OBSERVATIONS AND REMARKS IN ACUTE BRAIN INJURY REHABILITATION

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3. **Massimo Mantero**, MD, Head of Department of Rehabilitation Azienda Ospedaliera San Martino, Genova, Italy
4. **Domenico Riso**, MD, Health Science Department, University of Genoa, Genova, Italy

### Objectives:

1. To confirm the utility of disability and outcome scale to monitor the patients' functional evolution from the acute phase.
2. To understand if score variation of these indicators during first thirty days can have a functional prognostic meaning.
3. To understand if these evaluation scales are correlated with others indicators currently used during the acute phase.

### MATERIALS AND METHODS

The study involved 30 post-traumatic brain injured patients that were treated for the rehabilitation from their admission to the intensive care unit of San Martino Hospital in Genoa.

All patients were rated at admission for Glasgow Coma Scale (GCS), Injury Severity Scale (ISS), Abbreviated Injury Scale (AIS) and Marshall (DIS) scores.

Disability Rating Scale (DRS) and Glasgow Outcome Scale (GOS) were administered within the initial ten days (T0), then at one month (T1) and then at six months (T2) after the trauma.

The statistical analysis was carried out with Prism 2.0 software (Graph Pad San Diego, CA). The comparison of the variables relative to T0 and T1 was made through non-parametrical tests (Mann-Whitney and Wilcoxon test). The correlation among the variables was evaluated with the rS Spearman index. The value of  $P_0 < 0.05$  was considered as statistical significant. Exact values of P between 0.2 and 0.001 were reported. A non parametric test of the variance analysis was used for the comparison of the data relative to the three evaluations T0, T1 and T2.

### RESULTS

The variations of DRS and GOS showed to be statistically significant within the intervals T0-T1 and T0-T2, but not significant within the interval T1-T2.

The variations of DRS within the interval T0-T1 showed to be statistically significant for predicting the T2 functional improvement.



Only the total GCS showed to be meaningfully correlated with DRS and GOS six months after the accident. Others initial indicators (AIS Head-Neck and DIS) showed to be significantly correlated only at the thirty day (T1) assesment.

### **DISCUSSION AND CONCLUSIONS**

The analysis of the results of this study, taking into account limitation of number of the case studies, allows us however to put forward the following considerations:

- It is useful and expedient to monitor, from the initial acute phase, the evolution of the brain-injured patient making use of disability indicators such as DRS and GOS.
- The improvement evaluated by DRS during the initial thirty days is predictive of the outcome after six months.
- A good correlation between the initial total GCS and the functional outcome after six months is confirmed.

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## SLEEP IN THE BRAIN INJURED!

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### Objectives:

1. Identification of sleep disturbances in acquired brain injured (ABI) patients.
2. Denoting whether these disturbances are unique to ABI patients by comparison with sleep problems in patients without an ABI.
3. Use of gold standard in measuring sleep problems, overnight polysomnography.

Sleep disorders are a difficult entity to identify, and manage, especially in the acquired brain injured (ABI) population. This is in large measure due to the number of other complaints that may overshadow sleep problems.

The purpose of this study was to identify the type of sleep difficulties that may occur in patients with an ABI using the accepted gold standard, overnight polysomnography. Data were collected on 209 patients over a 3-year period. It was analyzed using standardized techniques in order to determine whether differences existed in sleep architecture between groups of patients with “ABI and sleep problems”, versus “those experiencing just sleep difficulties but having no clinical evidence of any ABI”. These groups were also compared against normative data.

No significant differences were noted between these two groups in their sleep onset latency (44.2 vs. 38.5 min.), duration of sleep (335.4 vs. 339.7 min.), sleep efficiency (77.8 vs. 80.6 %), intervening wakefulness (74.1 vs. 64.9 min.), REM onset latency (117.7 vs. 146.4 min.), or REM density (14.4 vs. 15.4 %). Patients with “ABI and sleep problems” did have significantly less Stage 1 sleep (6.4 vs. 7.9 %), stage 4 sleep (5.8 vs. 7.4 %), movement arousals / hr. (2.8 vs. 0.9), leg movements (66.0 vs. 49.6) increased periodic leg movements in sleep (86.9 vs. 32.1), and hypopnea (13.6 vs. 22.1 min.) [all  $p < 0.05$  or less]. All of these results are also abnormal when compared to normative data.

