Testing the Effect of Environmental Distraction: An Innovative Procedure for Improving Differential Diagnosis and Ecological Validity of the Neuropsychological Assessment

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The thesis is submitted in fulfilment of the requirement for the Degree of Doctor of Philosophy in Psychiatry at The University of Auckland in February 2013
Abstract

Traditional neuropsychological assessments are conducted exclusively in a quiet, distraction-free environment; clients’ abilities to operate under busy and distracting conditions remain untested. Environmental distractions, however, are typical for a multitude of real-life situations and present a challenge to clients with frontal-temporal brain injury. In an effort to improve ecological validity, an extension of the traditional neuropsychological assessment was developed, comprising a standardised distraction-condition. This allowed cognitive functions to be tested both in the traditional setting and with exposure to a specified audio-visual distraction. The problem of practice-effects arising from re-testing clients in two conditions was resolved by developing a set of alternative test stimuli that which can be used interchangeably with the standard stimuli. A first study (n=240), comprising clients with mild Traumatic Brain Injury (mTBI) (n=80), clients with Major Depression (MDE) (n=80), and a healthy control sample (n=80), was undertaken to validate the equivalence of the alternative stimuli. The second study (n=240) investigated how clients with mTBI (n=80), clients with MDE (n=80), and a healthy control sample (n=80) performed on sub-tests of the Wechsler Adult Intelligence Scale-IV and the Wechsler Memory Scale-IV both in the standard and the distraction conditions. Significant deterioration of performance in the distraction setting was observed among clients with mTBI. In contrast, the performance of a healthy control sample remained unchanged. Significant improvement of performance in the distraction setting was documented for clients with MDE. Contrary to their improved performance, depressed clients experienced the distraction setting as more distressing than the control group and the mTBI group.

Keywords: Environmental Distraction, Neuropsychological Assessment, Ecological Validity, Environmental Distraction, Traumatic Brain Injury, Major Depressive Episode, Practice Effect
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### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ADL</td>
<td>Activities of daily living</td>
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<tr>
<td>ANOVA</td>
<td>Analysis of Variance</td>
</tr>
<tr>
<td>BDI-II</td>
<td>Beck Depression Inventory 2nd Version</td>
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<tr>
<td>BOLD fMRI</td>
<td>Blood-Oxygen-Level-Dependent Functional Magnetic Resonance Imaging</td>
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<td>CT</td>
<td>Computer Tomography</td>
</tr>
<tr>
<td>CVA</td>
<td>Cerebral Vascular Accident</td>
</tr>
<tr>
<td>CVLT</td>
<td>California Verbal Learning Test</td>
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<tr>
<td>DF</td>
<td>Degrees of freedom (statistical term)</td>
</tr>
<tr>
<td>DSF</td>
<td>Digit Span Forward Test</td>
</tr>
<tr>
<td>DSM-IV TR</td>
<td>Diagnostic and Statistical Manual of Mental Disorders –Text revision</td>
</tr>
<tr>
<td>DST</td>
<td>Digit Span Total Test</td>
</tr>
<tr>
<td>fMRI</td>
<td>Functional Magnetic Resonance Imaging</td>
</tr>
<tr>
<td>GCS</td>
<td>Glasgow Coma Scale</td>
</tr>
<tr>
<td>GNP</td>
<td>Gross national product.</td>
</tr>
<tr>
<td>H</td>
<td>Hypothesis</td>
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<tr>
<td>HIV</td>
<td>Human immunodeficiency virus</td>
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<tr>
<td>INS</td>
<td>International Neuropsychological Society</td>
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<tr>
<td>LM</td>
<td>Logical Memory Test</td>
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<tr>
<td>LNS</td>
<td>Letter Number Sequencing Test</td>
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<tr>
<td>MDE</td>
<td>Major Depressive Episode</td>
</tr>
<tr>
<td>MRI</td>
<td>Magnetic Resonance Imaging</td>
</tr>
<tr>
<td>mTBI</td>
<td>Mild Traumatic Brain Injury</td>
</tr>
<tr>
<td>N</td>
<td>Number of participants</td>
</tr>
<tr>
<td>NART</td>
<td>National Adult Reading Test</td>
</tr>
<tr>
<td>P</td>
<td>Probability (statistical term)</td>
</tr>
<tr>
<td>PCS</td>
<td>Post Concussion Syndrome</td>
</tr>
<tr>
<td>PET</td>
<td>Positron Emission Tomography</td>
</tr>
<tr>
<td>RAVLT</td>
<td>Rey Auditory Verbal Learning Test</td>
</tr>
<tr>
<td>SD</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>SNRI</td>
<td>serotonin-norepinephrine reuptake inhibitors</td>
</tr>
<tr>
<td>SSRI</td>
<td>Serotonin reuptake inhibitors</td>
</tr>
<tr>
<td>SPSS</td>
<td>Statistical Package for Social Science</td>
</tr>
<tr>
<td>TBI</td>
<td>Traumatic Brain Injury</td>
</tr>
<tr>
<td>TMT</td>
<td>Trial Making Test</td>
</tr>
<tr>
<td>TCN</td>
<td>The Clinical Neuropsychologist (Journal)</td>
</tr>
<tr>
<td>TOMM</td>
<td>The Test of Memory Malingering</td>
</tr>
<tr>
<td>TCA</td>
<td>Tricyclic antidepressants</td>
</tr>
<tr>
<td>VAS</td>
<td>Visual Analogue Scale</td>
</tr>
<tr>
<td>WAIS-IV</td>
<td>Wechsler Adult Intelligence Scale 4th Edition</td>
</tr>
<tr>
<td>WCST</td>
<td>Wisconsin Card Sorting Test</td>
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<tr>
<td>WMS-IV</td>
<td>Wechsler Memory Score 4th Edition</td>
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Co-Authorship Form

This form is to accompany the submission of any PhD that contains research reported in published or unpublished co-authored work. Please include one copy of this form for each co-authored work. Completed forms should be included in all copies of your thesis submitted for examination and library deposit (including digital deposit), following your thesis Abstract.

Please indicate the chapter/section/pages of this thesis that are extracted from a co-authored work and give the title and publication details or details of submission of the co-authored work.

2nd "Insertion" Chapter – Publication: "Neuropsychological Assessment of Distractibility in mild Traumatic Brain Injury and Depression"

Nature of contribution by PhD candidate

1. Literature review regarding (a) cognitive impairment for Mild Traumatic Injury is not identified on standard TBI, (b) ecocological validity of the Neuropsychological Assessment, (b) distractibility of clients with Frontal-Temporal Lobe Injury, problems with complex attention for clients with Major Depression (c) absence of distraction testing in standard neuro-cognitive testing
2. Methods including (a) development of a distraction condition, (b) recruitment of participants (3) study design (4) clinical examinations and testing, and obtaining data for large clinical samples and control group.
3. Statistical analysis and documentation of findings, including graphs and tables
4. Discussion of findings
5. Revision of manuscript and undertaking amendments according to the feedback by peer reviewers of the publishing Journal

Extent of contribution by PhD candidate (%) 95

CO-AUTHORS

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<tr>
<th>Name</th>
<th>Nature of Contribution</th>
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| Prof Rob Kydd | 1 Support with obtaining Ethics Approval  
2 Feedback on initial version of the manuscript, including identifying the need for the inclusion of fMRI brain scans into the literature review and providing related articles  
3 Review of first draft of paper and advice on journal selection |

Certification by Co-Authors

The undersigned hereby certify that:

- the above statement correctly reflects the nature and extent of the PhD candidate's contribution to this work, and the nature of the contribution of each of the co-authors; and
- in cases where the PhD candidate was the lead author of the work that the candidate wrote the text.

Name: Prof Rob Kydd
Signature: [Signature]
Date: 20/7/12
1. Preface

1.1. Advancing the Interactive Relationship between Academia and Clinical Practice

This research project is rooted in ‘hands-on’ Clinical Practice, based on some 15 years of intensive daily work with clients encompassing both assessment of cognitive functioning and subsequent treatment/rehabilitation. The topic presented here has stood out as a key problem, repeatedly raising clinical concerns with high stakes involved, affecting clients’ rehabilitation, entitlements for compensation, and the use of health resources.

In the course of my clinical practice these concerns had grown to such an extent that they finally encouraged me to undertake systematic research into the issue and to develop innovative procedures to rectify these concerns, as will be presented in the body of this PhD thesis. It is my privilege to be able to present findings that may have practical implications for the very field of clinical practice from which these concerns arose. In this context, the concept of the “research-practitioner” (scientist-practitioner) deserves mentioning. This model proposes that clinical psychologists receive, as part of their professional training, a firm foundation in scientific methodology and research. This foundation serves to enable them to adhere to scientific methods and procedures throughout their careers as treating clinicians, to regularly update their knowledge by referring to current publications and to integrate the findings of academic research in an ongoing fashion into their day-to-day practice (1999).

In variation to this model, the research project presented here is based on the belief that the relationship between academic research on one end and clinical practice on the other end can be an interactive one, allowing for knowledge to be generated by and referred to from both ends. This transcends the traditional concept that defines the clinician as the recipient of knowledge generated in university departments; initially, during study or clinical training and, later, in pursuit of ongoing professional development. If an interactive approach was taken, the knowledge base of clinicians in private practices could be considered as an often untapped source of expertise that holds both questions and attempted solutions of great practical relevance and clinical value. Such practical knowledge can form the very raw material for further academic research which, once refined and published, provides feedback to clinicians working with similar questions and concerns.

Few clinicians in private practices find their way back into academia to undertake a major empirical study, due to the substantial commitment required in terms of time and funds, and the challenges in navigating various institutional barriers. It is encouraging, accordingly, that this
research project may serve as an example how the interface of clinical practice and academic research could become more permeable from both sides. Key to this aim is a research topic that is inextricably linked to daily clinical schedules and the wealth of empirical data constantly generated as part of ongoing assessment routines.

The University of Auckland, and specifically the Department of Psychological Medicine, created an opportunity that not only allowed me to comprehensively explore topics of clinical significance and publish the findings, but to do so within a supportive and inspiring context, the framework of a PhD study. This allowed the project to expand beyond the initial scope, to now encompass a substantial body of evidence suggesting key changes to the established approach for assessment and diagnosis, with implication for neuropsychological research and clinical evaluation. In turn, Eden Practice, a community-based rehabilitation centre and host of the empirical stages of the research project, invested institutional resources, including the efforts of staff and volunteers, to advance the standard of neuropsychological assessments as an expression of their commitment to evidence-based practice and quality of care.

For this reason the value of this project might be appraised, not only with regards to the merits of its research, but for its unique placement between academia and clinical practice, and for the synergy it created.
1.2. Outline of the Research Project

A wide range of physical and mental conditions are known to impact on brain function, including head injuries, degenerative conditions, cerebral vascular diseases, tumours, infectious diseases, toxic substances, hypoxia, mental health problems, and other. Basic vital functions, such as breathing and heart beat, motor control and balance may be affected; sensual perception, such as hearing, vision, or smell and taste may become impaired; higher brain functions, such as concentration, learning, memory, language, and comprehension may be compromised.

While basic physical or sensory impairment is relatively easy to determine by observation and clinical evaluation, for example, the client cannot walk, or smell, or hear, the assessment of higher brain functions requires more elaborate procedures, such as formalised testing. The present study undertakes a review of the established approach to testing such higher brain functions, or “cognitive functions.”

The introductory chapters explain how testing of cognitive functions developed from appraising brain damage in soldiers 100 years ago to the complex norm-based evaluation procedures of the modern neuropsychological assessment. Strengths and weaknesses of the current approach to neurocognitive testing are explored, and a critical appraisal is provided with regards to the question: How well are performances under standard neuropsychological testing conditions predicting clients’ performances under real-life conditions?

This is followed by theoretical considerations on how the standard approach to testing could be enhanced to provide a greater level of validity of test results. Two patient groups, clients with head injury and clients with depression, were more closely considered with regards to their cognitive profiles obtained on the traditional test approach, and a specific extension of the assessment is proposed. It is suggested that an innovative, additional test component could provide key diagnostic information on an important section of cognitive functioning, and enhance transferability of test results into real life conditions. The introduction completes its preliminary considerations by proposing that an empirical study must be conducted on a large, representative clinical sample to assess the benefits of the additional test procedure for differential diagnosis and ecological validity.

The methodological chapter of this study, chapter three, describes in greater detail the additional test procedure and explains the research design, selection of study groups, and statistical procedures.

In the planning process of this study, a major methodological hurdle became apparent. As the study proposes that participants are tested both in standard conditions and in the specific experimental condition, the problem of “test-learning” or “practice effects” arises. It was impossible to proceed with the main study unless highly compatible alternative test-stimuli were developed and
empirically validated for the same clinical target population selected for the main study. This process required a comprehensive review of literature addressing the problem of re-testing, the development of alternative stimuli, as well as the planning and execution of a separate empirical study to compare standard and alternative test stimuli.

Equivalence of the alternative stimuli was established, based on score analysis of a large clinical sample. Overcoming the problem of re-testing was not only a milestone for the present research, but constituted a point of general interest for neuropsychological science and clinical practice, where clients are frequently re-tested for evaluating treatment effects and recovery. The results of this empirical study were therefore published in the major peer-reviewed journal, The Clinical Neuropsychologist. This publication is presented in the first “insertion chapter”.

Returning to the main study, chapter four presents comprehensive evidence that the additional test condition is able to expose problems with cognitive functioning that are not identified in the traditional assessment setting. It is also shown that the additional test condition is able to differentiate between client groups that perform very similarly in the traditional test setting. These findings are of relevance for differential diagnosis, for developing treatment pathways, and for medico-legal disputes. It was therefore decided that the findings be published in a high-impact journal to ensure maximum exposure and distribution. Again, The Clinical Neuropsychologist was selected. Following peer review, the study was accepted for publication in May 2012. The second “insertion chapter” presents this publication at the end of chapter four.

Chapter five summarises the findings and discusses strengths and limitations of this study. Selected practical cases from clinical practice are discussed in the light of the research findings. An outlook for future research interest is provided.

The appendices contain the test stimuli developed for both studies.
2. Introduction

2.1. The Neuropsychological Assessment

More than a century ago, the German psychiatrist Konrad Rieger, clinician at the Juliusspital of Würzburg, published a study on the impact of brain-trauma on intelligence and presented replicable test procedures for the assessment of intelligence function (1888). He was amongst the first in a rapidly growing number of researchers and clinicians to not only develop empirical tools for measuring cognitive performance in different domains, but to include clients’ test performances into the examination of mental status. Rieger’s battery of 40 tests was designed to measure a range of cognitive and perceptual capacities, as well as speech and motor skills. These prototypes and points of reference encouraged the development of further tests and mental status examinations by researchers and clinicians after him, including Heilbronnner (1905), Binet & Simon (1907), Rossolimo (1911), Poppelreuter (1917), Franz (1919), Terman (1916), Gelb & Goldstein (1920), Lipmann (1922), Wells (1927) and Wechsler (1939). The number of tests investigating different areas of cognitive functioning has since exploded; the compendia by Lezak, Howieson, & Loring (2004) and Spreen & Strauss (1998) each describe several hundreds of established tests or test-batteries with defined distribution parameters for specified reference populations and for the assessment of multiple disorders and conditions. Tens of thousands of studies have since been undertaken focusing on different clinical groups, ethnicities, social populations, genders, ages, diagnoses, and areas of functioning. Amongst the most popular clinical populations for neuropsychological assessment are clients with traumatic brain injury (TBI) (Babikian & Asarnow, 2009; Belanger & Vanderploeg, 2005; Frencham, Fox, & Maybery, 2005; Schretlen & Shapiro, 2003), depression (Burt, Zembar, & Niederehe, 1995; Castaneda, Tuulio-Henriksson, Marttunen, Suvisaari, & Lonnqvist, 2008; Christensen, Griffiths, MacKinnon, & Jacomb, 1997; Huang, Wang, Li, Xie, & Liu, 2011; Kurtz & Gerraty, 2009; McDermott & Ebmeier, 2009), dementia (Backman, Jones, Berger, Laukka, & Small, 2005; Brayne, 2006; Huang, et al., 2011; Mathias & Burke, 2009; Mitchell & Shiri-Feshki, 2009; Nie et al., 2011), cerebral vascular accidents (CVA) (Gillespie, Bowen, & Foster, 2006), epilepsy (Tellez-Zenteno, Dhar, Hernandez-Ronquillo, & Wiebe, 2007), and multiple sclerosis (Thornton & Raz, 1997; Wishart & Sharpe, 1997).

As it was the case in many areas of technology and science, the development of neurocognitive assessments was advanced by WWI and WWII, which both produced overwhelming numbers of injured soldiers and civilians requiring brain injury assessment and care. Psychology acquired a reputation of providing solid objective assessments based on normative tests rather than
on clinical impression (“clinical eye”). Soon after WWII, Halstead (1947) and Reitan (1955) developed the Halstead-Reitan test battery, which has been described as the first modern neuropsychological assessment procedure, and is, in an adapted version, currently still in use (A. L. Benton, 1994).

Neuropsychological assessments today involve complex normative testing procedures of selected brain functions which quantify the changes in cognitive capacity that may result from a multitude of medical conditions, some of which involved cerebral impact or other, non-medical causes. Traditionally concerned with localising brain lesions, neuropsychological assessments today focus on clients’ levels of functioning in different cognitive domains. Such information is required for clinical reasons (e.g. differential diagnosis, rehabilitation planning, and assessing support needs), for research (e.g. evaluation of treatment approaches and other specific hypothesis testing), and for medico-legal reasons (e.g. for establishing ability to stand trial in a court of law, for compensation claims, and insurance entitlements).

Depending on national regulations and accreditation procedures, neuropsychological assessments are conducted or at least overseen by trained specialists, often clinical psychologists or neuropsychologists. In the USA, less skilled technicians are regularly relied on for administering tests, while the psychologist interprets the data and writes the reports. Such cost- and time-saving delegations, however, can result in important qualitative information to be lost, for example with regard to such questions as “How does a client approach a test?”, “Are there specific stress or fatigue symptoms arising?”, “Does the client’s presentation and performance match with reported data about symptoms and incapacities?”. There are also concerns about the minimal levels of training and competency required for technicians, pchometrists, and psychologist assistants and their subsequent ability to deal competently with mental health issues, cultural requirements, and other aspects of the interpersonal relationship during an assessment (Bornstein, 1991; National Academy of Neuropsychology, 2000b).

Serial neuropsychological examinations are employed to monitor changes of cognitive performance, either in response to specific treatment or spontaneous recovery, or for documenting decline in progressive conditions. When repeated testing is undertaken “practice effects” or “test-learning effects” need to be considered and controlled (R. McCaffrey, Duff, & Westervelt, 2000; R. J. McCaffrey, Ortega, & Haase, 1993) to avoid clients’ increasing familiarity with the test stimuli and procedures compromising the validity of the data obtained (Goldberg, Keefe, Goldman, Robinson, & Harvey, 2010). Not all tests are equally vulnerable to incurring practice effects (2000). In cases where periodic re-testing of a client can be anticipated from the outset, test selection should consider their usefulness for repeated presentation. The shorter the period between testing, the greater the risks for encountering practice effects (Salthouse, Schroeder, & Ferrer, 2004). Clients with profound
memory impairment are less likely to incur practice effects on re-assessment than clients with minimal impairment (Lezak, et al., 2004). Strategies for controlling practice effects include the use of validated alternative stimuli (Schnabel, 2012), learning-resistant tests (2000), or employing statistical procedures such as the Reliable Change Index (Jacobson & Truax, 1991) or the Reliability-Stability Index (Chelune, Naugle, Luders, Sedlak, & Awad, 1993).

The standardised test setting itself is clearly defined by the respective authors to ensure that the scores obtained by testing an individual client can be compared with the reference norms for this test. Guidelines consistently include standards regarding the physical environment, the client/assessor interaction, and the specific procedure to be followed when administering a test. These often include detailed instructions for the clinician on how to introduce a test, how long test stimuli can be viewed by the client, how long a client is allowed to work on a specific task, when to discontinue a test, and how to score a test. Clients’ responses or performances are usually noted during the test procedure on specific scoring sheets to enhance objectivity (Lezak, et al., 2004).

Test instructions for the physical environment demand a controlled, distraction-free environment (Lezak, et al., 2004; Spreen & Strauss, 1998). For example, Wechsler (2008) states the following:

To provide an ideal environment, administer the test in a well-lit, quiet room that is free from distraction and interruptions (e.g. an office or clinical treatment room). External distractions must be minimised to focus the examinee’s attention on the task presented and not on outside sounds or sights, physical discomfort, or testing materials not in use. If possible position the examinee to face away from any window. (Wechsler, 2008, p. 24)

Expectations for the client/assessor interaction include that rapport is established and maintained; a non-threatening, confident, relaxed manner by the clinician is expected (Wechsler, 2008). The client’s cultural background has to be considered by the clinician in planning the assessment, in communication with the client, and in interpreting assessment data (Lezak, et al., 2004). Since many neuropsychological assessments are conducted following critical life-events, such as injury or illness with impact on clients’ abilities to function normally in previous life-roles, anxieties over assessment findings and prognosis are common (Lezak, et al., 2004). In addition, testing itself can cause anxiety (test or performance anxiety), even in non-clinical populations such as students (Friedman & Bendas-Jacob, 1997; Lowe & Ang, 2012; Zeidner, 1998). Accordingly, the assessor is required to exert a calming influence, to provide encouragement, and to “demonstrate enthusiasm and interest by praising the examinee’s effort” (Wechsler, 2008, p. 26). Spreen and
Strauss (1998) highlighted that clients’ concerns can be eased by providing clear information about the test procedure, the length of assessment, and the rationale for the evaluation. This has become formalised in many countries as part of the procedure of obtaining informed consent prior to embarking on the assessment (Johnson-Greene, 2005; National Academy of Neuropsychology, 2003).

Neuropsychological assessments are generally conducted in a one-on-one setting to avoid decreased validity of test results because of social facilitation or inhibition (Howe & McCaffrey, 2010; National Academy of Neuropsychology, 2000a), unless there are clinical, cultural, or legal requirements/privileges for a third party to attend. This includes interpreters, medical nurses, chaperones, support persons, or attorneys.

Drawing on diverse test materials ranging from paper-pen-tasks, visual stimuli, puzzles, verbal tasks, and a multitude of computer-based tests, the assessor selects tests suitable to the needs of the client and the specific purpose of the assessment. Options include fixed test batteries and single tests. Well-established test batteries include the Wechsler Memory Scale (WMS), currently in its 4th edition (Wechsler, 2009), the Wechsler Adult Intelligence Scale (WAIS), also currently in 4th edition (Wechsler, 2008), and the Delis–Kaplan Executive Function System (DKEF) (Delis, Kaplan, & Kramer, 2001). Each of these comprehensive batteries explores an entire domain of cognitive functioning, e.g. memory, intelligence, or executive functions, but they are very time consuming. A whole assessment battery would require several hours to complete, which is taxing on clients’ fatigue levels and inefficient with regards to the use of clinical time, as such detailed investigation of a cognitive area may not be required. Instead, an eclectic approach to test selection has become increasingly common, which allows for a flexible choice of test tools to target the specific clinical functions affected and to screen functions peripheral to the investigation.

Sweet, Moberg, & Westergaard (1996) surveyed practicing neuropsychologists in 1984 and 1994 and documented that only 18% of clinicians took a fixed battery approach in 1984, which further decreased to 14% in 1994. All other clinicians took a flexible approach to test selection, tailored to the individual client and the clinical question(s) necessitated by the assessment. Neuropsychological assessments investigate a range of cognitive functions (domains) that are explored by normative testing, which covers attention/concentration (receptive functions), memory (information storage and retrieval), intelligence/comprehension (mental organisation of information), and expressive function (execution) (Lezak, et al., 2004). Each of these domains comprises a number of sub-functions that can be explored separately. In the domain of memory, encoding, storage, and retrieval of information can be investigated (Kolb & Whishaw, 1995) and assessment approaches that categorise memory function according to the type of data involved are
common. Auditory and visual memory can be explored (Benedict, Schretlen, Groninger, Dobraski, & Shpritz, 1996; S. Benton, 1992; Meyers & Meyers, 1995; Wechsler, 2009); learning of coherent, logical information and learning of abstract data can be tested (Delis, Kaplan, Kramer, & Ober, 2000; Schmidt, 1996; Wechsler, 2009); and immediate and delayed recall can be investigated (Delis, et al., 2000; Wechsler, 2009). Intelligence functions can be divided into verbal comprehension, perceptual reasoning, working memory and processing speed (Wechsler, 2008), although other grouping of sub-functions is possible (Guilford, 1988; Horn & Cattell, 1966; L. Terman & Merrill, 1960). Executive or frontal lobe functions are often categorised into volition, planning, purposive action, and effective performance (Lezak, et al., 2004). Other categorisations include updating, inhibition, and shifting (Miyaki et al., 2000). Executive functions can also be structured into components of working memory, management of emotional responses, self-directed speech, and problem-solving (Barkley, 1997). Established tests of executive functions include the STROOP Colour and Word Test (Golden & Freshwater, 1978), the Wisconsin Cart Sorting Test (Heaton, Chelune, Talley, Kay, & Curtis, 1993) and the Delis–Kaplan Executive Function System (Delis, et al., 2001).

In neuropsychological assessments, the performance of an individual client is always interpreted in context, either by comparing test achievement against a norm derived from an appropriate reference population (normative comparison), or by comparing a test achievement against previous capacities of this individual client (intra-individual comparison). Standards for normative comparison are compiled by analysing performances of a sufficiently large reference group, defined by parameters such as age, gender, education, and ethnicity. Performances of these reference groups have distribution norms, including mean and standard deviation, which can be used as benchmark criteria for judging an individual client’s performance as “above-average,” “average,” or “below-average.”

In an intra-individual comparison a client’s performance is compared to his or her previous abilities. In an ideal case, scores from a previous neuropsychological assessment are available. In the absence of such data, pre-morbid levels of cognitive functioning have to be estimated. Such an estimate can be based on biographical information, such as academic and vocational history. A client with brain injury, for example, who prior to his accident had obtained a degree in medicine and worked as a consultant in a busy ward, would be considered to have commanded “above-average” levels of cognitive functioning in many areas, as it is assumed that he or she would otherwise not have been able to complete tertiary education and hold a professional work role. Vice versa, estimates of pre-morbid intellectual functioning for an unskilled labourer with a basic school education would fall in the “average” or “lower average” range, unless confounding factors can be identified that account for the moderate school and work achievements of this client, such as
specific psycho-social factors. If both example clients obtain low-average scores on cognitive testing, this may represent a significant cognitive decline for the consultant and a largely unchanged performance for the labourer, compared to their estimated pre-injury status.

Another way of estimating pre-morbid levels of cognitive functioning is the use of decline-resistant holding tests. The cognitive sub-function “vocabulary,” and even more so the “ability to pronounce written words,” were found to be relatively well-preserved in clients with brain trauma and dementing conditions, while other cognitive functions were subject to relatively quick deterioration (Krull, Scott, & Sherer, 1995). Subsequently, word-reading tests were developed, such as the National Adult Reading Test (NART)(Nelson & Willison, 1991), which were found to be a relatively reliable measure of pre-morbid functioning (Crawford, Deary, Starr, & Whalley, 2001).

A further method of estimating pre-morbid capacities for intra-individual comparison is based on the analysis of a client’s overall score profile. Here, the assumption is made that most normally developed, healthy people have a general level of ability on which they operate. For example, if a client achieves “above average” scores in concentration functions, the expectation would be that his or her memory functions are equally on “above-average” levels. If a neuropsychological assessment shows marked discrepancies in a client’s performance on different cognitive functions, e.g. excellent concentration and impaired memory functions, then disturbing factors are suspected to interfere with performance, such as brain pathology or other causes. In a client with cerebral disease the relative best performance in a range of cognitive domains may represent the best preserved cognitive function and, therefore, be indicative of the original cognitive potential (Axelrod, Vanderploeg, & Schinka, 1999).

Each test completed by a client will produce a raw score, which in most cases comprises the number of correct items obtained. In some cases, the raw score is the number of seconds required for completing the task. Such raw scores only document the individual client’s performance on a particular test. These data is of limited value for the clinician, however, as it does not contain information on how this performance compares to a reference population. Distribution parameters are required, which inform the assessor about how many raw scores would represent a “good performance,” an “average performance,” or a “poor performance.” Typically, tests are constructed in such a way that test performances of a normative sample follow a Gaussian function (“symmetric bell curve distribution”) of the form:
The parameters are: $a$: height of the curve's peak, $b$: the position of the centre of the peak, $c$: width of the bell, and $e \approx 2.72$. A typical bell curve distribution, or normal distribution, is presented in Figure 1.

![Figure 1: Standard Distribution](image)

The majority of clients (68%) are placed within one standard deviation of the mean, representing an “average” achievement. Few clients (16%) achieve higher, few clients (16%) achieve lower scores, representing “above average” or “below average” performances, respectively. Raw scores are transformed into standard scores ($z$ scores) or other scaled scores, such as t-scores, percentiles, or IQ-scores, by referring to test-specific conversion tables. These are based on the distribution of raw scores in the normative sample, and are provided by the respective test authors.

Most neuropsychological testing is based on the theoretic framework of Classical Test Theory or True Score Theory, an influential approach to measurement in the social sciences, which can be traced back to Spearman (1904). Focus point of this theory is the accuracy of a measurement taken. Classical Test Theory explains how conclusions about a client’s abilities can be made based on this client’s performance on a specific test (Crocker & Algina, 1986). The basic axioms of this theory can be summarised as follows:
1. Each observed test score \( (X) \) is composed of the true score \( (T) \), representing the client’s actual capacity, and a random error \( (E) \), representing unpredictable variance of performance \( (E) \): 
\[
X = T + E
\]
2. Random errors are expected to cancel each other out over many repeated measurements; the expected mean of measurement errors should be zero.
3. As measurement errors are random, they are not correlated with the true score:
\[
\rho(T,E) = 0
\]
4. When the error term is zero, the observed score is considered the true score:
\[
X = T + 0
X = T
\]
5. Classical Test Theory is concerned with the reliability of a test, defined as the level of accurateness (absence of measurement errors), in other words, to what degree the observed score represents the true score. The smaller the error, the more reliably a test measures the actual capacity. A test is reliable, if the observed score is consistent over repeated measures. Reliability of a test can be estimated by correlating new scores with those obtained in an established measure, by correlating test/re-test results, or by splitting the test in half and correlating the results from both halves with each other. Estimated reliability = 
\[
\rho(X_{1\text{test}1},X_{2\text{test}2})
\]
A limitation of the Classical Test Theory, on a practical level, is the dependency on the specific sample(s) for the calculation of reliability. Another practical concern for test construction is that the characteristics of the items, such as difficulty or differentiation power, are not addressed specifically (Zimmerman, 2011). On a conceptual level, measuring changes of a variable over time (e.g. following treatment or recovery) imposes a problem in the Classical Test Theory, as tests are constructed on the basis that the underlying capacity remains stable (e.g. re-test reliability).

Despite these shortcomings, Classical Test Theory has remained the prominent theoretical framework for test construction and validation in the social sciences, and its key parameters, such as Cronbach’s alpha, are included in common standard statistical software packages, such as PASW/SPSS (IBM Corporation, 2011). Meanwhile, more sophisticated psychometric models within measurement theory have been developed, including the Item Response Theory and the Generalizability Theory, but these approaches have not gained popularity in research designs or
publications (Unick & Stone, 2010). As the present research project does not draw on either Item Response Theory or Generalizability Theory, these models of test theory are not further discussed.

Summary

In the past 100 years Neuropsychology has developed as an empirical science that focuses on cognitive functioning. Based on normative testing, key cognitive functions are investigated, including concentration, memory, intelligence, and executive functioning. Clients’ performances are compared with applicable reference norms, allowing for individual test achievements to be interpreted as “above,” “within,” or “below” average range in relation to the achievements of peer samples. Standardised testing conditions and procedures are observed in a neuropsychological assessment to ensure that test results are objective and reliable, and can be compared with norms. Neuropsychological assessments are often used for diagnosis, treatment planning, and for medico-legal purposes. A large body of neuropsychological research exists with regards to the impact of different medical and non-medical conditions on cognitive functioning.
2.2. Ecological Validity in Neuropsychological Assessments

A concern faced by neuropsychologists revolves around the following questions: “How do test results obtained in the laboratory-type environment of an assessment room relate to real-life situations?”, “Would an unimpaired performance on a concentration or memory test, obtained in a quiet, distraction-free assessment room, be a valid predictor for unimpaired capacity of a client returning to a busy family or a workplace with multiple stimulation and complex attention demands?” These questions address ecological validity, concerning the transferability of laboratory test results into other, potentially much more challenging environments (Sbordone, 1996).

The neuropsychological approach to assessment involves tests with diligently defined parameters, including distribution, standard error, re-test or split-half reliability, and internal validity. Comparative norms are available, based on analysing the test-achievements of reference-subjects (norm-control samples), classified by age, gender, education, and diagnosis, which also underwent the test in clinically controlled conditions. Any given test result of a client can be read against these norms: an individual test performance can be rated as “above-average,” “average,” or “below-average” compared to the performance index of the normative sample-group on this test under same conditions. The problem here is one of interpretation: do “average” test results obtained in a highly controlled standard test-setting translate into “appropriate capacity” in everyday life? Do test scores in the “impairment range” equal “substantial incapacity” in everyday-life roles, e.g. driving a car, caring for a child, or managing a particular vocational role?

Test theory defines “ecological validity” as the degree to which the behaviours observed and recorded in a controlled experiment or environment reflects the behaviours that actually occur in natural settings. Accordingly, ecological validity in neuropsychology is understood as the relationship between a client’s performance on neuropsychological testing and this client’s behaviour in a variety of real-world settings (Sbordone, 1996). Most neuropsychological tests attempt to measure key abilities of cognitive functioning, such as memory, processing speed, or comprehension, by providing specific (test) tasks which require the respective cognitive abilities in order to be completed. An impaired performance on such a sample task would be interpreted as indication for compromised cognitive capacity (Lezak, et al., 2004). By inferential conclusion, the client would be expected to encounter problems in everyday-life situations when approaching activities that involve this particular cognitive capacity.

Most neuropsychological tests involve test material (test stimuli and test procedures) that does not resemble tasks and challenges encountered in everyday life. The popular Trial Making Test (TMT), for example, is a paper-pencil-task that requires a client to connect circled numbers that are...
distributed randomly on a sheet of paper. In a second trial, the client is asked to connect, in
alternating sequence, circled numbers and circled letters. In both instances, the client is timed. The
completion time represents the test score. Norms are available for comparing the individual test
score with the applicable age, gender and education group (Tombaugh, 2004). Performance
problems on the TMT have been associated with a number of neurological conditions including
dementia, brain trauma, alcohol/substance abuse, hypoxia, and other brain damage (Spreen &
Strauss, 1998). It has been argued that the completion of the TMT involves a number of cognitive
functions, including processing speed, concentration, alternating attention, and executive
functioning (Lezak, et al., 2004; Spreen & Strauss, 1998). Impaired TMT scores are thus understood
as indicators for a range of incapacities expected to present in real-life situations that involve
planning, cognitive flexibility, and complex concentration. This includes activities such cooking, car
driving, or the tasks of managerial work. It is already a considerable inferential leap to stipulate from
a client’s inability to quickly complete the TMT worksheet his or her incapacity to undertake complex
everyday-life tasks. Such a leap is even bigger if the conclusion was to be drawn that a client with an
encouraging performance on TMT is “fit and proper” for returning to an executive role in an open
plan office, since the TMT presents a much lesser hurdle in terms of cognitive demands than the
executive work role.

The term “veridicality” (truthfulness) has come to be used for describing the degree to which
the performance on neuropsychological test predicts real-life performance (Franzen & Wilhelm,
1996). As most neuropsychological examinations do not measure real-life performance but use
laboratory-based tests for predicting real-life function instead, varying degrees of veridicality can be
attributed to each test or test-battery. A review of the predictive power of neuropsychological tests
for real-life situations, or, in other words, a review of the veridicality of neuropsychological tests, will
be addressed later in this chapter.

Given the concerns that abstract, clerical tests may poorly relate to the type of challenges
typical for real-life situations, efforts have been made towards developing test material with greater
intuitive resemblance to tasks of daily life. Such tests either directly include a specific observable
everyday-life activity, or they present a model-task with formal or conceptual characteristics that
relate closely to a key task in everyday life. The assumption here is that ecological validity would
increase based on the close relationship between the test-task and the real-world activity (Spooner
& Pachana, 2006). The degree to which a test resembles or approximates a real-life situation has
been described as the verisimilitude (“truthlikeness”) of a test (Franzen, 2000). The following tests
are examples for improved verisimilitude of test tasks and stimuli.
Based on an actual training movie for a fast-food chain, the Hamburger Turning Test requires clients to move faux hamburgers, using a spatula and a salt shaker, according to specific rules, and maintain attention. This allows direct observation of clients’ planning, executing, monitoring, and processing of a practical task, relevant to everyday-life functions (Shugars, 2007).

The Test of Everyday Attention (Bate, Mathias, & Crawford, 2001; Robertson, 1996) includes a number of “ecologically plausible” tasks, including searching maps, looking through telephone directories, and listening to lottery number broadcasts. Again, clients’ executive functioning is observed when engaging in mock-practical tasks that bear resemblance with a number of real-life activities.

The Zoo Map Test (Wilson, Alderman, Burgess, Emslie, & Evans, 2003) requires clients to plan a route on the map of a zoo visiting different animals in a strategic order. Clients are scored according to their ability to quickly and successfully plan their journey.

Even such practical tests, however, fall short of representing more than a small section of real-life demands. Each daily activity requires a specific profile of cognitive abilities. Moreover, daily activities are often characterised by multiple and simultaneous cognitive demands. Turning hamburgers is a different cognitive challenge to running a business or to shopping in a busy supermarket; planning a route on a Zoo-map is different from visiting this zoo in the company of two underage children. Only a few selected activities are captured by these practical tests, providing an incomplete appraisal of the client’s capabilities in managing tasks or responsibilities unrelated to the specific test task.

It was also noted that even tests with high verisimilitude in terms of their stimuli are conducted in an artificial testing environment with minimised distractions, one-on-one explanations and ongoing prompting support for task initiation and completion, emotional support and encouragement from the examiner, irrespective of task performance, and with relative short tasks that are completed one-by-one (Chaytor & Schmitter-Edgecombe, 2003; Long & Collins, 1997; Long & Kibby, 1995).

Neuropsychological assessments bear substantial weight in clinical settings and in a medico/legal context, and far reaching conclusions are drawn from a client’s cognitive capacity demonstrated on formal neurocognitive testing, including advice on work capacity, safety in personal, family, and occupational roles, decisions regarding injury/disability compensation, and recommendations for rehabilitation. Given the significance of neuropsychological assessments for such decisions, research efforts have been made to establish the predictive value of the classical neuropsychological assessments (or specific sub-tests) with regards to clients’ actual capacity in a number of real-life roles.
The overall findings suggest that a “moderate” relationship exists between performance on neurocognitive testing and everyday functioning, depending on the specific neuropsychological tests utilised, specific real-life capacity investigated, the type of injury/incapacity sustained, and the brain function analysed (Chaytor & Schmitter-Edgecombe, 2003). Classical criteria for appraising the ecological validity of a test include clients’ ability to return to work and their capacity in managing activities of daily living (Sbordone, 1996). Wen, Boone, & Kim (2006) documented an overall “weak” relationship between neuropsychological performance of medical and psychiatric patients and work capacity. Guilmette & Kastner (1996) concluded that underperformance during neurocognitive assessment has remained a modest predictor of vocational functioning in clinical groups, and is perhaps better at predicting failure than success. The findings by Kibby, Schmitter-Edgecombe, & Long (1998) suggest that performance on a verbal learning test (California Verbal Learning Test [CVLT]) is moderately predictive of work capacity; performances on CVLT and a test for executive functioning (Wisconsin Card Sorting Test [WCST]) were also predictive of the type of position held by a participant. According to the meta-analyses of different client groups undertaken by Kalechstein, Newton, and van Gorp (2003), the relative-strongest predictors for employed status were intellectual functioning, executive functioning, and verbal short-term memory. However, the predictive quality of clients’ performances in specific areas of cognition and vocational capacity was found to depend on the specific patient group. Brooks, McKinlay, Symington, Beattie, & Campsie (1987) identified performances during memory- and attention-tests predicting employment status in clients with severe traumatic brain injury. For clients with schizophrenia, executive functioning, working memory, and processing speed was correlated with vocational integration (McGurk & Mueser, 2006). Henninger (2006) investigated clients with infection of the Human immunodeficiency virus (HIV) and compared their levels of neurocognitive function with their respective employment status, documenting moderate correlations between global neuropsychological capacity and vocational functioning. Van Gorp found that verbal learning predicted return to work in an HIV-cohort (Van Gorp et al., 2007).

A variety of other factors, unrelated to the results on neurocognitive testing were found to impact substantially on clients’ return to work, such as demographic factors (including age, marital status, pre-morbid education, and ethnicity), psycho-social factors (including compensation status, litigation, mental health, job satisfaction), and work place factors (including type of work and work setting (Scollon, 2000). It was suggested, accordingly, that neuropsychological assessments that attempt to predict work capacity should include an appraisal of psycho-social factors (Guilmette & Kastner, 1996).
Activities of daily living (ADLs), including shopping, managing money, cooking, taking medication, and car driving, are a second domain in which neuropsychological assessments are utilised for predicting capacity/impairment. As expected, the relationship between neurocognitive test performance and actual functional capacity depended on a number of variables, including the specific functional task and the client’s diagnosis.

Heaton et al. (2004) found for HIV-sufferers that impairment in attention/concentration, memory, and executive functions correlated with problems managing ADLs independently. Successful management of money was associated with intact working memory in clients with Alzheimer’s disease (Earnst, 2001). Impairment of executive functioning was related to decline in functional capacity in vascular dementia (Boyle, Paul, Moser, & Cohen, 2004).

Farmer and Eakman (1995) examined clients in a post-acute brain injury rehabilitation program and found that well-preserved intelligence, visual memory, delayed memory, verbal learning, and cognitive flexibility were associated with successfully managing ADLs.

Although the ability to drive a car is part of ADLs, it is often investigated and reported as a separate issue, given the complexity of the task and the specific considerations about other people’s safety. Mixed findings were presented in studies that investigated the value of neuropsychological assessments for predicting driving competence. Bieliauskas, Roper, Trobe, Green, & Lacy (1998) and Fox, Bowden, Bashford, & Smith (1997) documented that neuropsychological assessments are poor predictors for the ability of Alzheimer clients to drive. In contrast, Fitten et al., (1995) and Hunt, Morris, Edwards, & Wilson (1993) documented a relatively encouraging relationship between the findings of neurocognitive evaluation and driving abilities for the same patient group.

Partially responsible for this variance are different criteria for capacity/incapacity for driving, different assessment methods (“on the road”-observation, driving simulator, or review of formal driving offences), the use of different neuropsychological tests, and different levels of impairment in patients (Marcotte & Scott, 2009). As with other domains of real-life functioning, neurocognitive factors represent only one aspect of clients’ capacities. Other factors include, but are not limited to, emotions, experience, and road/traffic-conditions.

A further area in which neuropsychological assessments are used to predict clients’ abilities in real-life roles include capacity to stand trial (Denney, 2008a; Franzen, 2003; Marcopoulos, Morgan, & Denney, 2008). As expected, a particular focus of the neuropsychological assessment in the forensic setting is on malingering (Denney, 2008b). While countless strategies and tests are available for documenting response bias, incomplete effort, or malingering (R. L. Heilbronner, Sweet, Morgan, Larrabee, & Millis, 2010; Tombaugh, 2003), it is difficult to establish the ecological validity of neuropsychological tests for genuine (non-malingering) clients. This is due to the lack of a clear...
external validation criterion: How is a neuropsychological assessment found to be either correct or incorrect in its appraisal of a client’s competence to stand trial? The court bases such competency decisions substantially on the findings of the neuropsychological assessments provided for this purpose. The court does not hold an independent criterion for questioning the ecological validity of a neuropsychological assessment other than requesting a second neuropsychological opinion, which, of course, faces similar limitations.

The assessment of decision-making capacity in older people has emerged as an area of increased interest (Moye & Marson, 2007). Key areas include decision-making for independent living, financial management, treatment consent, testamentary capacity, sexual consent, voting, and driving. In their judgments about capacity, courts have traditionally relied on the assessments made by clinicians working with the elderly client, often involving social workers, community nurses, general practitioners (medical officers), and psychiatrists (American Bar Association Commission on Law and Aging and American Psychological Association, 2005). As the clinical appraisal has been criticised for its low reliability and objectivity, neurocognitive testing has increasingly been sought to guide professional clinical judgment (Markson, Kern, Annas, & Glantz, 1994; Marson, McInturff, Hawkins, Bartolucci, & Harrell, 1997; Rutman & Silberfeld, 1992). Efforts have been made to develop standardised instruments to objectively measure clients’ abilities in these critical domains. Grasso & Appelbaum (1998) developed an assessment-tool for consent to treatment; Marson (2000) presented a prototype instrument for assessing capacity for financial decision-making. An overview of currently used assessment tools for establishing competence was given by Sturman (2005). As with the assessment of competence to stand trial, the capacity-assessments for making medical, financial, or other decisions face the problem that there is no generally accepted criterion by which a cognitive test could be validated (Moye, 2000; Moye & Marson, 2007), leaving considerable uncertainty regarding the ecological validity of these cognitive tools and approaches.