These results substantiate complaints of sleep difficulties frequently experienced by patients who sustain an ABI especially low stage 4 or slow wave sleep, and periodic leg movements in sleep.



## GROUP TREATMENT FOR MILD HEAD INJURY

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3. **P. Thorstensson**, Occupational Therapist, Dept of Rehabilitation, Danderyd Hospital, Sweden
4. **M. Östlund**, Psychologist, Dept of Rehabilitation, Danderyd Hospital, Sweden

### Objectives:

1. (7) Outline of behavioural components of mild head injury.
2. (9) Description of a group treatment model.

Mild head injuries constitute about 80% of all head injuries with considerable human suffering and far reaching socio-economical consequences. Despite the high incidence there are very few treatment programs specially designed for this groups. In 1997 a diagnostic and treatment unit for mild brain injuries was started and a group treatment program was developed at the rehabilitation clinic of Danderyds Hospital, Stockholm; Sweden. The present study describes an 8 week long neuropsychologically based holistic group treatment program. Evaluation data for more than 50 patients are presented. The basic principle for the structure of the program was to serve as a guideline for the participants for metacognitive strategies. Consequences of head injury are being dealt with within the framework of different topics integrating cognitive and emotional aspects. Role changes in the family after mild brain injury are different from those with moderate or severe injuries. Thus families are involved on a different level in the program. Data on changes in coping strategies, psychological well-being, assessment of quality of life and neuropsychological test results are presented.



## **VIRTUAL REALITY DEFINITIONS AND RATIONALE FOR ITS USE FOR COGNITIVE ASSESSMENT AND REHABILITATION**

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Objectives:

1. To define the various forms of virtual reality environments.
2. To detail the rationale for the applicability of this technology for the assessment and rehabilitation of CNS dysfunction.
3. To present the assets available with the use of VR and the cost/benefit issues that need to be considered for its rational application.

This will be a brief introduction to Virtual Reality that will serve to provide baseline information for a series of papers on the "Recent Advances in the Application of Virtual Reality for the Neuropsychological Assessment and Rehabilitation of CNS Dysfunction" that is being proposed.

Virtual Reality (VR) technology is increasingly being recognized as a useful tool for the study, assessment, and rehabilitation of cognitive processes and functional abilities (1-3). Much like an aircraft simulator serves to test and train piloting ability, virtual environments (VEs) can be developed to present simulations which target human cognition and behavior in normal and impaired populations. The capacity of VE technology to create dynamic, multi-sensory, three-dimensional (3D) stimulus environments, within which all behavioral responding can be recorded, offers clinical assessment and rehabilitation options that are not available using traditional methods. In this regard, a growing number of laboratories are developing research programs investigating the use of VEs for these purposes and initial exploratory studies reporting encouraging results are now beginning to emerge (3).

This work has the potential to advance the scientific study of normal cognitive and behavioral processes, and to improve our capacity to understand, measure, and treat the impairments typically found in clinical populations with central nervous system (CNS) dysfunction. Individuals who may benefit from these applications include persons with cognitive and functional impairments due to traumatic brain injury (TBI), neurological disorders, and developmental/learning disabilities. This introductory talk will present definitions of what Virtual Reality involves and describe the rationale for its application to the assessment and rehabilitation of cognitive/functional impairments.

As well, the key VR assets that are available for these purposes will be detailed along with a discussion of the hurdles that need to be considered for its rational and productive use.



*References:*

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2. Rose FD. *Virtual reality in rehabilitation following traumatic brain injury.* In: Sharkey P, ed. *Proceedings of the European Conference on Disability, Virtual Reality and Associated Technology*, 1996: 5-12.
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## VIRTUAL REALITY TO ASSESS EXECUTIVE FUNCTIONS IN ACQUIRED BRAIN DAMAGE

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### Objectives:

1. Discuss why Virtual Reality is an innovative tool to assess executive functions.
2. Describe specific VR applications.
3. Present results of single case and group studies of brain damaged individuals.