More open to critical evaluation of ecological validity is the field of academic achievement, in which neuropsychological assessments are frequently used for predicting ability and academic success. Consensus appears to be that performance on intelligence tests is a moderate predictor for academic achievements. Correlations around 0.5 and 0.6 have been reported between intelligence quotient and academic performance (Deary, Strand, Smith, & Fernandes, 2006; Sternberg, Grigorenko, & Bundy, 2001). The importance of other factors impacting on academic success has been highlighted, including home environment, school- and peer-factors, and psychological variables of the student/pupil (Portes, 1999).

The neuropsychological assessment in clinical practice and research can draw on a large number of normative tests, available for different age groups (e.g. child, adult, and geriatric clients),
different types and degrees of incapacity (for different degrees of either physically handicap or cognitive impairment), different diagnoses (medical or non-medical conditions with potential impact on cognitive function), different cognitive domains (e.g. memory, intelligence, executive functions), different investigative purposes (e.g. forensic examination, rehabilitation planning, treatment evaluation), different time limits (e.g. screening procedures, extensive evaluation), and other considerations (Lezak, et al., 2004; Spreen & Strauss, 1998).

Most neuropsychologists take a flexible, eclectic approach to test selection (Sweet, et al., 1996), taking into account the client characteristics and assessment parameters described above. Not surprisingly, considerations of verisimilitude and veridicality do not play a significant role in test selection (Rabin, Barr, & Burton, 2005), as neither of these approaches succeeded in establishing convincing ecological validity.

Summary

*Predicting everyday-life functioning based on standard neuropsychological measures has been shown to be an uncertain endeavour. Ecological validity, even of comprehensive neuropsychological batteries, is moderate at best. The complexity of stimuli involved in everyday-life tasks and environments was pointed out, contrasted with the relative basic test material and the restricted scope of testing undertaken in standard neuropsychological assessments.*
2.3. Short-coming of the Neuropsychological Assessment Setting

The ability of the standard neuropsychological assessment to predict everyday-life functioning has been questioned by highlighting the complexity of real-life tasks and environments in contrast to the rather basic test material and the limited scope of testing undertaken in standard neuropsychological assessments (Goldstein, 1996; Silverberg & Millis, 2009; Van der Elst, Van Boxtel, Van Breukelen, & Jolles, 2008). The relationship between neuropsychological test results and real-life capacity was described as “moderate” at best for different ethnic groups (Gioia, 2009), commonly used standard tests (Kibby, et al., 1998), specific cognitive domains (Odhuba, van den Broek, & Johns, 2005), different diagnoses (Chaytor & Schmitter-Edgecombe, 2003; Silverberg, Hanks, & McKay, 2007; Wood & Liossi, 2006), and different everyday functions (Marcotte, Scott, Kamat, & Heaton, 2010).

While efforts have been made to make neuropsychological tests more similar to everyday-life tasks by modifying the test stimuli and introducing procedures that bear greater resemblance to actual daily activities (verisimilitude), the common element of all established neuropsychological tests so far is the testing in a highly artificial, distraction-free environment (Chaytor & Schmitter-Edgecombe, 2003). The underlying rationale is that an optimum testing environment provides the best context for obtaining clients’ “true capacity” and showing what their brain is “really” capable of. Lezak (2004, p. 130) acknowledged that patients with brain injury are vulnerable to the effects of external influences, and their performances on testing can deteriorate easily. Arguing in favour of “maximising the patient’s performance” (2004, p. 130), she advocated an optimum assessment environment in order to elicit the best performance a patient is able to produce. This “clean” image of cognitive performance can then be utilised for determining the presence of structural brain damage or neuropathology of the brain (Long & Collins, 1997). In accordance with the tradition of localising brain lesions, the neuropsychologist would expect a healthy client in optimum testing conditions to achieve scores in line with the test achievements of the normative sample. Vice versa, if a client’s optimum performance in ideal conditions was found deficient in one or several cognitive domains, brain-organic causes have to be considered responsible for these short-comings (Chaytor & Schmitter-Edgecombe, 2003). For example, if verbal memory functions in a war veteran were found to be impaired despite optimum control of external factors that could hamper performance (such as environmental distractions), damage to the left temporal lobe is to be suspected as the underlying cause (Long & Kibby, 1995). Vice versa, a veteran’s unimpaired test achievements in controlled conditions would suggest that performance problems in everyday-life roles are likely to be due to ‘functional’ problems, such as mood/anxiety issues, motivation, or other non-organic causes. Thus
the traditional approach to cognitive testing resembles medical standard procedures, such as taking an x-ray. Here, too, possible interferences are minimised (e.g. the patient takes off jewellery and assumes an optimum posture). The image will either confirm pathology (e.g. a fracture), or will otherwise demonstrate no abnormalities, suggesting that no structural damage to the bone has occurred. The fundamental concern, however, remains: that pathology or incapacity may systematically be overlooked by restricting the cognitive assessment to evaluating a “best-case-scenario,” or, staying within the x-ray analogy, a fracture may not be visible on images solely taken from a frontal perspective, but may well be demonstrated on lateral view. A radiological example for the need to consider the later view is provided in the appendix (Figure 4, appendix).

A substantial body of research presented below, has highlighted that one of the most prominent features of acquired brain damage, specifically with frontal lobe impact, is the clients’ inability to manage distractions imposed by complex, busy environments. Damage to the frontal lobes of the brain has been shown to correlate with deficits in attention, working memory, and inhibitory control in children and adolescents. Hartnedy & Mozzoni (2000) documented the bewilderment of children with severe brain-trauma at mealtime, trying to cope with the environmental over-stimulation. They also demonstrated that a regime of limitation of environmental stimuli and reduction of stimuli, which had to be attended to by the child, resulted in decreased confusion and improved nutritional intake. Levin et al. (1993) compared 76 children at 3 months post traumatic brain injury with 57 healthy controls over a range of neurocognitive variables and Magnetic Resonance Imaging (MRI). Significant effects of injury on all of the cognitive measures were obtained, correlating frontal lobe damage with impaired performances in executive functions. An overview of effects on executive functions after traumatic brain injury in children was presented by Levin & Hanten (2005). The authors pointed out that a number of executive functions are affected, including working memory, inhibition, shifting, planning, metacognition (monitoring and control), decision making, discourse processing, social cognition, and behavioural self-regulation. Mild, moderate, and severe traumatic brain injury were found to impact on working memory, although the effect varied with a number of factors including the child’s age, the time since the injury, and the severity of the injury. Attention-inhibitory control was found to be impaired in children with closed head injury (Dennis, Guger, Roncadin, Barnes, & Schachar, 2001). The authors compared performances of 105 school-aged children on neuropsychological tests of attention–inhibitory control (vigilance, selective attention, response modulation) with parent ratings of attention and behavioural regulation in relation to injury variables (age at injury, time since injury, severity of injury, and frontal lobe impact). Problems with attention-inhibitory control and distractibility were confirmed; age at injury and time since injury were most predictive of outcome.
Levin et al. (2002) investigated the effects of traumatic brain injury on working memory in children with mild (n=54) and severe traumatic brain injury and a control group (n=44). The severity of traumatic brain injury equally affected the error rate and false-alarm rate in letter-search-tasks. Impaired working memory and diminished inhibition were found most pronounced in children with severe traumatic brain injury, followed by the mild brain injury group. The impact of traumatic brain injury on working memory in children was also investigated in a further study by Levin et al. (2004), which looked at a group of 144 children (79 with mild, 23 with moderate, and 42 with severe injuries), involving both MRI scanning and neurocognitive testing at 3, 6, 12, and 24 months post injury. More severe injuries were found to result in greater and more persistent incapacity. In another prospective longitudinal study by Levin at al. (2008), the neuropsychological outcomes in children with mild traumatic brain injury (mTBI) was investigated at 2 weeks, and 3, 6, and 12 months. Outcomes were compared between children whose post-injury Computer Tomography (CT) scans revealed brain pathology (n=32) and those with no changes on CT-imaging (n=48). Children with established brain pathology had significantly poorer episodic memory, slower cognitive processing, and greater problems with managing cognitive interference than children with uncomplicated brain injury.

Similar association between frontal lobe brain damage and subsequent problems with attention-control/distractibility have been documented for adults. Brewer, Metzger, & Therrien (2002) studied distractibility, impulsivity, irritability, and decreased executive functioning in a sample of 40 patients with mTBI at different points in time following the injury. They confirmed presence of all four features in all participants within 24 hours after injury. Twenty percent of participants continued to complain about distractibility, impulsivity, and/or irritability throughout the 30-day-study. The authors found that loss of consciousness is a risk factor for a longer continuation of symptoms. Methodologically, distractibility was measured by the performances on the Necker Cube Pattern Control Test, the Trail Making Test (Form A and Form B), the Digit Span Test (Forward and Backward), the Pattern Comparison Task, and the Continuous Performance Test. These measures are attention/concentration tests and measures of working memory, not of distractibility per se, as clients were not exposed to any environmental distractions. The authors argue that attention and working memory are important regulating brain functions required for task focus; impairment in attention function would, therefore, result in distractibility. This, however, was not tested in the study.

The challenge of providing an actual distraction stimulus was met by Knight, Titov, & Crawford (2006), who achieved a high verisimilitude in their study by constructing a virtual shopping precinct, integrating photographs, sounds, and video-segments. The model “shopping street” was
divided into a low distraction zone with low audio-visual stimulation and a high distraction zone with increased audio-visual distraction. Twenty clients with chronic Traumatic Brain Injury (TBI) (7 severe, 7 very severe, 6 extremely severe) and 20 matched controls were examined under both conditions. Clients had to walk along the street while completing ten errands with a checklist and, additionally, had to respond to targets that appeared intermittently. The authors were able to confirm that the TBI group was more affected by the distraction condition than the control group, with significant impact on task performance. In contrast, Krawczyk et al. (2008) did not provide an environmental distraction in their study on the impact of distractors on clients with two variants of frontotemporal lobe degeneration (n=16) vs. healthy controls (n=10). Clients worked on visual reasoning tasks trying to find analogies between picture sets. Distraction was provided by including irrelevant information into the picture or by adding choice options to unrelated categories. The authors found that clients with frontal lobe degeneration were more often misled by the distraction option than healthy controls. When the distractor-answer-choices were eliminated, clinical patients showed improvement in performance. These findings support the contention that intact prefrontal cortex functions are necessary for controlling interference from perceptual and semantic distractors in reasoning tasks.

Broglio, Pontifex, O’Connor, & Hillman (2009) examined 90 young athletes (mean age 19.7), half of them with a history of serial concussion/mTBI, using a standard neurocognitive assessment and electrophysiological measures. Those with a history of concussion were, on average, 3.4 years post injury. Although no significant differences were found between groups on standard neurocognitive scales, significant alterations of N2 and P3b amplitudes were documented on neuro-electric measures for the concussion sample, compared to the control group. These differences on the neuro-electric measures were obtained while clients had to work on a computer game requiring complex attention. The authors suggested that the standard clinical cognitive assessment may be insufficiently refined to demonstrate subtle but persistent cognitive changes imposed by serial sport mTBI.

Performances under different types of environmental distraction were examined by Whyte, Schuster, Polansky, Adams, & Coslett (2000) on a sample of 20 clients with severe TBI and a matched group of 20 control clients. Four normative, ecologically plausible distraction conditions were devised, comprising subtle distraction (examiner getting up from his chair and performing quiet tasks such as checking the thermostat), brief noisy distraction (examiner dropping and retrieving notebook from a desk), marked distractors (examiner playing noisy video-game in client’s view), and conversation distractors (examiner dictated or used telephone). The timing and length of exposure was carefully controlled. All clients had to work on three separate clerical tasks, graded according to
the level of challenge (making a collage, sorting items according to rules, and solving a 500-piece-puzzle), while exposed systematically to the different sets of distractors. Clients’ performances were videotaped and task-focus vs. off-task behaviour analysed. The TBI group demonstrated significantly higher frequencies and longer duration of off-task behaviour compared to the control group in all distracting conditions. The different types of distraction conditions varied in their impact on task-focus; predictably; the video game imposed the greatest distraction from attending to the task. The authors further demonstrated that the disruptive impact of distractions disappeared relatively quickly for controls, while clients with brain injury required a significantly longer recovery time from such distractions.

An older study by Trudel, Tryon, & Purdum (1998) examined 65 clients with severe TBI. Frontal lobe impairment was shown to result in reduced self-awareness of disability compared to carer ratings, higher scores on scales for maladaptive behaviour, and greater problems with complex concentration and working memory measured on WAIS R. Although the study did not involve testing with environmental distraction, the authors proposed that clinical populations with frontal lobe impairment, which are already struggling with attention/concentration in controlled conditions, are likely to experience compounding difficulties in a more challenging environmental context.

Conducting tasks with environmental distraction is already a challenge for healthy individuals with laboratory studies confirming that irrelevant auditory or visual stimuli can interfere with selective attention and impair cognitive performance. For example, even relatively quiet background noise was shown to have a negative effect on efficiency in performing cognitive tasks in healthy subjects (Banbury, Tremblay, Macken, & Jones, 2001) and decreased cognitive performance documented for music and everyday noise, compared to silence (Cassidy & MacDonald, 2007), although mediating effects were recognised relating to introvert vs. extrovert personality (Furnham & Strbac, 2002). Increased disturbance was documented when the auditory distraction was meaningful and semantically related to the primary attention tasks (Marsh, Hughes, & Jones, 2009). In this connection, the distracting effects of mobile-phone use while completing cognitive tasks (Kemker, Stierwaltf, LaPointet, & Heald, 2009) or driving a car (Collet, Guillot, & Petit, 2010; Kass, Beede, & Vodanovich, 2010; Lin & Chen, 2006; Strayer, Watson, & Drews, 2011) has been recognised. The negative effect of auditory distraction on cognitive performance increased with greater loudness of the distraction (LaPointe, Heald, Stierwalt, Kemker, & Maurice, 2007). In their study 40 young healthy adults were recruited for an experimental examination of the effects of different types of distraction (4-talker babble; word repetition; combined 4-talker babble with word repetition), and a quiet control condition, on performances on a range of computerized cognitive tasks including processing speed and working memory. The distractions were presented at two
levels of loudness, comfortable (<40 db) and uncomfortable volume (>60 db). Only very few
distraction effects on cognitive processing were found at low volume level. In contrast,
uncomfortable loudness resulted in significant decline of performance, affecting working memory,
reaction time, and accuracy. As expected, distractibility in clients with brain injury is not restricted to
interfering auditory stimuli. Visual distractions, too, were found to have a negative impact on
cognitive performance. In a study with 21 hospitalised clients following recent TBI and 21 controls,
Whyte, Fleming, Polansky, Cavallucci, & Coslett (1998) found processing speed measured as visual
reaction time in go-no-go task significantly decreased. The distraction here comprised a coloured,
moving stimulus appearing above the target location. The authors found a moderate effect of
severity of injury (within the TBI sample) on clients’ susceptibility to the distraction.

An influential conceptual approach to describing cognitive functions involved in attention
and in processing/storing of competitive information was presented by Baddeley and Hitch (1974) in
their model of “working memory”. The authors initially conceptualised three main components; the
“central executive” which acts as a supervisory system and controls the flow of information from
and to its “slave systems”: the phonological loop and the visuo-spatial sketchpad. The slave systems
are short-term storage systems dedicated to either verbal or visuo-spatial information. Subsequently
Baddeley (2000) added a third slave system to his model, the “episodic buffer”, dedicated to linking
information across domains to form integrated units of visual, spatial, and verbal information with
time sequencing.

In Baddeley’s model, the central executive is an information management system
responsible for controlling and regulating several cognitive processes, including binding information
from a number of sources into coherent episodes, coordination of the slave systems, shifting
between tasks, and managing selective attention and inhibition. It is the role of the central executive
to repress environmental distraction while maintaining attentional focus on the primary task
(selective attention). Consistent with their model, Baddeley, Sala, and Robbins (1996) documented,
that patients with Alzheimer’s dementia are impaired when performing multiple tasks
simultaneously, even when the difficulty of the individual tasks is within their abilities. Healthy
control clients with unimpaired central executive are able to attend to multiple attention demands
successfully. Following Baddeley’s terminology, this research investigates ‘selective attention’ a
short-term process of the central executive. Other concentration functions, such as ‘sustained
attention’ (‘vigilance’) are not investigated.

To summarise the above studies, there is a substantial base of evidence highlighting that
distractibility and impaired ability for blocking out environmental distraction is a key feature of
acquired brain injury. Nonetheless, testing of environmental distractibility has never been part of the
neuropsychological assessment. The longstanding argument in favour of this omission has been that a neuropsychological assessment should maximise client’s performance levels by means of providing an optimum environment. The distraction-free assessment has been considered replicable and normative, and thus compatible with the test conditions of the normative sample. While the advocates of the distraction-free assessment-setting acknowledge that many of their clients suffer from distractibility, they promote that such problems be avoided (minimised) rather than measured.

Another common concomitant of brain impairment is distractibility: some patients have difficulty shutting out or ignoring extraneous stimulation, be it noise outside the testing room, test material scattered on the examination table, or a brightly coloured tie or flashy earrings on the examiner. [...] To reduce the likelihood of interference from unnecessary distractions, the examination should be conducted in what is sometimes referred to as a “sterile environment”. The examining room should be relatively soundproof and decorated in quiet colors, with no bright or distracting objects in sight. (Lezak, et al., 2004, p. 124)

If the client nevertheless appears to be distractible within the context of the standard assessment, Lezak et al. (2004) recommended that such phenomenon be noted as an incidental qualitative observation, but not to be considered for further investigation. Methodologically, this approach and test-setting runs a risk of marginalising or missing entirely one of the key symptoms of brain injury. As testing in distraction-free conditions has a place in establishing performance in a “sterile environment”; testing performances in distracting conditions ought to have a place in establishing clients’ capacity to operate in real-life conditions. One approach does not exclude the other: In order to obtain a more realistic picture of a client’s cognitive capacities in everyday-life situations, it would seem desirable that at least some cognitive functions, namely those particularly vulnerable to the effects of environmental distractions, be tested not only in the quiet, concentrated setting of a standard neuropsychological assessment, but also, additionally, with (controlled) exposure to environmental distraction.

It was highlighted in the previous chapters that neuropsychological assessments have a high impact on clients’ rehabilitation pathway. Findings often direct the further treatment and entitlements. Clients who produce an acceptable performance in a neurocognitive assessment are deemed to be fit for a return to work or to previous family roles. Compensation claims and cover for further treatment are closed in the light of ‘objective’ neurocognitive findings stating that no cognitive problems were identified. Clients, however, go back to busy jobs, noisy environments, crying children, flashing lights, open-plan offices and factory floors. A number of these clients are ill-
prepared to meet these challenges and may rightfully feel that some of their problems have been under-assessed. The following example describes a clinical case.

Case Study 1

Mr K.F., a 45-year-old, small business owner/operator was involved in a high-speed Motor Vehicle Accident in 08/2007 with orthopaedic injuries to both legs, ribs, and left wrist. MTBI was documented (Loss of Consciousness longer than 20 minutes, midline shift on CT scan, Post Traumatic Amnesia 24 hrs, Glasgow Coma Scale 6/15 on scene of accident, 13/15 on admission). Cognitive problems were noted upon his graduated return to work 3 months post injury, including poor concentration, difficulties with remembering new information, problems with multi-tasking, and fatigue. These cognitive problems were noted in the context of his noisy work environment comprising a metal workshop and adjacent busy office space.

On Neuropsychological Assessment he performed in the high-average range (WAIS/WMS-III Scaled Scores between 9 and 13) in relevant dimensions of cognitive functioning, including (un-distracted) concentration, learning/retention, and intelligence, consistent with pre-morbid estimates. Equally unimpaired performance in tests of executive functioning were documented (STROOP, TMT, WCST).

Mr K.F.’s cognitive functioning was accordingly considered as intact and sufficient for resuming his work role. His ongoing performance problems were attributed to “likely depression” despite the absence of significant symptoms of depression on symptom scales (Beck Depression Inventory-II 10/63, Hospital Anxiety Depression Scale-D 04/21, Depression Anxiety Stress Scale-21 12/63). He was commenced on Serotonin Reuptake Inhibitors (SSRI) with minimal improvement of cognitive or functional capacity. His claim with the National Accident Compensation Corporation for income compensation and further treatment was closed. This decision was substantially based on the lack of positive findings in the neuropsychological assessment, and was upheld in review.

The risk of false negatives based on an incomplete investigation may not only apply to clinical settings but also affect research. A large number of cognitive studies following mTBI conducted over the past decades failed to document significant cognitive incapacity on formal testing (Binder, 1997; Frencham, et al., 2005; Rohling et al., 2011). These findings contrast the subjective appraisal of the sub-group of clients with mTBI who complain about a persistent constellation of cognitive, somatic and emotional symptoms, typically described as “Post-Concussion
Syndrome” (PCS) (Rees & Bellon, 2007; Ryan & Warden, 2003). All clients with mTBI participating in these studies had traditional neurocognitive examinations without exploration of distractibility, which raises concerns that specific attention issues may have been missed. Clients with severe brain trauma, by comparison, were “impaired enough” to score poorly on a number of measures, even in a quiet testing environment. Cognitive sequelae for severe brain injury have therefore positively been identified.

In the following chapter, a modification and extension of the traditional assessment will be proposed, which allows testing of distractibility as a separate cognitive function.

Summary

Real-life situations are characterised by environmental distractions. Substantial evidence has been brought forward highlighting that clients with frontal lobe brain damage encounter problems with managing distractions. While incapacity for managing distraction is a key characteristic for this client group, with significant impact on their ability to attend to everyday-life roles, this concern has remained un-examined in the standard neuropsychological assessment. An extension of the traditional cognitive assessment will be proposed in the following chapter.
2.4. Extension of the Standard Neuropsychological Assessment

Neuropsychological assessments are perceived by the client, by the referring agency, and by most other health professionals involved in the assessment and treatment of clients as objective measurements of cognitive functioning with defined properties with regards to population norms, reliability, and validity. Clients undergo the lengthy and expensive procedure of a neuropsychological assessment in the understanding that hard data are obtained about their cognitive strengths and weaknesses. Far reaching conclusions are drawn from a client’s cognitive capacity demonstrated on formal neurocognitive testing, including advice on work capacity, safety in personal, family, and occupational roles, decisions regarding injury/disability compensation, and recommendations for rehabilitation and environmental requirements. The previous chapter demonstrated that such conclusions and advice are drawn from a limited data base. As sophisticated and comprehensive as neuropsychological tests are, the impressive test-parameters obtained within the confined setting of a standard assessment, are limited to exactly such setting.