Disorders of executive functions (EF) are common sequelae of brain damage and may lead to severe social incompetence. Dysexecutive conditions (DES) are hard to assess with cognitive tests that do not tap behavioral complexity, are too structured, compress time and space, and do not represent real conditions. Virtual Reality is an innovative tool to provide contextual information and to stimulate complex behavioural sequences. Learning in VR requires the integration of perceptual and motor activities with processing guided by goal assignments. As a result, VR users initiate more voluntary action sequences and take more decisions than users of more structured information-providing systems. We have been developing a virtual version (1) of a paper-and-pencil test used to assess subjects' ability to achieve a strategy by trial and error, to maintain it when it is reinforced and to change it when necessary. Our VR analog adds space to be navigated, dilates the timing of events, and makes it necessary to integrate specialized abilities such as navigation and interaction with the typical cognitive steps of the task. When dysexecutive patients interact with a VR it is easier to show that the dynamics of executive control are impaired and that an uncoupling occurs between processes that the executive control is meant to keep behaviorally dependent and which - in the case of severe DES - is associated with reduced awareness of failure (2). Furthermore, group studies show that performance on the VR task is better predicted by current neuropsychological models of executive control (3).

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## ASSESSING PROSPECTIVE MEMORY AFTER VASCULAR BRAIN INJURY USING VIRTUAL REALITY

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### Objectives:

1. To use virtual reality to assess prospective memory after vascular brain injury.
2. To compare patients' performance with performance of age-matched controls.
3. To identify any patients who are significantly impaired.

Impaired memory is one of the most pervasive and disabling consequences of brain damage (see e.g. Tate, 1997). A particularly disabling type of memory impairment is associated with prospective memory, the ability to remember to perform tasks in the future. For example, forgetting to take medication would have dire consequences for independent living. It is therefore important to assess whether there are impairments in prospective memory after vascular brain injury and to identify any patients who are significantly impaired. Unfortunately, it is difficult to devise reliable and realistic prospective memory tasks that can be performed in a rehabilitation unit. Virtual reality provides a solution to this problem by allowing prospective memory to be measured in a pseudo real-life situation whilst retaining a laboratory level of scientific control.

The virtual environment used in this study was run on a desktop computer, explored using a joystick, and manipulated using a mouse. Vascular brain injury patients instructed the experimenter how to organise furniture and objects in a virtual bungalow according to which room they thought they should occupy in a new house. The prospective memory tasks they were asked to remember to instruct the experimenter to do were: to put "Fragile" notices on the five items with glass components (event-based task); to press a button beside a clock in the hall at exactly five minute intervals to allow removal men access (time-based task); and to keep the kitchen door closed to keep the cat in (activity-based task). Performance of patients with vascular brain injury and age-matched control participants in the three prospective memory tasks was compared.

### References:

- Tate, R.L. (1997). *Beyond one-bun, two-shoe: recent advances in the psychological rehabilitation of memory disorders after acquired brain injury*. *Brain Injury*, 11, 907-918.



## VIRTUAL ENVIRONMENTS IN THE ASSESSMENT AND TREATMENT OF TOPOGRAPHICAL DISORIENTATION

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3. **Giuseppe Riva**, PhD, Applied Technology for Neuro-Psychology Lab, Istituto Auxologico Italiano, Verbania, Italy

### Objectives:

1. Introduction to topographical disorientation.
2. Clinical rationale and technical details for the Virtual Environment for Topographical Orientation (VETO).
3. Details of work in progress.

The capacity for orientation is a fundamental requisite for moving around in an autonomous way in the environment. The lack of spatial orientation frequently represents the warning light of a diffused cerebral impairment, such as the one at the origin of a confusional state or of a mental disorder. Topographical orientation disorders may be the expression of memory or attention deficits, unilateral spatial neglect, or elementary visuo-perceptive disorders. In a minority of cases, topographical disorientation presents as an isolated disorder and is the expression of a focal brain lesion.

Virtual reality technology could have a strong impact on neuropsychological assessment and rehabilitation. They enable the therapist to present a wide variety of controlled stimuli and to measure and monitor a wide variety of responses made by the user. The paper describes the clinical rationale and the technical characteristics of the Virtual Environment for Topographical Orientation - VETO.

The aim of this project is the creation and validation of various VEs to improve the assessment and rehabilitation of topographical disorientation. As compared to traditional pencil-and-paper neuropsychological tests, assessment via VR makes it possible to investigate in greater depth the functionality of the higher cognitive skills and to infer the degree of integrity of the underlying neural processes implicated in the tasks of topographical orientation. Our hypothesis is that the study of spatial orientation through specific tasks can bring greater comprehension and validation of cognitive models of spatial orientation present in literature (see the recent theoretical model of wayfinding in virtual environments proposed by Chen and Stanney (1999)).