The previous chapter outlined that the controlled, distraction-free setting of a standard neuropsychological assessment is less than representative of the often busy and distracting conditions of everyday life. The standard neuropsychological assessment fails to investigate and appropriately document clients’ abilities to cope with environmental distractions, as the cognitive operation of a client in a distracting environment remains untested. Clients suffering from damage to the frontal-temporal lobes of the brain were identified as a population particularly vulnerable to the disturbing/confusing effects of environmental distractions. There is a demand for neuropsychological assessments to provide information on clients’ ability to manage such distractions and thus improve the level of ecological validity. It is therefore necessary that clients’ abilities to operate cognitively and functionally under distracting conditions be tested specifically.

An extended approach to neuropsychological testing needs to be devised that can evaluate cognitive performance in two settings: the traditional quiet, concentrated assessment format, and, additionally, with (controlled) exposure to environmental distraction. Such an additional distraction condition would need to include complex yet standardised, replicable, distraction-parameters that structurally resemble daily-life situations for ensuring verisimilitude. The distraction stimuli therefore have to be sufficiently comprehensive and include combined auditory/visual components in order to match key characteristics of the daily-life environment. Such dual assessment under quiet and distracting conditions would need to focus on cognitive functions that are particularly sensitive to environmental distractions, concentration, and memory. For reasons of clinical practicality, it would further be required that testing in a distracting setting can be undertaken effortlessly, as part
of an extended, comprehensive neuropsychological assessment, consisting of a brief addition to the usual procedure of not more than a few minutes. Finally, it would be desirable that a direct comparison can be made between performances under distraction and under standard conditions. This would require re-testing of the client with and without normative distraction within the same session; here practice effects (test-learning effects) would need to be carefully controlled.

Structurally, a type of environmental distraction that occurs simultaneously and competitively with an initial attention demand would be optimal. Examples of such everyday-life distracters include: listening to a person while there are people talking in the background, trying to read a text (newspaper, e-mail, book, etc.) with voices in the background, watching TV while family members talk, trying to write down a new phone number or an order/confirmation number in a noisy restaurant or an open plan office, hearing children quarrelling in the background while trying to participate in a conversation. Accordingly, the required setting is defined by two parameters: (1) a demanding primary attention tasks (focus task) in which the client is fully engaged and tries to remain fully engaged, and (2) simultaneous, competitive environmental stimulation (distraction) which interferes with processing the primary attention task.

Such setting is structurally different from so-called “distraction conditions” in certain neuropsychological list-learning tests. In such tests, participants are given a list of items (“List A”) which have to be learned, usually over several trials. This is followed by a second learning task, involving a different set of items (“List B”) which is called the “distraction” task or list. Afterwards participants are asked to produce the initially learned items (“List A”). Examples for such tests are the Rey Auditory Verbal Learning Test [RAVLT] (1996; Spreen & Strauss, 1998) or the California Verbal Learning Test [CVLT] (Delis, et al., 2000). These tests do not, at any stage, include an environmental distraction such as noise. They are undertaken in the concentrated laboratory setting of the standard neuropsychological assessment. The distraction here lies solely in the temporary shift of focus on a different primary attention task. RAVLT and CVLY are tests of successive primary task attention (and related memory performance), not of environmental distraction. They do not include competing sensory stimulation that the client tries to block out or to ignore as it interferes with the encoding of the primary attention data. The environmental distraction setting proposed in the current study is also different to traditional tests for “divided attention” (dual task processing), which refers to the ability to conduct two tasks at the same time, or to concentrate on two stimuli with competing attention demands (Van Zomeren & Brouwer, 1994). Examples of tests for divided attention during which a client has to attend to visual and auditory stimuli simultaneously include the Divided Attention sub-test of the Test for Attention Performance (Zimmermann & Fimm, 1995).
and the combined Go-no-go and Digit Span Test (Leclercq et al., 2000). These tests do not involve environmental distraction and are conducted in the traditional, quiet assessment setting.

The specific neurophysiological process of trying to focus on a primary attention task while attempting to ignore environmental distraction was described as a specific function of the frontal lobes of the brain and documented in positron emission tomography (PET) studies by Gisselgård et al. (2003; 2004) and Campbell (2005). Conceptual and physiological aspects of this process will be explored in a separate chapter. Suffice to highlight at this stage that clients susceptible to environmental distraction need to be identified, based on specific testing of such susceptibility by means of modelling a distracting environment as part of the assessment procedure.

This may result in diagnostic gain for identifying frontal lobe changes, and for improved rehabilitation planning for clients returning to pre-morbid life-roles at home or at work.

**Summary**

* A more realistic appraisal of clients’ capacities to manage distracting real-life environments would require the standard neuropsychological assessment to be extended, involving specific cognitive functions to be tested both under the usual quiet condition and with environmental distraction. Identifying problems in the distraction setting can assist with documenting changes to the underlying brain structure and help with rehabilitation planning.*
2.5. Depression and Cognitive Functioning

The significant risk of developing a major depressive episode or depressive disorder during lifetime has been highlighted frequently. The 4th edition of the Diagnostic and Statistical Manual of Mental Disorders [DSM-IV-TR] (American Psychiatric Association, 2000) proclaimed a lifetime risk for major depressive disorder in community samples of 10 to 25% for women, and 5 to 12% for men. 15% of clients with diagnosed depression die by suicide. While the prognosis for treatment is generally positive, more than half of diagnosed patients experience a relapse within two years; between 50 and 80% of clients suffer more than one Major Depressive Episode in their lifetime (Goeleven, De Raedt, Baert, & Koster, 2006; Harkness, Monroe, Simons, & Thase, 1999; Kennedy, Abbott, & Paykel, 2003). These incidence rates have broadly been replicated in New Zealand (Oakley-Browne, Wells, & Scott, 2006) higher prevalence of depression in Maori and Pacific people were noted. Depression presents a significant challenge not only for affected individuals and their families, but also for health services, insurance and compensation corporations, and the community at large.

In terms of economic impact, the member states of the European Union estimated the cost of depression to be on average 3 to 4 % of GNP. In the USA, the estimates for national spending on depression ranged from $30 to $44 billion with approximately 200 million days lost from work each year (Gabriel & Liimatainen, 2000). The cost of depression in Europe (EU25 and EFTA countries) was calculated to exceed €118 billion per year (Sobocki, Jonsson, Angst, & Rehnberg, 2006). Almost two thirds of these costs arose as the direct result of lost productivity caused by early retirement, premature mortality or sick leave. Healthcare costs only comprised a small fraction of these costs (Sobocki, et al., 2006).

The severe impact of depression in terms of personal suffering and socio-economic burden encouraged wealth of research, which has furthered the understanding of the combined cognitive, behavioural, and emotional aspects of this disorder. It was highlighted in the DSM-IV-TR diagnostic criteria for depression that “low (depressed) mood” and “loss of interest or pleasure” represent only two of several diagnostic indicators. Other diagnostically critical features include: physiological markers (such as low-energy or agitation, sleepiness or insomnia), interpretive/emotional markers (such as negativity of outlook and judgement), and cognitive problems (such as difficulties with concentration and decision-making) (American Psychiatric Association, 2000, p. 356). The DSM-IV further specified depression-related cognitive incapacity as follows:

Many individuals report impaired ability to think, concentrate, or make decisions (Criterion 8). They may appear easily distracted or complain of memory difficulties. Those in intellectually demanding academic or occupational pursuits are often unable to function
adequately even when they have mild concentration problems (e.g. a computer programmer who can no longer perform complicated but previously manageable tasks). In children, a precipitous drop in grades may reflect poor concentration. In elderly individuals with a Major Depressive Episode, memory difficulties may be a chief complaint and may be mistaken for early signs of a dementia (“pseudo-dementia”). When the Major Depressive Episode is successfully treated, the memory problems often fully abate.

(American Psychiatric Association, 2000, p. 350)

Growing awareness, particularly of the cognitive impact of depression, created a demand for neuropsychological assessments in the field of mental health. Previously firmly placed in the domain of brain injury, neuropsychological assessments are increasingly utilised for comprehensively assessing the cognitive impact of a client’s depression, monitoring the progress of cognitive recovery from depression, vocational rehabilitation of clients with depression (Elinson, Houck, Marcus, & Pincus, 2004), and differential diagnosis between organic changes to the brain and depression (Attix & Welsh-Bohmer, 2005; Sweet, Newman, & Bell, 1992).

Research efforts led to successful documentation of the impact of depression on concentration/attention and working memory (Kampf-Sherf et al., 2004; Paelecke-Habermann, Pohl, & Leplow, 2005; Rose & Ebmeier, 2006; Watts & Sharrock, 1985; Zakzanis, 1999). Decreased processing speed was noted by Nebes et al. (2000). Depression-related impairment of executive function was documented consistently in other relevant research (Austin et al., 1999; P Fossati, Coyette, Ergis, & Allilaire, 2002; P Fossati, Ergis, & Allilaire, 2002; Harvey et al., 2004; Rogers et al., 2004). According to an older meta-analysis of 22 studies (Zakzanis, 1999), the cognitive functions most significantly affected by depression are episodic memory and attention. A recent comprehensive review of the relationship between depression and neurocognitive functioning was provided by McClintock, Husain, Greer, & Cullum (2010), which included a detailed synopsis of 35 empirical studies undertaken in this area since 1991. The authors noted an overall consensus about the likely impact of depression on frontal lobe functions, encompassing a range of measurable neurocognitive sub-functions including executive functions and concentration/attention, which, in turn, influence performance in other areas, such as memory.

The correlation between severity of depression and severity of cognitive impairment was found to be complex (Gualtieri, Johnson, & Benedict, 2006). As expected, cognitive functioning declined with the severity of depression, measured by scores on depression-symptom scales at the time of the assessment (Elderkin-Thompson et al., 2003). However, there were other characteristics of depression which were found to impact on clients’ neurocognitive functioning as well. Negative
impact on cognition was documented for recurrent depression (L. V. Kessing, 1998), presence of psychotic symptoms (Reichenberg et al., 2008), and duration of depressive episode (M. M. Grant, Thase, & Sweeney, 2001).

Methodological problems were highlighted, which make it difficult to directly compare severity of depression and levels of cognitive incapacity. There is a high rate of co-morbidity of depression and numerous medical conditions that in themselves adversely affect cognitive function. Such conditions with documented impact on cognition include, but are not limited to, diabetes (Awad, Gagnon, & Messier, 2004), vascular disease (Roman et al., 2004), substance abuse (Lamers, Bechara, Rizzo, & Ramaekers, 2006), HIV (Heaton, et al., 2004), and other mental health disorders. The effect of medication for treating depression or other medical problems was also noted as a further factor confounding results (McClintock, et al., 2010).

With the advent of advanced imaging technology, renewed efforts have been made to better understand neurobiological aspects of depression, and, specifically, to investigate brain-physiological components of cognitive dysfunction in depressed clients. Keedwell, Andrew, Williams, Brammer, & Phillips (2005) researched the neurobiological basis of anhedonia in clients presenting with major depressive disorder by exploring the correlations between severity of anhedonia and strength of neural responses to happy and sad stimuli using blood oxygen level dependent (BOLD) functional magnetic resonance imaging (fMRI). These findings suggest that anhedonia is associated with a dysfunction within the neural systems underlying the response to rewarding emotive stimuli. Leung, Lee, Won, Li, Yip, and Khong (2009) explored the clinically frequently observed attention-bias towards negative information in clients with major depressive disorder. Voxel-based morphometry confirmed a structural attention bias towards depression-related stimuli for depressed clients compared to matched controls. Such attention biases towards negative stimuli were found to be associated with reduced gray-matter concentration in the right superior frontal gyrus, the right anterior cingulate gyrus, and the right fusiform gyrus. Similar sensitivity of depressed clients for negative stimuli was documented by Mitterschiffthaler, Williams, Walsh, Cleare, Donaldson, Scott, and Fu (2008). Based on a modified (emotionally charged) Stroop-task, interference effects were investigated in information processing both for clients with depression and for controls. The findings confirmed that clients with depression required greater response-time in shifting between sad/neutral stimuli. FMRI demonstrated significant engagement of left rostral anterior cingulate cortex (BA 32) and right precuneus during sad words in depressed clients relative to controls. Rostral ACC activation was also correlated with latencies of negative words in depressed clients. In contrast, controls did not have any regions of increased activation.
Van Wingen, van Eijndhoven, Cremers, Tendolkar, Verkes, Buitelaar, and Fernandez (2010) researched mood-congruent attention/memory bias using positive, neutral, and negative face stimuli in several groups, including acutely depressed clients, recovered clients, and controls. FMRI documented a distinct pattern of neuronal activation in the amygdala and posterior cingulate cortex when processing positive information during acute depression. Their findings also suggest an ongoing bias in information processing in the fusiform gyrus and prefrontal cortex after recovery. Mood-congruent processing biases were also investigated by Elliott, Rubinsztein, Sahakian, Dolan (2002), who analysed neuronal response patterns to happy, sad, and neutral words using fMRI. Compared to controls, depressed clients were shown to have greater activation in rostral anterior cingulate extending to anterior medial prefrontal cortex in response to sad stimuli. Hugdahl, Specht, Biringer, Weis, Elliott, Hammar, Ersland, and Lund (2007) used BOLD fMRI for scanning patients during a major depressive episode and after recovery. Clients and controls were asked to complete a mental arithmetic/working memory task. The findings included significant differences in the activation of the inferior frontal gyrus and the superior and inferior parietal lobule between acutely depressed and recovered clients. The activation patterns of recovered clients matched those of controls. A significant negative correlation was documented between scores on the Hamilton Depression Rating Scale and neuronal activation of the frontal and parietal lobe of the brain (hypofrontality). An innovative study looking at family risk factors was presented by Mannie, Harmer, Cowen, and Norbury (2010). The authors examined young people, who had one parent with depressive disorder but had no history of depression themselves, and compared findings with a control group. FMRI was employed while participants had to work on concentration/working memory tasks of varying complexity. Both groups, controls and clients with family-history of depression, performed at similar levels and achieved comparable results in accuracy and response latency. However, clients with a family history of depression showed greater levels of activation in the lateral occipital cortex, superior temporal cortex, and superior parietal cortex. Task performance for clients with family history of depression required a significant increase in the load-response activity of the cortical regions. The authors suggested that this neural abnormality could form part of the predisposition towards developing depressive disorders.

Gotlib, Hamilton, Cooney, Singh, Henry, Joormann (2010) investigated neurobiological processing of reward and punishment. As in the study by Mannie (2010), the focus was not on clients with current or previous depression, but on neurobiological features that could be identified as risk factors for developing depression. They tested 10- to 14-year-old healthy girls who had mothers with recurrent depressive disorder. The results were compared to an age-matched control group of girls with no parental mental health history. FMRI documented different patterns of
activation in the putamen and left vs. right insula in the two groups when under reward-and-punishment-conditions. The authors established that different neural mechanisms responsible for the processing of rewards highlight the neurobiological correlates in young girls at risk for developing depression.

Using fMRI data, Harvey et al. (2005) confirmed “hypofrontality” in depressed patients performing a cognitive challenge compared to control subjects. The authors demonstrated that depressed patients showed greater activation of the lateral prefrontal cortex and the anterior cingulate while completing the same concentration/working memory task compared to healthy subjects. In other words, clients with depression need greater levels of activation of their neural networks to achieve a comparable level of performance than controls during a working memory task.

Summarising these findings, there is substantial evidence that depression can alter neurocognitive functioning; specifically, performances on tests for concentration, working memory, and executive functions have been found to be impaired. These cognitive limitations are underpinned by a change of neurological activation of the frontal lobe, demonstrated on fMRI imaging. Further, fMRI studies suggest that even when depressed patients are performing tests adequately or at a similar level to controls, they have to recruit more brain resources.

Consistent with tradition, neurocognitive assessments for clients during a major depressive episode are conducted solely in a quiet setting with minimised environmental distractions. In this setting, frontal lobe functions, such as concentration and working memory, are not challenged by additional attention-demands, such as noise or unrelated visual stimuli. A distraction-free test-environment engages frontal lobe functions to the degree that attention or working memory is required for the specific test. Such frontal lobe activation has been found to be sub-optimal in depressed clients (hypofrontality) with subsequent problems in task performance. This study proposes that short-term exposure to highly demanding environmental distraction during testing could increase activation of frontal lobe functions in this clinical group. Temporary activation of this brain area is expected to result in (temporarily) improved capacity for concentration and working memory tasks and, therefore, to lead to improved performance compared to baseline testing.

The expected effect is already well-known in clinical settings. Depression-related rumination interferes with performance on academic tasks (Lyubomirsky, Kasri, & Zehm, 2003). Depressed patients tend to think about their symptoms, problems, and performances instead of focusing on the task, with negative impact on test achievement (Berman, 2010; Watkins & Brown, 2002). Vice versa, task-focus and test-performance improve when depressed clients get temporarily distracted from rumination (Donaldson & Lam, 2004). Accordingly, we expect a powerful environmental distraction
to serve as an incentive for the depressed client to momentarily suspend unrelated thoughts or concerns and to focus instead on the actual test task. This improved task-focus is expected to enhance test performance. The quiet standard setting, in contrast, is less likely to distract from rumination and, thus, partially accounts for the decreased performance of depressed clients.

As with clients with mTBI, distraction testing for clients with MDE could be undertaken effortlessly as part of an extended, comprehensive neuropsychological assessment. This would allow for a direct comparison between performances under distraction and under standard conditions.

The following is another clinical case, which serves as representative example to illustrate this point.

Case Study 2
Mrs C.D., a married, 43-year-old mother of two grown up children with fulltime employment in a managerial role was diagnosed with major depressive episode. Mrs C.D. is otherwise in good physical health and has no history of brain-trauma. After 11 months off work she was referred for neuropsychological assessment to investigate ongoing problems with concentration, memory, and planning. Mrs C.D. achieved low-average to borderline scores in memory and concentration tasks (WMS-IV: Logical Memory [LM], VP; WAIS-IV: Letter-Number-Sequencing [LNS], DS; Standard Scores between 6 and 8), contrasted by high-average to above-average achievements in verbal and perceptual comprehension (WAIS-IV; Standard Scores between 14 and 12). Mild psychomotor retardation was documented (WAIS-IV: SS, CD; Standard Scores 8 and 7, respectively). Executive functions on tests with an attention component (STROOP, COWAT) were found to be decreased, but not impaired. Adequate performance on effort tests was noted. The cognitive profile obtained was found to be consistent with ongoing marked depressive symptom cluster (Beck Depression Inventory II [BDI] 34/63). On clinical appraisal, Mrs C.D. was frustrated with her performance, expressing a sense of failure. She frequently voiced negative biographical references and worried about her future vocational capacity.

The expectation for Mrs C.D.’s performance in a powerful distraction setting is that she will temporally suspend her negative self-evaluation and future worries, and dedicate her full and undivided attention on the actual task instead. This is expected to result in a considerable improvement of test achievements, compared to her performance in the standard condition.
The current study seeks to develop and to evaluate a short, standardised, replicable, additional test condition, which includes normative auditory/visual distraction stimuli. The performances of clients with MDE on standard neuropsychological tests can consequently be analysed both with and without distraction.

**Summary**

Problems with concentration, working memory, and executive functioning have been recognised as part of the symptom cluster of depression. FMRI research demonstrated that these cognitive problems are underpinned by altered patterns of neuronal activation, and suggests that clients with depression require either more intensive activation or activation of additional brain areas to complete concentration working memory tasks, compared to healthy controls. The current study hypothesizes that decreased cognitive functioning documented in the standard neuropsychological assessment is germane to the pattern of frontal lobe activation specific to such (distraction free) setting. Intensive short-term activation of frontal lobe functions through exposure to significant environmental distraction may temporarily lift cognitive performance.
2.6. Differential Diagnosis Brain Injury vs. Depression

A specific challenge presented to neuropsychologists is to differentiate between clients with organic changes to the brain and clients with depression. To most laypeople such differentiation seems simple enough: either someone had a stroke or an accident with subsequent cognitive problems, or someone developed depression in absence of a significant, usually easily identifiable, brain event. At closer examination, however, the complexity of this problem becomes apparent:

An older client may develop clinical symptoms of apathy, poor concentration, psycho-motor retardation, and low mood. This may represent either early symptoms of dementia or features of a late onset depression. Another client may have post-concussion symptoms after an accident, involving fatigue, irritability, concentration problems, and social withdrawal. Years later he still complains of the same symptoms. Is this an ongoing effect of the brain injury, or has a depressive illness overtaken those symptoms initially triggered by concussion? Yet another client with a longstanding history of recurrent depressive disorder suffers a stroke: are his mood problems and difficulties with managing everyday-life tasks a result of the stroke or a relapse of depression, or a combination of both?

The answers to such questions are of high significance for determining treatment pathways and compensations claims, with high stakes and far reaching consequences for the client. An elderly person found to be depressed and treatment-resistant to standard medication may be subjected to electro-convulsive-treatment in a last effort to control his depression. If his symptoms, however, were actually due to early dementia and not due to depression, such treatment may further accelerate his cognitive problems (Semkovska & McLoughlin, 2010). Vice versa, a client falsely labelled as demented may miss out on treatment efforts that could restore function and quality of life. A client with former head-injury may remain trapped in established illness-beliefs and avoidance behaviour, based on well-meant advice given at early stages of their recovery, to adhere to a strict regime of break-taking and activity-restriction, when in fact they have made a substantial recovery. Ongoing disability of this client is imposed by de-conditioning and loss of confidence, which may remain untreated until the historic diagnosis of ‘post-concussion’ syndrome is challenged. A client’s mental health diagnosis may be used by insurance or compensation agencies for rejecting a valid claim to cover a brain injury.

Finding answers to these questions is essential for developing effective treatment and rehabilitation pathways. It is equally relevant for using public health resources and for resolving medico-legal disputes. Often neuropsychologists find themselves in a key position for providing advice on these matters. Thus, it is worthwhile to review how well-placed neuropsychology is in this role.
Clinicians in Geriatric Health Services have long faced the challenge of distinguishing between pseudo-dementia and dementia. The term ‘pseudo-dementia’ is used to describe a syndrome that presents with cognitive impairment and other symptoms of dementia, such as agitation, disorientation, low mood, headaches, fatigue and apathy (Kasahara et al., 2006; Peritogiannis, Zafiris, Pappas, & Mavreas, 2008), which are reversible and have no underlying neuropathology. Instead, the symptoms are caused by depression and resolve with successful treatment of the underlying mood-disorder (Koskinen, 1992; McAllister, 1983). A diagnostic challenge exists, as ‘pseudo-dementia’ mimics the same symptoms that characterise the early stages of a dementia. The diagnostic difficulty is increased by the fact that both conditions frequently coincide. Depressive disorder was found to be a risk factor for developing Alzheimer’s dementia (L. Kessing & Anderson, 2004; Modrego & Ferrandez, 2004). Conversely, a high likelihood for the development of depression was documented in clients with Alzheimer’s disease (Kasahara, et al., 2006). Given the increased risk of clients with pseudo-dementia to developing dementia of the Alzheimer’s type, a diagnostic spectrum was postulated, ranging from depression without cognitive problems to depression with cognitive impact (pseudo-dementia), to early Alzheimer’s disease and advanced Alzheimer’s disease (Kasahara, et al., 2006). This concept gained some support by CT brain imaging, which indeed documented brain organic changes in clients with pseudo-dementia compared to controls (Cho et al., 2002; Pearlson, Rabins, Kim, Speedie, & et al., 1989). Controversy, however, remains with regards to considering pseudo-dementia as pre-dementia (McNeil, 2001; Reifler, 2001), as it is argued that, in clinical terms, the prognosis for treated pseudo-dementia is positive, forecasting a considerable symptom-free/symptom-controlled lifespan for patients affected. Pre-dementia, in turn, should be used as a category for describing early stages of actual dementia with a clinical picture of progressive decline.

Clinical features of early dementia include a gradual onset of symptoms, worsening of symptoms at nights, unawareness or denial of cognitive problems, shallow and labile mood, problems with ADL, and incontinence (Yalug, Polat, & Tufan, 2006). Language problems occur in both client groups (da Silva Novaretti, Freitas, Mansur, Nitrini, & Radanovic, 2011), although depressed clients appear to command better episodic memory. Differences in cognitive plasticity, measured as performance on the Auditory Verbal Learning Test of Learning Potential, was also confirmed by (Calero & Galiano, 2009). The use of specific neurocognitive tests with sensitivity for distinguishing depression-related and organic decline in older people was suggested (Van Gorp, Root, & Sackeim, 2004). In this context, specific differences in verbal new-learning and recall between Alzheimer- and depression-clients were highlighted, in particular, increased confabulation (‘intrusion-items’) in verbal memory (Gainotti & Marra, 1994) in Alzheimer-clients. Cognitive markers for Alzheimer’s
disease were identified, albeit with moderate specificity (Debetignles, Swihart, Green, & Pirozzolo, 1997; Gainotti, Marra, Villa, Parlato, & Chiarotti, 1998; I. Grant & Adams, 2009).

Consensus was achieved, based on consideration of functional capacities (such as ADL), neurocognitive abilities, CT/MRI scan, and clinical information (depression features, onset of symptoms, physical examination etc), that the diagnosis of dementia is the prerogative of a multi-disciplinary specialist service (Wolfs, Dirksen, Severens, & Verhey, 2006), comprising a geriatrician, a neuropsychologist and a nurse (Collighan, Macdonald, Herzberg, Philpot, & Lindesay, 1993; De Lepeleire et al., 2008; Ferran, Wilson, Doran, & Ghadiali, 1996; Waldemar et al., 2007; Wolfs, Dirksen, Kessels, Severens, & Verhey, 2009).

A significant number of clients (Sweet, et al., 1992) with TBI develop a persistent constellation of cognitive, somatic, and emotional symptoms, typically described as “post-concussion syndrome” (PCS). The most commonly reported symptoms are physical and mental fatigue, headache, dizziness, decreased concentration, memory problems, irritability, fatigue, sensitivity to noise and light, problems with decision making, depression, and anxiety (Rees & Bellon, 2007; Ryan & Warden, 2003).

Depending on parameters of the injury and on the criteria for PCS, prevalence of PCS following mTBI ranges from 40 % at 3 months and 23.6 % at 12 months post-injury (Sigurdardottir, Andelic, Roe, Jerstad, & Schanke, 2009) to 6 % at 3 months and less than 1 % at 6 months post-injury (Spinos et al., 2010). These percentages are consistent with the reported frequency of depression after TBI. In a follow-up study of 666 TBI clients, 27% met the DSM-IV criteria for major depressive episode. Fatigue (29%), distractibility (28%), anger or irritability (28%), and rumination (25%) were the most common depressive symptoms reported (Seel et al., 2003). A considerable overlap was documented between the cognitive, physical, and emotional symptoms of PCS syndrome and the symptom cluster commonly experienced by clients with chronic pain, depression, and stress disorders (G. Iverson & McCracken, 1997). Studies were undertaken to explore whether there is a specific neurological mechanism that links TBI with post-concussion syndrome. To this effect it was necessary to investigate how frequent symptoms of “PCS” are reported by healthy subjects in order to obtain a baseline. Rather surprisingly high endorsement rates of “PCS” were documented consistently for healthy subjects with no history of brain injury, including fatigue, insomnia, poor memory, and concentration difficulties (Chan, 2001; Garden & Sullivan, 2010; Gunstad & Suhr, 2004; G L Iverson, 2006; Wong, Regennitter, & Barrios, 1994). Post-concussion syndrome remains a controversial symptom-conglomerate that some patients experience following a traumatic brain injury or concussion, which is clearly not exclusive to brain trauma but also commonly observed even in healthy and cognitively intact populations, such as students (Wang, Chan, & Deng, 2006).
Iverson and Lange (2003) demonstrated not only a high base rate of symptoms of PCS in healthy controls, but also a strong correlation between depression and symptoms of PCS. The authors concluded that there are non-neurological mechanisms in the experience and expression of post-concussion syndrome following brain trauma and called for caution in the clinical interpretation of results from symptom inventories of PCS.

Diagnostic challenges outlined for dementia vs. depression and brain trauma vs. depression are similar, in principle, to those of other acquired brain injuries (Sas, Pardutz, Toldi, & Vacsei, 2010), as they share pathological mechanisms and psycho-social consequences (Schmid et al., 2011). Depression was documented to occur frequently after CVA, with incident rates between 25% and 54% (Haq, Symeon, Agius, & Brady, 2010; Kouwenhoven, Kirkevold, Engedal, & Kim, 2011). MRI findings confirmed that infarcts in the frontal subcortical circuits was significantly associated with post-stroke depression (Tang et al., 2011). Frequent and persistent deficits in executive function and information processing speed in connection with a high rate (30.4%) of depression were also reported by Barker-Collo, Feigin, Parag, Lawes, & Senior (2010). The authors emphasise that depression made a significant and independent contribution to functional outcomes.

In taking these findings together, uncertainty remains in the interpretation of ambiguous clinical symptoms, which can be caused either by depression or by brain pathology, or even by a combination of both. Overlap of symptoms of both conditions was documented in different areas, including cognitive functioning, mood/affect, and somatic complaints. Cognitive problems comprise concentration, working memory, and executive function; mood/affect symptoms include apathy, low mood, lack of enjoyment/engagement; somatic symptoms include headaches, low energy, and changes in appetite, sleep or libido. Traditional neuropsychological assessments are able to quantify some of the cognitive incapacities but struggle to determine the causes of these changes. The two clinical populations affected by depression and brain organic changes differ insufficiently from each other in the traditional, distraction-free assessment setting. The current study undertakes a novel approach to differential diagnosis. The introduction of a controlled environmental distraction is expected to have different impacts on these clinical groups. Cognitive performance of depressed clients and clients with brain injury is expected to change under distraction in specifically different ways. Depressed clients’ performances are expected to improve. Clients with brain injury are expected to decline. Clients without medical or psychiatric diagnosis are expected to show no change of performance. Unlike clients with mTBI, healthy clients command the frontal lobe capacity to block out distractions. Unlike clients with MDE they already perform at their usual, longstanding level of capacity in the standard setting. As they do not suffer from intrusive negative thoughts
hampering their performance, the forceful environmental distraction will not result in a temporary
lift of task focus and test achievement.

The following is a clinical case example to illustrate this point.

Case Study 3
A 32-year-old single male patient, Mr P.M., sustained mild/trivial head injury caused by a fall
while being intoxicated (loss of conscious not witnessed, GCS 15, no post-traumatic
amnesia). Otherwise there is no significant medical or psychiatric history. He has
longstanding history of intermittent employment and welfare dependency. Mr P.M. was
diagnosed with persistent symptoms of PCS, including concentration problems, fatigue,
headaches, irritability, mood swings, and sensitivity to light and noise. He has remained off
work since the injury. An MRI brain scan 1 year post injury demonstrated no abnormalities.
Mr P.M. was referred 4 years after the injury for neuropsychological assessment to
investigate ongoing cognitive impairment. Mr P.M. had not been diagnosed with depression.
The expectation is that Mr P.M. will achieve test scores in the average range in a standard
assessment condition based on his estimated pre-injury capacity and the rate of cognitive
recovery anticipated for his injury. On testing in the distraction condition, no changes are
expected compared to his performance in the standard condition.

If confirmed as effective, distraction testing is expected to become a useful tool for
distinguishing mood-related and brain organic conditions, as well as identifying cognitively intact or
recovered clients.

Summary

Diagnostic differentiation between brain-organic changes and mood-related incapacities has
remained insufficiently resolved. A significant overlap of symptoms of both conditions was
documented. The role of traditional neuropsychological assessments has been to identify the
cognitive area affected and to quantify the degree of cognitive impairment. Causation has
been difficult to establish. A novel approach to neurocognitive testing that differentiates
between these populations is required. It is expected that testing in a condition of
environmental distraction will result in changes of performance specific to a diagnostic
category.
2.7. Research Questions – Expected Impact of Distraction

The previous chapters highlighted that cognitive functioning is usually tested in a quiet, laboratory-type-environment free of environmental distraction. Distractions, however, regularly occur in clients’ usual life circumstances at home and at work, posing an untested challenge to cognitive functioning. We have proposed that ecological validity of neuropsychological assessment could be enhanced if clients were assessed not only in the distraction-free standard setting but also, additionally, with a controlled environmental distraction. This would allow for comparing the individual clients’ performances in both conditions with potential benefits for understanding their functioning in situations with complex attention demands such as real-life conditions.

We have also suggested in the previous chapters that client groups may differ substantially in how well they are able to cope with distraction. The anticipated specific difference in performing under the condition of distraction could become a key for differential diagnosis. Research has been presented that identifies clients with frontal lobe brain injury as particularly vulnerable to the effects of environmental distractions. Accordingly we expect clients with brain injury of this type to perform cognitive tasks significantly better in noise-free, standard testing-conditions than in conditions with environmental distraction.

The research that has been presented in the previous chapters also indicates that clients suffering a major depressive episode generally have difficulties with concentration, but may be able to temporarily overcome these difficulties by extending particular effort. As the distraction-setting presents a significant additional challenge to concentration, we expect participants with depression to substantially increase concentration-efforts and thus improve task-focus and test performance. We anticipate no significant change of performance for members of a control group of healthy individuals. Members of the control group are expected to be able to manage the environmental distraction effectively without impact on performance. We expect that all effects of the distraction-condition on performance can be demonstrated equally for raw scores, which comprise the number of correct items obtained, and for scaled scores, which place raw scores in context to reference norms according to the test-specific conversion tables provided by the test authors.

We expect that participants with frontal lobe brain damage will experience a sense of being overwhelmed by the distraction-setting as they structurally do not have the capacity to effectively process and block out the distraction. However, we do not expect this client group to experience significant distress or frustration, anticipating that instead they may feel puzzled and quickly disengage. In contrast, participants with depression are expected to experience significantly greater frustration and general stress in the distraction setting than in the standard condition, as they have
to extend supreme effort. In group comparison, participants with depression are expected to rate greater levels of stress in the distraction condition than the brain injury group. Members of the control group are expected to find the distraction setting emotionally more taxing than the standard setting but to experience significantly less stress than participants with depression.

As a variant of standard clinical practice, we developed and refined a standardised distraction condition, based on client feedback and analysis of performances with different test settings and distraction stimuli. The process of development, standardisation, and the operational definition of the distraction condition will be described in the following chapter. The hypotheses of this study are based on distraction testing under the specific, defined parameters of the distraction condition specified in the chapter “Formal Characteristics of the Distraction-Condition” and the stimuli included in the appendix.

The following hypotheses will be tested:

**Depression Group**

H1: mean Logical Memory (standard condition, raw scores) < mean Logical Memory (distraction condition, raw scores)

H2: mean Logical Memory (standard condition, scaled scores) < mean Logical Memory (distraction condition, scaled scores)

H3: mean Digit Span Forward (standard condition, raw scores) < mean Digit Span Forward recall (distraction condition, raw scores)

H4: mean Digit Span Forward (standard condition, scaled scores) < mean Digit Span Forward (distraction condition, scaled scores)

H5: mean Digit Span Total (standard condition, raw scores) < mean Digit Span Total recall (distraction condition, raw scores)

H6: mean Digit Span Total (standard condition, scaled scores) < mean Digit Span Total (distraction condition, scaled scores)

H7: mean Letter/Number Sequencing (standard condition, raw scores) < mean Letter/Number Sequencing (distraction condition, raw scores)

H8: mean Letter/Number Sequencing (standard condition, scaled scores) < mean Letter/Number Sequencing (distraction condition, scaled scores)

H9: mean stress (distraction condition, visual analogue scale) > mean stress (distraction condition, visual analogue scale) [any other group]
Brain Injury Group

H10: mean Logical Memory (standard condition, raw scores) > mean Logical Memory (distraction condition, raw scores)

H11: mean Logical Memory (standard condition, scaled scores) > mean Logical Memory (distraction condition, scaled scores)

H12: mean Digit Span Forward (standard condition, raw scores) > mean Digit Span Forward recall (distraction condition, raw scores)

H13: mean Digit Span Forward (standard condition, scaled scores) > mean Digit Span Forward (distraction condition, scaled scores)

H14: mean Digit Span Total (standard condition, raw scores) > mean Digit Span Total recall (distraction condition, raw scores)

H15: mean Digit Span Total (standard condition, scaled scores) > mean Digit Span Total (distraction condition, scaled scores)

H16: mean Letter/Number Sequencing (standard condition, raw scores) > mean Letter/Number Sequencing (distraction condition, raw scores)

H17: mean Letter/Number Sequencing (standard condition, scaled scores) > mean Letter/Number Sequencing (distraction condition, scaled scores)

Control Group

H18: mean Logical Memory (standard condition, raw scores) = mean Logical Memory (distraction condition, raw scores)

H19: mean Logical Memory (standard condition, scaled scores) = mean Logical Memory (distraction condition, scaled scores)

H20: mean Digit Span Forward (standard condition, raw scores) = mean Digit Span Forward recall (distraction condition, raw scores)

H21: mean Digit Span Forward (standard condition, scaled scores) = mean Digit Span Forward (distraction condition, scaled scores)

H22: mean Digit Span Total (standard condition, raw scores) = mean Digit Span Total recall (distraction condition, raw scores)

H23: mean Digit Span Total (standard condition, scaled scores) = mean Digit Span Total (distraction condition, scaled scores)

H24: mean Letter/Number Sequencing (standard condition, raw scores) = mean Letter/Number Sequencing (distraction condition, raw scores)

H25: mean Letter/Number Sequencing (standard condition, scaled scores) = mean Letter/Number Sequencing (distraction condition, scaled scores)
These research hypotheses can be condensed into graph form, where the expected change of performance in the distraction setting for each study group is easily apparent (Figure 2).

**Figure 2**
Expected change of performance in the distraction condition for different study groups

MDE; Major Depressive Disorder
mTBI; Mild Traumatic Brain Injury

**Summary**

*Performances of participants with brain injury are expected to significantly deteriorate with environmental distraction. Performances of depressed participants are expected to improve with distraction. Members of the control group are not expected to change their performances with distraction. Subjective stress levels in the distraction condition are expected to be highest for participants with depression.*
3. Method

3.1. Additional Testing under a Distraction Condition

3.1.1. Development of an effective distraction-condition.

The distraction stimulus, as well as the setting for presenting the stimulus had to meet a number of criteria. The distraction has to be powerful enough to interfere with usual task processing in a measurable way without causing distress to the client. The stimulus has to bear close resemblance to distracting conditions commonly experienced in real-life situations both at home and at work to promote ecological validity (verisimilitude) and acceptance. The stimulus has to be simple and easily reproducible by other clinicians in various clinical set-ups. The distraction condition has to be short to ensure that the overall neuropsychological evaluation does not extend by more than 4 to 5 minutes in total. The development and refinement of an effective distraction setting is therefore considered an important preliminary stage based on experimenting with a multitude of options.

In an initial trial-and-preparation-period conducted as clinical exploration prior to commencing the formal study, a practice nurse was asked to read out loud, in the background, articles from the daily newspaper while the memory and concentration test of the Wechsler test batteries were presented. At the same time, different physical set-ups were trialled including different physical distance between nurse and client and sitting arrangements with the nurse inside or outside the visual field of the client. Different volumes were also tested. The effect of different reading material was explored, varying in levels of interest for different client groups, including sports news, fashion, and national events. Finally, the effects of reading out loud random numbers vs. reading a coherent text were investigated.

Formal and informal feedback was sought from participants regarding the challenge imposed by the distraction, both emotionally and cognitively. Participants were also asked to rate how natural the specific test-setting felt and how closely it matched the experience of a busy environment in their daily lives. The impact of different set-ups on test performances was analysed. Very quickly it became apparent that the condition rated as most “typical” and “natural” for daily life distractions involved auditory distraction by a visible speaker. It was also confirmed by all our initial participants that the perceived interference was greatest when test-material and distraction material were similar. Hearing the stories of the Wechsler Memory Scale (WMS) and other prose simultaneously in the background was felt more distracting than hearing the WMS stories with random numbers in the background. Correspondingly, the distraction imposed by hearing numbers
in the background while working on “number tests,” including the Digit Span Forward (DSF), the Digit Span Total (DST) and the Letter-Number Sequencing (LNS) of the Wechsler Adult Intelligence Scale (WAIS-IV), was far greater than the distraction caused by prose. This subjective impression of increased interference posed by similar stimuli was confirmed by greater decline of test scores in the distraction setting compared to the standard setting. Vice versa, participants with non-matching distraction stimuli had slightly better test scores in the distraction setting. With regards to the actual theme of the distracting articles, a sub-group of participants reported that they felt it was harder to block out information which was of personal interest (e.g. sports results), while others reported the semantic material was not of importance.

3.1.2. Formal characteristics of the distraction-condition.

In taking into consideration client feedback and the impact of different arrangements on test scores defining parameters for an effective distraction setting were available. The following format was adhered to in the study:

- The seating of client and examiner, as well as other context variables of the test setting, such as temperature, light, and sitting arrangement, remained identical in the standard condition and the distraction condition.
- The distraction was provided by playing two specific computerised audio-visual recordings showing a woman reading a news item (“file 1”) and random numbers (“file 2”). The files were played on a laptop computer with a screen sized 360mm x205 mm with an external speaker providing a sound level of 55 Decibel (+/- 10 decibel) for each file.
- The selected distraction story was rated as moderately interesting by both men and women without gender bias. The story line featured a non-violent robbery of diamonds from a London bank in low difficulty English. Readability parameters were broadly comparable to the WMS stories, comprising a Flesch Reading Ease score of 50 and Flesch-Kincaid Grade score of 9.
- The laptop was positioned like a third person in an equilateral triangle, with a distance of approximately 90 cm from both client and examiner.
- After playing “file 1” (story file) for 8 seconds the examiner provided a short lead-in talk, comprising the following sentences (verbatim): “So, you now hear and see our distraction. I will keep talking over her voice for a while so you get used to this background noise. You do not have to look at the screen. You can look at me or somewhere else in the room if you like. When I start reading my story you only listen
to my story. Try to ignore this background noise; just listen to me. Okay, here is my first story.”

- The recording was stopped immediately after the examiner has finished reading the first story. Then the client was asked to tell back as many items he or she remembered from the story, in accordance with the WMS test manual. After noting the client’s responses, the examiner resumed playing “file 1” in the background while reading out the second story. Upon completion of the reading, the examiner discontinued playing “file 1” and noted client’s recall of the second story.
- In a similar fashion, the WMS-IV sub-tests Digit Span Forward (DSF), Digit Span Total (DSF), and Letter-Number-Sequencing were presented. Here, however, “file 2” was played in the background comprising uninterrupted sequences of random numbers.
- Upon completion of the entire distraction procedure, the client was asked how he or she felt about this experience. Relevant comments were noted, and a visual analogue scale was presented for rating stress levels.
- The “distraction procedure” was additional to testing under standard conditions. Selected sub-tests of the WMS-IV were presented twice: under quiet conditions and with controlled environmental distraction. The order of presentation was randomised.
- Learning effects for LM were controlled by presenting alternative stimuli.

3.1.3. Managing practice effects on re-testing Logical Memory.

Testing of clients both in the standard condition and the distraction condition essentially constitutes a test/re-test setting, which can bear the risk of incurring learning effects. This risk is relatively small in the number repetition/ordering tests (DSF, DST) and the Number Letter Sequencing Task (LNS), as participants are unlikely to learn and recall random multi-digit-numbers after a singular exposure. In contrast, re-testing participants’ recall of short stories presents a considerable challenge. The stimulus stories of the WMS LM are easily remembered even after a considerable time gap between first exposure and re-testing (Wechsler, 2009). Here it is necessary to utilise alternative stories with identical formal characteristics which can be presented interchangeably with the original Wechsler stories. Regrettably, a comprehensive literature research and enquiries with relevant test-publishers confirmed that such equivalent stories with empirically proven equivalence for key populations of neurocognitive research do not exist. The issue of controlling learning effects, however, presented a critical and decisive methodological hurdle, which
required to be addressed comprehensively, otherwise, the main study was unable to proceed further.