**NEW DIRECTIONS IN DRIVING ASSESSMENT FOLLOWING TBI: VIRTUAL REALITY**

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3. **Ronald R. Maurant**, PhD, Northeastern University, Boston, MA, USA
4. **Michael Recce**, PhD, New Jersey Institute of Technology, Newark, NJ, USA

## Objectives:

1. Present limitations to current driving assessment protocols.
2. Present benefits of the application of VR to driving assessment following acquired brain injury.
3. Present limitations and consideration in application development for clinical populations.

The ability to drive an automobile is a vital component of independent functioning. However, it has been documented that cognitive dysfunction, resulting from etiologies, such as acquired brain injury (ABI), can result in decreased performance of driving abilities. Current available protocols for the assessment of driving capacity are fraught with limitations. Virtual reality (VR) offers an innovative approach to addressing these limitations. For example, through its ability to allow control and consistency in both stimulus delivery and performance recording, VR can eliminate the subjective interpretations and provide quantifiable, objective measures of "behind-the-wheel" performance. The interactive, modifiable driving environments created using VR can allow the evaluation of cognitive abilities in "real-life" and challenging driving situations, while still maintaining safety for both the clinician and patient. These advantages can help standardize measures of driving ability and better identify the cognitive demands of driving, which may potentially lead to improved methods for quantifying deficits, leading to individualized interventions and re-training opportunities. The current study was designed to examine the efficacy of a VR Driving System (VRDS) for the assessment of driving ability in persons with ABI. The primary objectives are to evaluate the concurrent validity of a VR driving protocol, by comparing it to a traditional behind-the-wheel driving evaluation and to examine the effects of adding complex and challenging driving factors (i.e. nighttime, traffic congestion) on driving performance. Issues regarding development of the VRDS and preliminary data comparing performance between ABI adults and healthy controls will be presented.



## THE VIRTUAL CLASSROOM AND OFFICE: EFFORTS TO IMPROVE ECOLOGICAL VALIDITY IN THE ASSESSMENT AND REHABILITATION OF ATTENTION AND OTHER COGNITIVE PROCESSES

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3. **Galen Buckwalter**, PhD, Senior Scientist, Southern California Permanente Medical Group, Pasadena, California, USA
4. **Ulrich Neumann**, PhD, Associate Professor, University of Southern California, Los Angeles, California, USA

### Objectives:

1. To describe and explain the rationale for the use these virtual environments for more ecologically valid cognitive/function assessment and rehabilitation for persons with attention deficits due to CNS dysfunction.
2. To describe the methodology and current data on our research using the Virtual Classroom and our development of the Virtual Office. tools.

The Virtual Environments Laboratory at the University of Southern California (USC) has initiated a research program aimed at developing virtual reality (VR) technology applications for the study, assessment, and rehabilitation of cognitive/functional processes. We will present a brief review on attention processes and issues for the development of a Head Mounted Display (HMD) VR system designed to address attention disorders. Our efforts to target this cognitive process are supported by the widespread occurrence and relative significance of attention impairments seen in a variety of clinical conditions across the human lifespan. Most notably, attention difficulties are seen in persons with Attention Deficit Hyperactivity Disorders (ADHD), Traumatic Brain Injury (TBI), and as a feature of various neurodegenerative disorders (i.e., Alzheimer's Disease, Vascular Dementia, etc.). Virtual Environment (VE) technology appears to provide specific assets for addressing these impairments that are not available using existing methods. VEs delivered via HMDs are well suited for these types of applications as they serve to provide a controlled stimulus environment where cognitive challenges can be presented along with the precise delivery and control of "distracting" auditory and visual stimuli. This level of experimental control allows for the development of attention assessment/rehabilitation tasks that are more similar to what is found in the real world and could improve on the ecological validity of measurement and treatment in this area. Two recent projects that will be presented involve the development of virtual "classroom" and "office" scenarios that are designed to specifically target the assessment/rehabilitation of Attention Deficit Hyperactivity Disorder (ADHD) and attention (and other cognitive) deficits that are common sequelae to traumatic brain injury. Data on initial user-studies and the ongoing progress of clinical trials will be detailed. Time permitting, we will also show video footage of a series of visuospatial scenarios that we have also developed and tested.