The first part of this research project was therefore dedicated to resolving this key methodological challenge, which required a theoretical investigation of the concepts ‘re-assessment’ and ‘practice effects,’ development of alternative test stimuli, and empirical validation of the alternative stories on a sufficiently large clinical sample, comprising clinical populations identical to the groups investigated in the prospective main study. The following chapter presents, in summarised form, the quest of overcoming the challenge of re-testing logical memory. It also includes a copy of the first of two major peer-reviewed journal articles published from this PhD.
This article identifies the risk of incurring practice-effects in neuropsychological re-assessments, in particular, when re-testing logical memory. Clients often remember the commonly used stimulus stories of the Wechsler Memory Scales (WMS) in subsequent re-assessments. Insufficiently controlled practice-effects could result in improved test scores on re-assessment and falsely be interpreted as recovery when, in fact, the underlying cognitive function has remained unchanged or deteriorated. Alternative stimulus stories for logical memory tests are needed for research and clinical practice. This study undertook the development and statistical evaluation of a new set of logical memory stories that can be utilised inter-changeably with the traditional Wechsler stories. Highly compatible structural and statistical properties to the WMS stories were demonstrated on a large clinical sample (n= 240), comprising three equally sized study groups: mTBI, MDE, and a control group.

The following article was published in the peer-reviewed journal *The Clinical Neuropsychologist* (TCN). *The Clinical Neuropsychologist* is the official journal of The American Academy of Clinical Neuropsychology. It is designed to provide a forum for presentations and discussions of matters central to the concerns of clinical neuropsychologists, including conceptual aspects of assessment, brain function, and injury, as well as clinical issues including assessment, treatment, and new measurement techniques. The journal is leading in proving a highly publicised platform for innovation in neuropsychology. TCN has an impact factor of 2.075. It is published by Psychology Press. Ralf Schnabel (2012) is the sole author of this publication. The copyrights for this article are held by the Taylor & Francis Group. An electronic copy of this article can be obtained though the following link:

Overcoming the Challenge of Re-assessing Logical Memory

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Practice effects present a challenge for neuropsychological re-assessments. Insufficiently controlled test-learning effects could result in “improved” test scores on re-assessment, which could wrongly be interpreted as recovery when in fact the underlying cognitive function has remained unchanged or deteriorated. Logical memory is highly sensitive to practice effects. Clients often remember the commonly used stimulus stories of the Wechsler Memory Scales (WMS) in subsequent re-assessments. Therefore alternative test stimuli are needed for research and clinical practice. This study undertook the development and statistical evaluation of a new set of logical memory stories, which can be utilised interchangeably with the traditional Wechsler stories. Empirical testing with different client groups (n = 240) confirmed that the newly created test stimuli have highly compatible structural and statistical properties to the WMS stories.

Keywords: Practice effect; Neuropsychological assessment; Logical memory; Wechsler Memory Scale.

INTRODUCTION

“Practice effects” or “test-learning effects” can impact on test scores and compromise the validity of a neuropsychological re-assessment (McCaffrey, Duff, & Westervelt, 2000; McCaffrey, Ortega, & Haase, 1993). Improved performance on cognitive testing may be mistaken as “significant recovery” or “positive response to treatment” when in fact the client remembers their previous assessment and the test stimuli involved, and performs quite well based on the training effect of a previous assessment (Goldberg, Keefe, Goldman, Robinson, & Harvey, 2010).

Various factors have been shown to mitigate the likelihood of practice effects, including the characteristics of the specific test (McCaffrey et al., 2000), the time span between initial and subsequent testing (Salthouse, Schroeder, & Ferrer, 2004), and the level of the clients’ impairment (Lezak, Howieson, & Loring, 2004). The risk for incurring practice effects decreases when a longer time interval between test and re-test is observed, and when the degree of memory impairment is profound; nevertheless, statistically significant practice effects may still occur after 18 months even in cognitively challenged client groups (Heaton, Gladsjo, et al., 2001).

A growing body of literature has emerged analyzing the test/re-test problem from a statistical perspective and offering guidance in interpreting score changes on repeated testing. The Reliable Change Index (Jacobson & Truax, 1991) and the Reliability-Stability Index (Chelune, Naugle, Luders, Sedlak, & Awad, 1993) provide formulae by which a change in an individual’s score on repeated testing can
be judged as statistically significant. Increasingly complex procedures have since been developed to control for confounds such as practice effects and regression-to-mean by introducing constants for the expected practice effect and by using regression models. A synopsis of methods was provided by Collie, Darby, Falleti, Silbert, and Maruff (2002). Efforts to statistically determine and control practice effects were made by Martin et al. (2002) and Sawrie, Chelune, Naugle, and Luders (1996). The authors analyzed test/re-test data of intractable-epilepsy sufferers on the waiting list for receiving surgery (n=42 and 51, respectively) and determined the raw score improvement on re-testing for different neuropsychological tests. “Corrected Reliable Change” indices were then calculated by factoring in the predicted test-learning effect for each sub-test. Restrictions in the generalizability of the constant apply due to high variability of practice effects for individual clients and sub-tests, fixed re-test intervals, and the use of a small and very specific clinical population. Heaton, Temkin, et al. (2001) investigated test/re-test reliabilities and practice effects of the Halstead-Reitan Battery (Dikmen, Heaton, Grant, & Temkin, 1999) and of older versions of the Wechsler Adult Intelligence Scale (Wechsler, 1955, 1981), based on different populations, including a large non-clinical participant group (n = 384), a group with schizophrenia (n = 69), and a group with recent brain trauma (n = 33). Despite similarities across samples in reliability coefficients and practice effects, norms for change did not generalize adequately from non-clinical to clinical groups. In comparing different methods of establishing change, the more complex regression-based prediction models did not prove to be superior compared to the practice-effect-corrected Reliable Change Index. Using a substantial sample of older clients (n = 445), Duff et al. (2005) presented data on test/re-test stability and practice effects of the Repeatable Battery for the Assessment of Neuropsychological Status (Randolph, 1998). No significant practice effects were found based on a re-test interval of over 1 year.

Suggestions have been made that practice effects could be minimized by presenting alternative test stimuli. Regrettably, many established tests do not offer either parallel versions of the tests or alternative stimuli for re-testing (Lezak et al., 2004). Examples of tests with parallel test stimuli include the Rey Auditory-Verbal Learning Test (Schmidt, 1996; Spreen & Strauss, 1998) and the California Learning Test (Delis, Kaplan, Kramer, & Ober, 2000; Spreen & Strauss, 1998); both are list-learning tests of random words or categorized words. Here alternate word lists are available (Lezak et al., 2004, pp. 422–434; Uchiyama et al., 1995). Less satisfactory are tests for which an alternative stimulus exists, in principle, but comprehensive norms only apply to the initial version, not the alternative stimulus. An example is the Rey Complex Figure Test (Meyers & Meyers, 1995), a test for visual comprehension and memory, for which an alternative but insufficiently co-validated stimulus is available (Taylor, 1969). In the absence of empirical data confirming equivalence of initial and alternative stimuli the use of alternative stimuli is restricted to qualitative screening (Hubley, 2010).

A particular challenge that has remained insufficiently resolved applies to logical memory, most commonly appraised by presenting a set of short stories that have to be repeated by the client immediately following narration by the health practitioner and also after a 30-minute delay. Commonly used test stimuli involve short, “catchy” storylines with clear themes and a number of emotive details, which
bear considerable risks of being remembered in subsequent re-assessments. The popular Logical Memory Test of the Wechsler Memory Scale (WMS) comprises two stories, one of which has remained unchanged in the last three editions of the test battery. This spans a period of 23 years of regular updates to norms, although the easily learned test stimulus has been retained (Wechsler, 1987, 1997, 2009). Furthermore, the second stimulus story has remained essentially unchanged since the previous revision in 1997. The authors on the Technical and Interpretive Manual of the WMS-IV point out the substantial improvements in scores on repeated presentation of the WMS stimulus stories. After a time interval of 14 to 84 days (mean of 23 days) a representative adult sample of 173 examinees improved on second testing by 1.9 standard score points (0.63 SD) for immediate recall and 2.3 (0.77 SD) for delayed recall (Wechsler, 2009, pp. 50–51). Based on the continued use of the widely known WMS stories, most clinicians in neuropsychological practice can remember a number of clients asking: "Are you going to read me that story again with the woman who got robbed?"

Faced with the challenge of re-assessing logical memory in the light of likely practice effects, attempts have been made to develop alternative test stimuli. Morris, Kunka, and Rossini (1997) devised two stories that matched the WMS stories in the number of semantic units, emotive tone, and readability. In a sample of 50 undergraduate students, moderate levels of correlation were found between individual stories, ranging from .44 to .63. The usefulness of these alternative stories is limited due to colloquial idioms, such as “quarterback”, and the injury-related content of both stories, such as “it took seventeen stitches to close the wound”. Another problematic issue is the restriction of the study to students (mean age of 21.6 years) and the relatively small sample size, which do not allow conclusions about the value of these alternative stories in clinical populations.

A further attempt was made by Sullivan (2005), where six stories with matching lexical and linguistic characteristics were developed and colloquialisms were eliminated through external reviewers. All of the six new stories and the two WMS standard stories were presented to a sample of 32 undergraduate psychology students (mean age of 21 years). Subsequently, three pairs of new stories were created using the six stories by grouping together stories which, when combined as a pair, were most comparable to the pair of WMS stories. Sullivan reported similar means of remembered items for the three pairs of new stories (28.3, 28.5, and 28.9), and the published WMS-R mean (25.7) for the examined age group. As in the study by Morris et al. (1997), uncertainty remains regarding the compatibility of new and standard stories in clinical populations, given the use of a small, young, and academic test sample. Furthermore, Sullivan did not publish the actual alternate stories, reporting only on the procedure of stimulus creation and the statistical findings; hence these cannot be replicated in clinical settings.

The most recent attempt to provide alternate forms of logical memory was presented by Cunje, Molloy, Standish, and Lewis (2007). The authors developed three very short stories (“paragraphs”), unrelated to the WMS. Each of their stories comprised a short description of an animal’s activity (“The red fox ran across the ploughed field”) followed by two sentences describing the natural environment surrounding the animal. Encouraging levels of consistency were documented for the three stories in different client groups, including, mild cognitive impairment
(n = 45), dementia (n = 55), and controls (n = 46). This consistency was demonstrated both for immediate and delayed recall. The stories were not designed as alternate stimuli to the WMS stories, but served the specific research interest of the authors who were investigating cognition in different clinical populations. Accordingly no age norms are available for these new stories, and the results cannot be used to calculate compounded memory indices provided by the WMS.

The current study sought to address the need for the availability of empirically validated test stimuli that can be used as alternatives to the established WMS stories in clinical populations. This will be beneficial in addressing the concerns regarding uncontrolled practice effects both in clinical practice and research settings.

METHOD

Development of alternative test stimuli

Logical memory in the WMS-IV is assessed by presenting two test-stories, each story consisting of 25 separate semantic entities in the format of congruent, sequential, and emotionally engaging, but non-threatening storylines. The total items remembered from both stories are summed together, resulting in a raw score between 0 and 50. The items recalled are noted at two time-points: immediately after presentation (immediate recall) and with a 20- to 30-minute delay (delayed recall). We developed two alternative stories with similar formal characteristics, each containing 25 semantic items and involving a coherent, plausible, and moderately emotive narrative. A peer review was undertaken to confirm cultural appropriateness of the story lines and the vocabulary used, including absence of colloquialisms.

A small pilot study (n = 60) was undertaken to ensure ease of readability and comprehension of the stories. In addition, objective scoring criteria for each semantic unit were established. Inter-scorer reliability was assessed by audio-taping the responses of 20 clients for the standard and new stories and then presenting the recordings to two health professionals for independent scoring. An acceptable inter-scorer reliability (r = .97) was observed. A structural comparison between the WMS standard stories and newly developed stories demonstrated similar but non-identical linguistic characteristics (Table 1).

Table 1. Formal and linguistic parameters of WSM IV standard stories and new stories

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Standard stories</th>
<th>New stories</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A-story</td>
<td>B-story</td>
</tr>
<tr>
<td>Words (n)</td>
<td>65</td>
<td>86</td>
</tr>
<tr>
<td>Characters (n)</td>
<td>278</td>
<td>388</td>
</tr>
<tr>
<td>Sentences (n)</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Words per sentence (mean)</td>
<td>21.6</td>
<td>17.2</td>
</tr>
<tr>
<td>Characters per word (mean)</td>
<td>4.1</td>
<td>4.4</td>
</tr>
<tr>
<td>Passive sentences (%)</td>
<td>33</td>
<td>0</td>
</tr>
<tr>
<td>Flesch Reading Ease</td>
<td>74.2</td>
<td>63.4</td>
</tr>
<tr>
<td>Flesch-Kincaid Grade Level</td>
<td>8.2</td>
<td>8.6</td>
</tr>
</tbody>
</table>
Compared to the pair of standard stories, the pair of new stories was found to have slightly fewer words, shorter sentences, and was generally easier to understand according to the Flesch-Kincaid Grade Level and the percentage of passive sentences. The Flesch Reading Ease scores were largely identical for standard and new stories. Given the similarities noted in the number of items recalled between standard and new stories in the pilot study, no further alterations were made. The final versions of the two new stories and their scoring criteria are presented in Table 2.

Participants

A total of 160 clinical clients were recruited from a community-based Psychological Assessment and Rehabilitation Centre in Auckland, New Zealand, over a period of 18 months. This consisted of 80 clients with mild Traumatic Brain Injury (mTBI) and 80 clients with Major Depressive Episode (MDE). A control group of 80 healthy volunteers was recruited informally.

Clients were included in the mTBI sample when they were referred with such a diagnosis made by a multi-disciplinary team, based on standard diagnostic parameters (Carroll et al., 2004; Ruff et al., 2009). The criteria comprise a traumatic disruption of brain function, as manifested by at least one of the following: any loss of consciousness, any loss of memory for events immediately before or after the accident, any alteration in mental state at the time of the accident, and focal neurologic deficit(s) that may or may not be transient. The diagnostic parameters further include that the injury-related loss of consciousness does not exceed 30 minutes; an initial Glasgow Coma Scale score of 13–15 needs to be obtained after 30 minutes, and post-traumatic amnesia of less than 24 hours needs to be documented. All clients included in the sample were in the post-acute stage, ranging between 2 to 10 months post-injury at the time of assessment. None of the mTBI clients had a current or historic diagnosis of mental health disorder; none of the mTBI clients had a history of acquired brain injury (other than the current mTBI), including previous significant TBI, cerebral vascular accident, tumour, neuro-toxic exposure, HIV, dementia, or other cerebral conditions. Clients with mTBI who were suspected of extending incomplete test-effort according to the criteria of the Test of Memory Malingering (TOMM; Tombaugh, 2003) were excluded from the sample.

Clients with MDE were included in the study upon referral under such diagnosis according to DSM-IV TR criteria (American Psychiatric Association, 2000), assessed by the client’s general practitioner (general medical officer) and confirmed separately by a psychiatrist. MDE was the only mental health diagnosis at the time of the assessment. For 77.5% of clients selected for the study this was their first formally diagnosed depressive episode. For 22.5% of the depression sample the current MDE represents a relapse; this sub-group can, by DSM IV TR definition, be classified as suffering a MDE in the context of a Major Depressive Disorder. This sample did not include clients in the depressive cycle of a diagnosed bipolar disorder. About 9% of clients had a previous anxiety disorder diagnosis. None of the clients had a history of psychotic disorder, including schizophrenia, or a
### Table 2. Alternative test stories

<table>
<thead>
<tr>
<th>Item</th>
<th>Criteria</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Logical Memory Story A</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Maria</td>
<td>Maria or variation of name</td>
<td>0 1</td>
</tr>
<tr>
<td>2. Anderson</td>
<td>Anderson required</td>
<td>0 1</td>
</tr>
<tr>
<td>3. was a law student</td>
<td>Indication being a student/scholar of law</td>
<td>0 1</td>
</tr>
<tr>
<td>4. at Otago University,</td>
<td>Otago University or University in Dunedin</td>
<td>0 1</td>
</tr>
<tr>
<td>5. She and her two friends</td>
<td>Indication two other people joined her</td>
<td>0 1</td>
</tr>
<tr>
<td>6. Anna and</td>
<td>Anna or variation of name</td>
<td>0 1</td>
</tr>
<tr>
<td>7. Michael</td>
<td>Michael or variation of name</td>
<td>0 1</td>
</tr>
<tr>
<td>8. went skiing</td>
<td>Indication of any type of snow sport</td>
<td>0 1</td>
</tr>
<tr>
<td>9. in Queenstown</td>
<td>Queenstown required</td>
<td>0 1</td>
</tr>
<tr>
<td>10. over the winter holidays.</td>
<td>Indication of any type of vacation in the cold season</td>
<td>0 1</td>
</tr>
<tr>
<td>11. They arrived in the afternoon,</td>
<td>Indication of arrival in the afternoon</td>
<td>0 1</td>
</tr>
<tr>
<td>12. checked into their hotel</td>
<td>Indication of going to hotel</td>
<td>0 1</td>
</tr>
<tr>
<td>13. and went out for dinner.</td>
<td>Indication of going out for an evening meal</td>
<td>0 1</td>
</tr>
<tr>
<td>14. This night</td>
<td>Indication that it happened on the day of arrival</td>
<td>0 1</td>
</tr>
<tr>
<td>15. Maria fell ill</td>
<td>Indication of sickness</td>
<td>0 1</td>
</tr>
<tr>
<td>16. with fever,</td>
<td>Indication of elevated body temperature</td>
<td>0 1</td>
</tr>
<tr>
<td>17. nausea,</td>
<td>Indication of nausea of any type</td>
<td>0 1</td>
</tr>
<tr>
<td>18. headache,</td>
<td>Indication of pain/ache affecting the head</td>
<td>0 1</td>
</tr>
<tr>
<td>19. and stomach cramps.</td>
<td>Indication of stomach cramps or pain</td>
<td>0 1</td>
</tr>
<tr>
<td>20. The doctor advised her</td>
<td>Indication of medical attention</td>
<td>0 1</td>
</tr>
<tr>
<td>21. to stay in bed</td>
<td>Indication of bed-rest</td>
<td>0 1</td>
</tr>
<tr>
<td>22. for two days</td>
<td>Two days required</td>
<td>0 1</td>
</tr>
<tr>
<td>23. and to drink tea.</td>
<td>Indication of drinking tea</td>
<td>0 1</td>
</tr>
<tr>
<td>24. Maria recovered quickly</td>
<td>Indication of timely recovery</td>
<td>0 1</td>
</tr>
<tr>
<td>25. enjoying the rest of her holiday.</td>
<td>Indication of successful continuation of holiday</td>
<td>0 1</td>
</tr>
<tr>
<td><strong>Logical Memory Story B</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Amanda</td>
<td>Amanda or variation of name</td>
<td>0 1</td>
</tr>
<tr>
<td>2. Wright</td>
<td>Wright required</td>
<td>0 1</td>
</tr>
<tr>
<td>3. was driving</td>
<td>Indication of driving</td>
<td>0 1</td>
</tr>
<tr>
<td>4. to the supermarket in her</td>
<td>Indication of shopping-related destination</td>
<td>0 1</td>
</tr>
<tr>
<td>5. blue</td>
<td>Blue required</td>
<td>0 1</td>
</tr>
<tr>
<td>6. Toyota</td>
<td>Toyota required</td>
<td>0 1</td>
</tr>
<tr>
<td>7. along Church Road,</td>
<td>Church Road or Church Street required</td>
<td>0 1</td>
</tr>
<tr>
<td>8. when she saw</td>
<td>Indication of noticing visually</td>
<td>0 1</td>
</tr>
<tr>
<td>9. a white</td>
<td>White required</td>
<td>0 1</td>
</tr>
<tr>
<td>10. limousine.</td>
<td>Indication of stretch-vehicle</td>
<td>0 1</td>
</tr>
<tr>
<td>11. She was excited</td>
<td>Indication of emotional arousal</td>
<td>0 1</td>
</tr>
<tr>
<td>12. thinking this may be a celebrity’s car</td>
<td>Indication of famous person</td>
<td>0 1</td>
</tr>
<tr>
<td>13. visiting her town</td>
<td>Indication of temporary visit</td>
<td>0 1</td>
</tr>
<tr>
<td>14. for a concert.</td>
<td>Indication of public performance</td>
<td>0 1</td>
</tr>
<tr>
<td>15. She slowed down</td>
<td>Indication of slowing her car</td>
<td>0 1</td>
</tr>
<tr>
<td>16. and tried to get a closer look.</td>
<td>Indication of trying to see celebrity</td>
<td>0 1</td>
</tr>
<tr>
<td>17. Just then</td>
<td>Indication of simultaneous event</td>
<td>0 1</td>
</tr>
<tr>
<td>18. her two</td>
<td>Two required</td>
<td>0 1</td>
</tr>
<tr>
<td>19. young</td>
<td>Indication of youth</td>
<td>0 1</td>
</tr>
<tr>
<td>20. children,</td>
<td>Indication of children</td>
<td>0 1</td>
</tr>
<tr>
<td>21. sitting in their back seats,</td>
<td>Indication of back seat or back of the car</td>
<td>0 1</td>
</tr>
<tr>
<td>22. started quarrelling.</td>
<td>Indication of quarrel, or becoming noisy</td>
<td>0 1</td>
</tr>
<tr>
<td>23. She told them</td>
<td>Indication of Amanda verbally attending to her children</td>
<td>0 1</td>
</tr>
<tr>
<td>24. to be quiet,</td>
<td>Indication of request to behave</td>
<td>0 1</td>
</tr>
<tr>
<td>25. and continued her trip.</td>
<td>Indication of continuation of trip</td>
<td>0 1</td>
</tr>
</tbody>
</table>
personality disorder. Participating MDE clients had no history of acquired brain injury, including brain trauma, or other diagnosed cerebral conditions.

Inclusion criteria for the control group were absence of current or past mental health disorders (of any type), and absence of current or past acquired brain injury. Participants from all three groups had not been previously exposed to cognitive testing and were presented with the standard and new stories for the first time. The specific clinical client groups were chosen for this study as they are frequently subjected to neuro-cognitive research, are highly prevalent clinical populations, and were accessible to the author.

**Design and procedure**

The sets of WMS-IV standard stories and new stories were presented, in random order, to clients with MDE \( n = 80 \), clients with mTBI \( n = 80 \), and members of a control sample \( n = 80 \), resulting in a total of 240 participants. Each client was given both standard stories and both new stories, whereby the order of presentation was alternated between consecutive clients. For instance, the first client was presented with the two new stories followed by the two standard stories, and the next client first heard the two standard stories followed by the two new stories. Within each set of stories the order was not varied; the first standard story was always followed by the second standard story, in accordance with the instructions of the WMS-IV test manual; correspondingly, the first new story was always followed by the second new story. Clients were asked to re-tell each sub-story immediately after hearing it. After recording the number of items recalled by the client, the next sub-story was presented. Less than 2 minutes elapsed between noting the recall of each sub-story and presenting the next sub-story. The stories of both sets were presented without a substantial break between sets. In accordance with the WMS-IV test instructions, raw scores were calculated by adding the number of items remembered from both sub-stories. After a 20–30 minute delay clients were asked to again re-tell standard and new stories, and the number of correct items was recorded for each set. For each client four raw scores were obtained: immediate recall of standard and new stories, and delayed recall of standard and new stories. The conversion of raw scores into scaled scores was undertaken based on the client’s age at the time of the assessment and the WMS-IV conversion tables. The WMS-IV subtask Logical Memory Recognition was not presented for either standard or new stories.

**Statistical methods**

Each set of stories (standard and new) resulted in two types of recall scores: raw scores (number of items remembered) and scaled scores (age-weighted). Stratified by client group (mTBI, MDE, controls), correlation analyzes between recall scores for the standard stories and new stories were done separately for immediate and delayed recall. A mixed model ANOVA was used to explore the within-participant (new vs standard stories) and between-participant relationships (MDE, mTBI, controls), separately for each of the raw and scaled logical memory scores (immediate and delayed). Mixed model and independent sample \( t \)-tests were
used to analyze the impact of education, age, and gender on immediate and delayed recall, both for standard and new stories. Wilcoxon rank sums tests were employed to investigate how the order of presentation of story sets impacted on scores. These analyses were done using PASW/SPSS version 18 (IBM Corporation, New York, USA).

RESULTS

Broadly consistent with the epidemiological distribution of the diagnostic categories is the apparent gender bias in this sample (American Psychiatric Association, 2000; Rickels, von Wild, & Wenzlaff, 2010; Tagliaferri, Compagnone, Korsic, Servadei, & Kraus, 2006). Men were significantly more frequently represented in the mTBI group, while the MDE groups had a significantly higher proportion of females than males (Table 3). The MDE group was significantly older than the mTBI and control groups. In addition, participants in the MDE group were significantly more highly educated than those in the MTBI and control groups; they had the highest proportion of participants (32.5%) with 16 or more years of education.

Table 3. Participants’ sociodemographic characteristics by study group

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>MDE (n = 80)</th>
<th>mTBI (n = 80)</th>
<th>Controls (n = 80)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean ± SD)</td>
<td>48.9 ± 9.1*</td>
<td>44.6 ± 11.6</td>
<td>40.4 ± 14.0</td>
</tr>
<tr>
<td>Age (min/max)</td>
<td>22–65</td>
<td>28–64</td>
<td>16–69</td>
</tr>
<tr>
<td>Gender (n, %)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>49 (61.3)</td>
<td>26 (32.5)**</td>
<td>44 (55.0)</td>
</tr>
<tr>
<td>Male</td>
<td>31 (38.8)***</td>
<td>54 (67.5)</td>
<td>36 (45.0)</td>
</tr>
<tr>
<td>Years of education (n, %)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 8</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>5 (6.3)</td>
</tr>
<tr>
<td>9 to 11</td>
<td>2 (2.5)</td>
<td>9 (11.3)</td>
<td>15 (18.8)</td>
</tr>
<tr>
<td>12</td>
<td>24 (30.0)</td>
<td>31 (38.8)</td>
<td>30 (37.5)</td>
</tr>
<tr>
<td>13 to 15</td>
<td>28 (35.0)</td>
<td>30 (37.5)</td>
<td>21 (26.3)</td>
</tr>
<tr>
<td>≥ 16</td>
<td>26 (32.5)****</td>
<td>10 (12.5)</td>
<td>9 (11.3)</td>
</tr>
<tr>
<td>min/max</td>
<td>11–28</td>
<td>8–23</td>
<td>7–20</td>
</tr>
<tr>
<td>Ethnicity (n, %)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caucasian</td>
<td>75 (93.8)****</td>
<td>56 (70.0)</td>
<td>63 (78.8)</td>
</tr>
<tr>
<td>Maori/Pacific</td>
<td>2 (2.5)</td>
<td>17 (22.3)****</td>
<td>9 (11.3)</td>
</tr>
<tr>
<td>Asian</td>
<td>2 (2.5)</td>
<td>5 (6.3)</td>
<td>3 (3.8)</td>
</tr>
<tr>
<td>Other</td>
<td>1 (1.3)</td>
<td>1 (1.3)</td>
<td>5 (6.3)</td>
</tr>
</tbody>
</table>

MDE, Major Depressive Episode.
mTBI, Mild Traumatic Brain Injury.
$p^* < .005$; MDE group is older than mTBI and control group.
$p^{**} < .005$; fewer women in mTBI group than in other groups.
$p^{***} < .005$ fewer men in MDE group than women.
$p^{****} < .005$; education ≥ 16 years occurs more frequently in MDE group than in other groups.
$p^{*****} < .005$; Caucasian more frequent in MDE group; Pacific/Maori more frequent in the mTBI group.
of education. The mTBI and control groups had more comparable levels of education. This educational bias in favor of the MDE group appears to be due to different referring agencies from which the clinical samples were sourced. In New Zealand blanket cover is provided by the National Accident Compensation Corporation for TBI and other personal injuries, resulting in clients with varying socio-economic levels being referred for assessment. In contrast, comprehensive neuro-cognitive assessment for depression is accessible mostly to clients with private insurance cover or private funds. The suspected socio-economic bias of the MDE group is further confirmed by the ethnic distribution, comprising the significantly highest number of Caucasian clients. In contrast, Maori/Pacific clients are significantly more frequently represented in the mTBI group than in other groups. The control group is well consistent with the ethnic distribution of the New Zealand population (Statistics New Zealand, 2010).

Within each study group the distributions of logical memory scores obtained from immediate and delayed assessments were comparable for WMS standard stories and the new stories developed in the present study (Table 4). This was demonstrated for the raw and scaled scores. Some differences were noted between different client groups, whereby the MDE and control group obtained similar results; the mTBI group obtained significantly lower scores in immediate and delayed recall. Both sets of stories (standard and new) demonstrated these group differences equally.

A mixed model ANOVA was used to explore the within-participants (new vs standard stories) and between-participants (MDE, mTBI, controls) relationships. There were no differences in immediate or delayed logical memory scores between the standard and new stories (within-participants differences) \((p > .88)\), and effect sizes were small—immediate raw score \((\eta^2 = .001)\), immediate scaled score \((\eta^2 = .003)\), delayed raw score \((\eta^2 = .001)\), delayed scaled score \((\eta^2 < .001)\). Differences between the diagnostic groups (MDE, MTBI, control) were significant \((p < .001)\), but the effect sizes were small to medium—immediate recall raw score \((\eta^2 = .034)\), immediate recall scaled score \((\eta^2 = .038)\), delayed recall raw score \((\eta^2 = .091)\), delayed recall scaled score \((\eta^2 = .074)\).

In addition, Pearson correlations computed for the logical memory scores from the standard and new stories (raw scores and scaled scores) demonstrated very strong correlations in all three client groups and for both recall modalities (Table 5). The correlation coefficients ranged from .79 to .94, documenting high concurrent validity.

With regard to the order of presentation of story-sets (standard followed by new stories, or new followed by standard stories) Wilcoxon rank sums tests documented no overall differences in raw scores and scaled scores for both immediate and delayed recall. Standard and new stories equally confirmed that younger participants recalled more items (raw scores) than older participants immediately after story presentation \((p < .05)\) and with 30 minutes delay \((p < .05)\); no difference between stories was documented \((p > .35)\). No age-related impact on scaled scores was found both according to standard and new stories (difference between age groups: \(p > .63\); difference between stories: \(p > .39\)). No gender differences were found either for immediate \((p > .66)\) or for delayed recall
### Table 4. Differences between standard and new stories and between study groups

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<th>Logical memory</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Min/max</th>
<th>Mean</th>
<th>SD</th>
<th>Min/max</th>
<th>p</th>
<th>MDE group</th>
<th>mTBI group</th>
<th>Control group</th>
<th>p**</th>
<th>MDE group</th>
<th>mTBI group</th>
<th>Control group</th>
<th>p***</th>
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<td>9.40</td>
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</table>

MDE, Major Depressive Episode.  
mTBI, Mild Traumatic Brain Injury.  
*p* Difference between standard and new stories.  
*p** Difference between study groups (MDE, mTBI, control) according to standard stories.  
*p*** Difference between study groups (MDE, mTBI, control) according to new stories.
A significant impact of clients’ levels of education on story-recall was noted, comparing less-educated clients (12 years or less) with more-educated clients (more than 12 years). Higher-educated clients performed significantly better both in immediate and delayed recall than less-educated clients ($p < .01$). This effect was demonstrated equally by standard and new stories ($p > .63$).

**DISCUSSION**

The results demonstrate that the newly created test stimuli have compatible structural and statistical properties as the established stories of the WMS-IV logical memory test for three clinical groups evaluated. Consistently high levels of compatibility were demonstrated for MDE, mTBI, and healthy control participants, representing focal areas of neuropsychological interest. Compatibility was also shown for different points of recall; that is, immediate recall and delayed recall of the newly acquired verbal (logical) information. Very high levels of correlation in raw scores and scaled scores were demonstrated between standard stories and new stories for the three groups and two points of assessment. Analyzing raw and scaled scores there were no significant differences between the standard and new stories, irrespective of whether recall was assessed immediately or after a 30-minute delay, within any of the study groups. Clinical application extending beyond the demographic characteristics of the current samples should be considered experimental at this time, and further clinical validation is needed.

Limitations of this study include a possible socio-economic bias of the MDE group with a disproportionately high representation of Caucasian and well-educated participants. While the mTBI and Control group are comparatively well matched in ethnicity and education to their respective reference populations, the use of a solely New Zealand test population may reduce the generalizability of results.
No comparison of standard and new stories had been undertaken for the sub-test Logical Memory Recognition. It should also be considered that scaled scores for the new stories were calculated based on the WMS-IV normative sample (Wechsler, 2009). There are insufficient data to assert that raw scores for the new stories will universally correspond to the score distribution provided by the WMS-IV normative sample for the standard stories. Furthermore the clinical samples did not include clients aged 16–21 years or older than 65 years, suggesting that additional validation efforts be undertaken for these age groups. Clearly clinicians should not derive demographically adjusted norms (e.g., correcting for education, gender and ethnicity) for the new logical memory stimuli using the Advanced Clinical Solutions (NCS Pearson, 2009) normative information. Further validation with different clinical samples and a greater diversity of healthy normative peers, particularly ethnic minorities, is needed.

It is worth noting, however, that even excellent alternative test stimuli provide no blanket protection against practice effects. Although learning of test material is the most obvious pitfall, Goldberg et al. (2010) pointed out that practice effects can occur as a result of decreasing test anxiety, having greater familiarity with the test settings, procedural learning, and improvement in test-taking strategy. In a double-blind, placebo-controlled pharmaceutical study, moderate improvements on repeated testing were documented even on a test (verbal list learning) in which alternative stimuli were used (Keefe et al., 2008). Goldberg et al. (2010) suggest that additional efforts are required to address the risk of practice effects unrelated to stimulus learning. Such efforts could include a period of surrogate testing or lead-in testing at the beginning of the assessment to increase clients’ familiarity with the testing procedure, both from the perspective of anxiety management and from operational competency of clients on how to strategically approach test tasks.

REFERENCES


3.2. Participants

Having resolved the problem of re-testing logical memory, it was possible to return to the main research topic, the exploration of distractibility and enter the empirical stage. 240 participants were recruited, comprising 80 clients with mTBI and 80 clients with a current diagnosis of MDE, who were referred to a community-based Psychological Assessment and Rehabilitation Centre in Auckland, and a sample of 80 healthy volunteers (Control Group), who were recruited informally. None of the participants in the main research study had taken part in the previously reported study “Overcoming the challenge of re-assessing Logical Memory” (Schnabel, 2012). The recruitment period for participants of the three study groups was from 2010 to 2012. Clinical clients were included in the study in consecutive order, as they attended their assessments in the Centre. Members of the control group were recruited informally throughout the empirical stage of the study (convenience sample) and included sequentially. All participants gave informed consent for participating in the assessment (clinical consent) and for the use of the data obtained in the study (research consent). All participants fulfilled the inclusion/exclusion criteria set out below.

Clients were included in the mTBI sample when they were referred with such diagnosis made by a multi-disciplinary team based on standard diagnostic parameters, (Carroll et al., 2004; Ruff et al., 2009). The criteria comprised traumatic disruption of brain function as manifested by at least one of the following: any loss of consciousness, any loss of memory for events immediately before or after the accident, any alteration in mental state at the time of the accident, and any focal neurologic deficit(s) that may or may not be transient. The diagnostic parameters further included that the injury-related loss of consciousness did not exceed 30 minutes. An initial Glasgow Coma Scale score of 13–15 needed to be obtained after 30 minutes, and post-traumatic amnesia of less than 24 hours needed to be documented.

For 74 clients of the mTBI sample, comprehensive medical records were available that noted GCS scores between 10 and 15 upon arrival in hospital\(^1\) (mean 14.2, Standard Deviation [SD] 1.3). All clients suffered LOC, with estimates ranging from 3 to 30 minutes (mean 9 min, SD 6 min). Length of PTA was formally documented for only 62 clients, and was less than 24 hours in all cases. 59 clients received a CT Brain scan; for 27 clients changes were identified on imaging which were treated conservatively. None of the mTBI clients had a pre-existing history of epilepsy; 8 clients suffered epileptic seizures either at the scene of the injury (6 clients) or within one month following the injury (2 clients). 31 clients had previous concussions or minor mTBI; however, none of these injuries had

\(^1\)In 9 cases GCS scores below 13 were documented upon admission, which improved in A&E upon medical stabilisation within 30 minutes
resulted in significant or prolonged symptoms. For all clients, post-injury headaches, dizziness, fatigue, and concentration problems were recorded on file; these symptoms were confirmed as ongoing concerns at the time of the assessment. All mTBI clients were assessed between 54 to 129 days (mean 88 days, SD 21 days) post injury. None of the mTBI clients had a formal psychiatric history or a history of acquired brain injury, including previous TBI (of any severity), cerebral vascular accident, tumour, neurotoxic exposure, HIV, dementia, or other diagnosed cerebral conditions. The assessment was undertaken in the context of rehabilitation planning, not as part of a medico-legal dispute. All clients had an established claim with the national Accident Compensation Corporation; about one third of the sample had additional claims with private insurance companies and cover decisions were pending. The Test of Memory Malingering [TOMM] (Tombaugh, 2003) was presented to all participants; 11 mTBI clients failed the criteria by a wide margin (means 34.39, and 31, respectively for sub-tests) and were therefore not included in the sample. Recruiting continued until a target sample size of n=80 had been reached. The mean TOMM scores for the mTBI sample were 49.6, 50, and 50, respectively. Within the scope of mTBI definition, the sample recruited would rank in the “middle” to “upper-end” of severity, with at least one third of the sample presenting with formal complications (prolonged LOC, low initial GCS, seizures, abnormalities on CT imaging). It is also important to highlight that the study sample was selected from the minority of clients with mTBI, who presented to hospital-based emergency services and who continued to experience neurocognitive changes for longer than a few weeks post injury.

Clients with MDE were included in the study upon referral under such diagnosis according to DSM-IV TR criteria (American Psychiatric Association, 2000) assessed by the respective client’s general practitioner (general medical officer) and confirmed separately by a psychiatrist. MDE clients were referred for Neuropsychological Assessment by the Case Managers of their insurance companies in order to identify depression-related cognitive impairment, to assist with rehabilitation planning, and consider options for a return to work.

For 52.5% of clients selected for the study, this was their first formally diagnosed depressive episode; for the remaining 47.5 the current episode was a relapse of symptoms in the context of a major depressive disorder. The sample did not include clients in the depressive cycle of a diagnosed bipolar disorder. 12.5 percent of clients had a previous anxiety disorder diagnosis. None of the clients had a history of psychosis or a diagnosed personality disorder. Participating MDE clients had no history of acquired brain injury, including brain trauma, or other diagnosed cerebral conditions. All members of the MDE sample had been commenced on a stable regime of antidepressant medication, either on selective serotonin reuptake inhibitors (SSRI) [61 clients], serotonin-
norepinephrine reuptake inhibitors (SNRI) [15 clients] or combined tricyclic (TCA) and SSRI medication [4 clients].

Inclusion criteria for the control group were the absence of current or past mental health disorders (of any type) and the absence of current or past acquired brain injury, other than trivial concussions. All members of the control group and of the MDE group met the TOMM criteria for sufficient test effort. Participants from either group had not been previously exposed to comprehensive neurocognitive testing.

Members of the two clinical groups (mTBI, MDE) participated in a comprehensive Neuropsychological Assessment in accordance with their referral to the Centre. The psychometric assessment procedure included numerous single tests, test-batteries, and evaluation instruments, including Beck Depression Inventory II (BDI II), Anxiety and Depression Scale (HADS), Depression Anxiety and Stress Scale (DASS21), Wechsler Adult Intelligence Scale (WAIS-IV), Wechsler Memory Scale-III (WMS-III/IV), Rey Complex Figure Test (RCTF), Controlled Verbal Association Test (COWAT), Behavioural Dyscontrol Scale (BDS), Stroop Colour Test (STROOP), Test for Memory Effort (TOMM), Wisconsin Card Sorting Test (WCST), National Adult Reading Test (NART II), Delis–Kaplan Executive Function System (D-KEFS), and other psychometric tools as required. These tests were presented in the same sequence for all clinical participants. Sub-tests relevant to this research project were administered about 30 minutes after the start of the assessment. For the present study only the results of specified sub-tests and test conditions were relevant.

Members of the control group only underwent the specified sub-tests and test conditions, relevant to the research project, but not additional comprehensive cognitive testing.

3.3 Design and procedure

Three sub-tests of the WAIS-IV (DSF, DST, and LNS) and one sub-test of the WMS-IV (LM) were chosen for presentation with and without distraction. The common link of the selected sub-tests is a working memory component that was expected to be affected by distraction. DSF and DST were overlapping measures; DSF is a fully integrated sub-task (singularity) of the DST, a comprehensive compound-test, which additionally included Digit Span Backwards and Ascending Digit Span. While not independent measures, DSF, DST, and LNS represented increasing levels of complexity, ranging from simple, to mixed-simple and complex, to very complex. The above tests are presented, with and without distraction, to clients with mTBI (n=80), clients with MDE (n=80) and a control sample (n=80), resulting in a total of 240 subjects. Each client was tested twice in the distraction condition and in the standard condition. The order in which the conditions were presented was changed between consecutive clients, so that the first client took part in the distraction setting followed by the standard setting, and the second client was presented with
standard testing followed by distraction testing. Within the four sub-tests, the order was not varied; LM was always followed by DSF, DST, and LNS. Alternative test stimuli and standard test stimuli for LM were presented in randomised order, using the “coin flipper”-application of a random-generation website (Haahr, 2002).

No significant amount of time elapsed between standard testing and distraction testing. Both raw scores and scaled scores were calculated. The conversion of raw scores into scaled scores was undertaken based on the client’s age at the time of the assessment and the WMS-IV/WAIS-IV conversion tables. Subjective levels of distress posed by the standard and distraction conditions were obtained immediately after each condition was completed, using a 10 point Visual Analogue Scale (VAS). Scores on a clinical depression scale, Beck Depression Inventory 2nd Edition (BDI-II) (Beck, Steer, & Brown, 1996) were obtained for all participants prior to commencing testing.

3.4. Statistical methods

Biases in the distribution of gender, age, ethnicity and education in the sample were explored using Chi square analysis. A mixed-model Analysis of Variance (ANOVA) was used to explore the within-subject (standard vs. distraction condition) and between-subject relationships (MDE, mTBI, Controls) separately for each test (LM, DSF, DST, LNS). Both raw and scaled scores were analysed. Independent Sample T-Tests were used to analyse the impact of education, age, and gender on change of performance in the experimental condition for all sub-tests. Independent Sample T-tests were also employed to investigate whether the order of testing conditions (standard setting followed by distraction setting, or distraction setting followed by standard setting) impacted on the scores obtained. Pearson correlations were conducted for exploring the relationship between BDI-II scores and the change in test performance under the distraction condition. All analyses were performed using PASW/SPSS version 18 (IBM Corporation, New York, USA).

Summary

A practical, replicable, and standardised distraction condition that allowed controlled exposure to environmental distraction and observation of changes in clients’ performances was developed and refined. Test achievements in quiet and distracting conditions could be compared directly. The performances of 240 clients from three equally sized study groups, MDE, mTBI, and controls, were examined both in the standard and the distraction setting. Between-group comparison and within-subject comparison were undertaken. Additional measures included a VAS for subjective stress levels in each condition and a depression scale (BDI-II).
4. Results

Consistent with a higher prevalence of depression amongst women (American Psychiatric Association, 2000), 60% of the MDE sample was female. Equally consistent with the epidemiological distribution of mTBI (Rickels, von Wild, & Wenzlaff, 2010; Tagliaferri, Compagnone, Korsic, Servadei, & Kraus, 2006) was the higher representation of male clients in the mTBI group (61%). The control group was selected to have equal gender balance. Maori and Pacific Islanders were over-represented in the mTBI sample (25%), consistent with the elevated incidence-rate of mTBI in this ethnic group in New Zealand (New Zealand Guidelines Group, 2006). The control group is consistent with the ethnic distribution of the New Zealand population (Statistics New Zealand, 2010) (see Table 1).

Table 1

Participants’ Sociodemographic Characteristics by Study Group

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<th>Characteristics</th>
<th>MDE</th>
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<td>mTBI (n=80)</td>
<td>(n=80)</td>
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<td>Age (mean ± SD)</td>
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<td></td>
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<td>Female</td>
<td>48 (60.0)**</td>
<td>31 (38.8)</td>
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<td>Male</td>
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<td>49 (61.3)**</td>
<td>40 (50.0)</td>
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<td>8 (10.0)</td>
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<td>6 (7.5)</td>
</tr>
</tbody>
</table>

MDE, Major Depressive Episode
mTBI, Mild Traumatic Brain Injury
p* < .05; MDE group older than mTBI group
p** < .05; Female over-represented in MDE group,
\[\text{Male over represented in mTBI group}\]
p*** < .05; Maori/Pacific over-represented in mTBI group
Baseline testing of the different study groups in the controlled condition revealed overall similar achievements in most tests for all three groups, apart from LNS where MDE clients held an advantage over mTBI clients. The distraction condition impacted markedly on achievements of clients with mTBI, resulting in substantial decline of performance in all sub-tests. For participants of the control group only marginal decrease of test performance was noted in the distraction condition. In contrast, clients with MDE were found to improve their performance in the distraction condition on most sub-tests. The described changes were demonstrated equally for raw scores and for scaled scores (see Table 2).
Table 2

Test Scores Derived from Standard and Distraction Setting by Study Group

<table>
<thead>
<tr>
<th>Tests by study group</th>
<th>Standard Condition</th>
<th>Distraction Condition</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Logical Memory</td>
<td>80</td>
<td>26.60</td>
<td>5.57</td>
</tr>
<tr>
<td>Digit Span Forward</td>
<td>80</td>
<td>10.45</td>
<td>1.61</td>
</tr>
<tr>
<td>Digit Span Total</td>
<td>80</td>
<td>28.44</td>
<td>3.54</td>
</tr>
<tr>
<td>Letter-Number-Seq.</td>
<td>80</td>
<td>21.03</td>
<td>2.54</td>
</tr>
<tr>
<td>Logical Memory</td>
<td>80</td>
<td>10.59</td>
<td>2.02</td>
</tr>
<tr>
<td>Digit Span Forward</td>
<td>80</td>
<td>9.88</td>
<td>1.74</td>
</tr>
<tr>
<td>Digit Span Total</td>
<td>80</td>
<td>10.34</td>
<td>1.68</td>
</tr>
<tr>
<td>Letter-Number-Seq.</td>
<td>79</td>
<td>10.94</td>
<td>1.92</td>
</tr>
<tr>
<td>Logical Memory</td>
<td>80</td>
<td>23.06</td>
<td>5.10</td>
</tr>
<tr>
<td>Digit Span Forward</td>
<td>80</td>
<td>10.18</td>
<td>1.97</td>
</tr>
<tr>
<td>Digit Span Total</td>
<td>80</td>
<td>25.71</td>
<td>4.51</td>
</tr>
<tr>
<td>Letter-Number-Seq.</td>
<td>37</td>
<td>17.27</td>
<td>3.76</td>
</tr>
<tr>
<td>Logical Memory</td>
<td>80</td>
<td>9.18</td>
<td>2.24</td>
</tr>
<tr>
<td>Digit Span Forward</td>
<td>80</td>
<td>9.78</td>
<td>2.09</td>
</tr>
<tr>
<td>Digit Span Total</td>
<td>80</td>
<td>9.09</td>
<td>1.92</td>
</tr>
<tr>
<td>Letter-Number-Seq.</td>
<td>37</td>
<td>8.24</td>
<td>2.20</td>
</tr>
<tr>
<td>Logical Memory</td>
<td>80</td>
<td>27.36</td>
<td>5.92</td>
</tr>
<tr>
<td>Digit Span Forward</td>
<td>80</td>
<td>10.55</td>
<td>1.93</td>
</tr>
<tr>
<td>Digit Span Total</td>
<td>80</td>
<td>27.48</td>
<td>5.19</td>
</tr>
<tr>
<td>Letter-Number-Seq.</td>
<td>76</td>
<td>19.94</td>
<td>2.98</td>
</tr>
<tr>
<td>Logical Memory</td>
<td>80</td>
<td>10.24</td>
<td>2.54</td>
</tr>
<tr>
<td>Digit Span Forward</td>
<td>80</td>
<td>10.19</td>
<td>2.36</td>
</tr>
<tr>
<td>Digit Span Total</td>
<td>80</td>
<td>9.99</td>
<td>2.55</td>
</tr>
<tr>
<td>Letter-Number-Seq.</td>
<td>76</td>
<td>10.31</td>
<td>2.69</td>
</tr>
</tbody>
</table>

MDE, Major Depressive Episode
mTBI, Mild Traumatic Brain Injury
p* Difference between study groups in standard condition
p** Difference between study groups in distraction condition
p*** Intra-subject difference between standard condition and distraction condition
The above demonstrated change of performance for each study group becomes easily apparent in Figure 3.

Figure 3
Change of Performance in Standard vs. Distraction Condition (n=240)

MDE; Major Depressive Disorder
mTBI; Mild Traumatic Brain Injury
LM; Logical Memory Test
DSF; Digit Span Forward
DST; Digit Span Total

A mixed-model ANOVA showed significant differences (p < 0.001) and medium to large effect sizes (eta² values between 0.07 and 0.49) on within-subject comparison of performances in the two testing conditions. In comparing performances of different study groups (between-subject comparison) again significant differences (p < 0.001) and large effect sizes (eta² values between 0.23 and 0.38) were obtained. Each comparison of the performances of the study groups revealed that the cognitive tests differ in usefulness and differential power. LM and DST produced the largest changes of performances in the distraction setting (raw score: eta² = 0.12 and 0.17; mean differences = 3.03 ± 3.83 and 2.49 ± 2.83, respectively). The within-subject performance on DSF still varied significantly with distraction, albeit to a lesser degree (eta² = 0.07; mean differences = 1.40 ± 1.20) (see Table 3).
The highly demanding LNS-test did not provide useful measurements: a substantial number of participants (20% MDE, 54% mTBI, 56% Control) abandoned working on the LNS-test in distraction setting, as they felt overwhelmed. The significant drop-out rate for LNS makes this sub-test not a viable option for distraction testing. LNS has subsequently been excluded from further analysis.

Consistent with our expectations, the study groups differed significantly in their reported symptoms of depression on the BDI-II. The depression group scored in the range of “moderately severe” symptoms (27.25 ± 5.99); the mTBI\(^2\) clients obtained scores in the “mild” range (16.61 ± 6.92), and control subjects in the “minimal” range (3.48 ± 3.25). In analysing the relationship between BDI-II scores and change of performance under distraction, significant correlations were noted in the MDE sample. In the MDE group, clients with higher BDI-II scores were found to achieve greater improvement in the distraction condition (r = .32 for LM, r = .44 for DSF). No significant

\(^2\) It is important to note the overlap between PCS symptoms and the BDI-II questions, including ambiguous items such as “concentration difficulties,” “problems with decision-making,” “low energy,” “fatigue,” “irritability,” etc. MTBI clients inevitably score in the “mild symptom range” on the BDI-II when they endorse common PCS symptoms.
correlation between BDI-II scores and change of performance was documented for either mTBI or control group (see Table 4).

Table 4
Pearson Correlation between BDI-II Score and Changes in Performance (within subjects) by Study Group (raw scores)

<table>
<thead>
<tr>
<th>Tests by Study Group (raw scores)</th>
<th>n</th>
<th>Within-Subject Changes between Standard and Distraction Condition (mean/SD)</th>
<th>BDI-II Scores</th>
<th>Pearson Correlation Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>MDE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Logical Memory</td>
<td>80</td>
<td>3.03* ± 3.83</td>
<td>27.25** ±</td>
<td>.32**</td>
</tr>
<tr>
<td>Digit Span Forward</td>
<td>80</td>
<td>1.40* ± 1.20</td>
<td>5.99</td>
<td>.44**</td>
</tr>
<tr>
<td>Digit Span Total</td>
<td>80</td>
<td>2.49* ± 2.83</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mTBI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Logical Memory</td>
<td>80</td>
<td>-6.36* ± 4.91</td>
<td>16.61** ±</td>
<td>-.13</td>
</tr>
<tr>
<td>Digit Span Forward</td>
<td>80</td>
<td>-2.46* ± 1.96</td>
<td>6.92</td>
<td>-.08</td>
</tr>
<tr>
<td>Digit Span Total</td>
<td>80</td>
<td>-6.14* ± 4.15</td>
<td></td>
<td>-.05</td>
</tr>
<tr>
<td>Controls</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Logical Memory</td>
<td>80</td>
<td>-.14 ± 4.13</td>
<td>3.48** ±</td>
<td>-.14</td>
</tr>
<tr>
<td>Digit Span Forward</td>
<td>80</td>
<td>-.10 ± .95</td>
<td>3.25</td>
<td>-.05</td>
</tr>
<tr>
<td>Digit Span Total</td>
<td>80</td>
<td>-.56 ± 2.05</td>
<td></td>
<td>-.07</td>
</tr>
</tbody>
</table>

p* < .001 within subject difference between conditions
p** < .01 correlation between change of performance and BDI-II scores
MDE, Major Depressive Episode
mTBI, Mild Traumatic Brain Injury
BDI-II, Beck Depression Inventory 2nd Version

Subjective Levels of Stress (VAS) under the distraction condition were explored for different sub-groups within the clinical sample. In contrast to their actual performance, MDE clients considered the distraction setting significantly more distressing than the mTBI clients. No significant gender differences were noted in the appraisal of stress in all clinical groups. In comparing the stress levels of participants who abandoned the letter-number-sequencing-tasks under the distraction condition with participants who completed this task, greater stress was reported by those participants who had continued exposure (see Table 5).
Table 5

*Differences in Stress-Levels under Distraction Condition for Different Groups*

<table>
<thead>
<tr>
<th>Stress Levels (VAS)</th>
<th>Groups</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MDE n=80</td>
<td>mTBI n=80</td>
<td>Female n=128</td>
<td>Male n=132</td>
<td>Complete LNS n=142</td>
<td>Incomplete LNS n=108</td>
</tr>
<tr>
<td>mean ± SD</td>
<td>6.58 ± 1.56</td>
<td>5.23 ± 1.64</td>
<td>5.36 ± 1.74</td>
<td>5.45 ± 2.05</td>
<td>5.82 ± 1.83</td>
<td>4.86 ± 1.87</td>
</tr>
<tr>
<td>Mean Difference</td>
<td>1.35*</td>
<td>.09</td>
<td>.96*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p < .001 (2-tailed)

MDE, Major Depressive Episode
mTBI, Mild Traumatic Brain Injury
LNS, Letter Number Sequencing Test
VAS, Visual Analogue Scale

With regard to the order of test conditions (standard setting followed by distraction setting, or distraction setting followed by standard setting) no significant differences were found between orders in either of the tests (LM, DSF, DST). No gender bias was demonstrated with regards to performance under distraction. No age bias was noted: the effect of distraction was not significantly different for older participants (43 years or older) than for younger participants (younger than 43 years). No significant mitigation effect was noted with regards to education: highly educated participants (more than 12 years of education) were equally affected by the distraction setting as less educated participants (12 or less years of education). This was demonstrated for all measures (LM, DSD, DST), both for raw scores and scaled scores (see Table 6).
Table 6

Change of Performance (Standard vs. Distraction Condition) by Education, Gender, and Age

<table>
<thead>
<tr>
<th>Years of Education</th>
<th>Gender</th>
<th>Age</th>
<th>Order of Test Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 12 Years (n=129)</td>
<td>Male (n=121)</td>
<td>Female (n=119)</td>
<td>&lt; 43 Years (n=115)</td>
</tr>
<tr>
<td>&gt; 12 Years (n=111)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tests</th>
<th>Mean</th>
<th>SD</th>
<th>Mean</th>
<th>SD</th>
<th>p</th>
<th>Mean</th>
<th>SD</th>
<th>p</th>
<th>Mean</th>
<th>SD</th>
<th>p</th>
<th>Mean</th>
<th>SD</th>
<th>p</th>
<th>Mean</th>
<th>SD</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changes in LM (Raw Scores)</td>
<td>1.96</td>
<td>4.87</td>
<td>1.14</td>
<td>6.65</td>
<td>.27</td>
<td>2.31</td>
<td>6.35</td>
<td>.83</td>
<td>5.01</td>
<td>.05</td>
<td>.05</td>
<td>2.07</td>
<td>5.2</td>
<td>.13</td>
<td>6.25</td>
<td>.20</td>
<td>.13</td>
</tr>
<tr>
<td>Changes in DSF (Raw Scores)</td>
<td>.38</td>
<td>1.83</td>
<td>.40</td>
<td>2.47</td>
<td>.95</td>
<td>.59</td>
<td>2.39</td>
<td>.18</td>
<td>1.85</td>
<td>.15</td>
<td>.15</td>
<td>.61</td>
<td>1.9</td>
<td>.18</td>
<td>2.30</td>
<td>.13</td>
<td>.13</td>
</tr>
<tr>
<td>Changes in DST (Raw Scores)</td>
<td>1.57</td>
<td>4.35</td>
<td>1.22</td>
<td>5.19</td>
<td>.57</td>
<td>1.57</td>
<td>4.97</td>
<td>1.24</td>
<td>4.53</td>
<td>.99</td>
<td>.99</td>
<td>1.85</td>
<td>4.1</td>
<td>.99</td>
<td>5.24</td>
<td>.16</td>
<td>.16</td>
</tr>
<tr>
<td>Changes in LM (Scaled Scores)</td>
<td>.60</td>
<td>2.14</td>
<td>.54</td>
<td>2.87</td>
<td>.86</td>
<td>.96</td>
<td>2.73</td>
<td>.18</td>
<td>2.19</td>
<td>.02</td>
<td>.02</td>
<td>.38</td>
<td>2.34</td>
<td>.38</td>
<td>2.63</td>
<td>.21</td>
<td>.21</td>
</tr>
<tr>
<td>Changes in DSF (Scaled Scores)</td>
<td>.49</td>
<td>2.36</td>
<td>.40</td>
<td>2.57</td>
<td>.77</td>
<td>.66</td>
<td>2.60</td>
<td>.23</td>
<td>2.28</td>
<td>.17</td>
<td>.17</td>
<td>.65</td>
<td>2.41</td>
<td>.26</td>
<td>2.49</td>
<td>.21</td>
<td>.21</td>
</tr>
<tr>
<td>Changes in DST (Scaled Scores)</td>
<td>.80</td>
<td>2.17</td>
<td>.62</td>
<td>2.64</td>
<td>.57</td>
<td>.82</td>
<td>2.55</td>
<td>.61</td>
<td>2.23</td>
<td>.51</td>
<td>.51</td>
<td>.89</td>
<td>2.11</td>
<td>.56</td>
<td>2.62</td>
<td>.29</td>
<td>.29</td>
</tr>
</tbody>
</table>

LM, Logical Memory I
DSF, Digit Span Forward
DST, Digit Span Total
The following chapter presents the research project “Neuropsychological Assessment of Distractibility in mild Traumatic Brain Injury and Depression” in form of a comprehensive stand-alone publication. It includes a copy of the second of the two major publications in a peer-reviewed journal from this PhD.

Summary

- **Baseline testing in the traditional, quiet setting documented broadly similar test achievements for the three study groups.**
- **On within-subject comparison, significant decrease of test achievements was documented for clients with mTBI in the distracting condition. Members of the control group did not change in their performances with distraction. Clients with MDE were found to improve with distraction.**
- **Significant between-group differences were documented in the distraction condition, with MDE performing best, followed by control group, and tailed by the mTBI group.**
- **No significant impact of gender, education, age, and order on test results was found.**
- **Despite their improved performance, the MDE group rated the distraction setting as significantly more distressing than the other groups. Higher depression scores correlated with greater improvement in the distraction condition in the MDE group.**
This article highlights concerns with regards to ecological validity of the standard neuropsychological assessment. Clients’ abilities to cope with environmental distractions are not routinely explored in neuropsychological assessments. The article documents the effects of a controlled environmental distraction on cognitive functioning for three client groups (N=240): (1) Clients with mTBI, (2) Clients with MDE, (3) Control Sample. Significant deterioration of performance in the distraction setting was documented for clients with mTBI. In contrast, the performance of a healthy control sample remained unchanged. Significant improvement of performance in the distraction setting was documented for clients with MDE. Test effort was controlled.

In recognition of the wide impact of The Clinical Neuropsychologist both in research and clinical practice with a broad world-wide readership, this article was submitted to this journal (impact factor 2.075) and, following peer review, accepted for publication in May 2012. This article was co-authored by Ralf Schnabel and Rob Kydd; a copy is included below (Schnabel & Kydd, 2012). The copyrights for this article are held by the Taylor & Francis Group. An electronic copy of this article can be obtained though the following link:


A research paper, based on this article, was presented by Ralf Schnabel on the World Congress of the International Neuropsychological Society (INS) in Oslo, Norway, June 27-30, 2012. The abstract of this presentation was published in the Journal of the International Neuropsychological Society (JINS) which has an impact factor of 2.77.
Neuropsychological Assessment of Distractibility in Mild Traumatic Brain Injury and Depression

Ralf Schnabel and Rob Kydd
Department of Psychological Medicine, University of Auckland, New Zealand

Traditional neuropsychological assessments are conducted exclusively in a quiet, distraction-free environment; clients’ abilities to operate under busy and distracting conditions remain untested. Environmental distractions, however, are typical for a multitude of real-life situations and present a challenge to clients with frontal-temporal brain injury. In an effort to improve ecological validity, an extension of the traditional neuropsychological assessment was developed, comprising a standardized distraction condition. This allowed cognitive functions to be tested both in the traditional setting and with exposure to a specified audio-visual distraction. The present study (n = 240) investigated how clients with mild Traumatic Brain Injury (mTBI) (n = 80), Major Depression (MDE) (n = 80), and a healthy control sample (n = 80) performed on sub-tests of the Wechsler Adult Intelligence Scale-IV and the Wechsler Memory Scale-IV both in the standard and the distraction conditions. Test effort was controlled. Significant deterioration of performance in the distraction setting was observed among clients with mTBI. In contrast the performance of a healthy control sample remained unchanged. Significant improvement of performance in the distraction setting was documented for clients with MDE. Contrary to their improved performance, depressed clients experienced the distraction setting as more distressing than the control and mTBI group.

Keywords: Environmental distraction; Neuropsychological assessment; Ecological validity; Traumatic brain injury; Major depressive episode.

INTRODUCTION

A large number of cognitive studies in the past decades investigating mild Traumatic Brain Injury (mTBI) have failed to document significant cognitive incapacity on formal testing (Binder, Rohling, & Larabee, 1997; Frencham, Fox, & Maybery, 2005; Rohling et al., 2011). These findings contrast the subjective appraisal of a sub-group of clients with mTBI who complain about a persistent constellation of cognitive, somatic, and emotional symptoms, typically described as “post-concussion syndrome” (PCS). The most commonly reported symptoms are physical and mental fatigue, headache, dizziness, decreased concentration, memory problems, irritability, sensitivity to noise and light, problems with decision making, depression, and anxiety (Rees & Bellon, 2007; Ryan & Warden, 2003). However, the construct of a PCS, neurologically related to mTBI, was challenged by the considerable overlap between the cognitive, physical, and emotional symptoms of PCS and the cluster of symptoms experienced by clients with chronic pain.
depression, and stress disorders (Iverson & McCracken, 1997; Iverson & Lange, 2003). High endorsement rates of “PCS” symptoms were documented even for healthy participants with no history of brain injury (Chan, 2001; Garden & Sullivan, 2010; Gunstad & Suhr, 2004; Iverson, 2006; Wang, Chan, & Deng, 2006; Wong, Regennitter, & Barrios, 1994). The authors concluded that there are non-neurological mechanisms in the experience and expression of PCS following brain trauma, and called for caution in the clinical interpretation of results from symptom inventories of PCS. This has further been endorsed by concerns about the validity of cognitive impairment following mTBI. Studies investigating the role of motivational factors for sub-optimum test performance in mTBI populations have acknowledged the context of litigation and secondary gain, and highlighted the need to control for poor test effort, malingering, and factitious disorders (Bush et al., 2005; Green, Rohling, Lees-Haley, & Lyle, 2001; Sollman & Berry, 2011).

In recognizing the lack of evidence for significant cognitive impairment even for motivated mTBI sufferers, the following methodological question arises: Is there no cognitive impairment after mTBI or has the established approach to testing and assessment failed to identify cognitive changes secondary to mTBI? For instance, newer brain-imaging techniques suggest that at least a subset of these patients may have diffuse axonal injury, not evident on standard CT or MRI scans (Bigler & Bazarian, 2010). In other words, how sure can we be that test results obtained with traditional tools in the laboratory-type environment of a standard assessment are sufficiently representative of the clients’ actual capacity; would an unimpaired performance on a concentration or memory test obtained in a quiet, distraction-free evaluation room be a valid predictor for unimpaired capacity of a client returning to a busy family or a workplace with multiple stimulation and complex attention demands? The question concerned is one of ecological validity, focusing on “transferability” of neuropsychological test results into other, potentially much more challenging, environments (Sbordone, 1996). The term veridicality (“truthfulness”) has come to be used for describing the degree to which the performance on neuropsychological tests predicts real-life performance (Franzen & Wilhelm, 1996), and a substantial body of research has emerged analyzing the relationship between test achievements and actual functional capacity. The overall findings suggest that a “modest” or “moderate” relationship exists between performance on neurocognitive testing and everyday functioning, depending on the specific neuropsychological tests utilized (Kibby, Schmitter-Edgecombe, & Long, 1998), the specific real-life capacity investigated (Marcotte, Scott, Kamat, & Heaton, 2010), the type of injury/incapacity (Chaytor & Schmitter-Edgecombe, 2003; Silverberg, Hanks, & McKay, 2007; Wood & Liossi, 2006), and the brain function analyzed (Chaytor & Schmitter-Edgecombe, 2003).

Given concerns that abstract, clerical tests may insufficiently relate to challenges typical of real-life, efforts were made towards developing test material with greater intuitive resemblance to tasks of daily life. Such tests present a model-task with formal or conceptual characteristics which are closely related to a key task in everyday life. The assumption here is that ecological validity would increase, based on the close relationship between the test-task and the real-world activity (Spooner & Pachana, 2006). The degree to which a test resembles or approximates a real-life situation has been described as the verisimilitude (“truth-likeness”) of a test.
Examples for tests with improved verisimilitude are the Hamburger Turning Test (Shugars, 2007), the Test of Everyday Attention (Bate, Mathias, & Crawford, 2001; Robertson, Ward, Ridgeway, & Nimmo-Smith, 1996), and the Zoo Map Test (Wilson, Alderman, Burgess, Emslie, & Evans, 2003), which include a number of “ecologically plausible” tasks, such as searching through telephone directories, operating a faux barbecue, and planning a strategic route on the map of a zoo. Even such practical tests, however, are conducted in a testing environment with minimized distractions and fall short of representing more than a small section of the cognitive challenges in real-life (Chaytor & Schmitter-Edgecombe, 2003; Long & Collins, 1997; Long & Kibby, 1995).

Previous research has highlighted that one of the most prominent features of acquired brain damage, specifically with frontal lobe impact, is clients’ inability to manage distractions imposed by complex, busy environments. Damage to the frontal lobes of the brain was demonstrated to correlate with deficits in working memory and inhibitory control in children and adolescents (Hartnedy & Mozzoni, 2000; Levin et al., 1993, 2002, 2004, 2008; Levin & Hanten, 2005). Similar association between frontal lobe brain damage and subsequent problems with attention control/distractions have been documented among adults (Brewer, 1998; Brewer, Metzger, & Therrien, 2002; Couillet et al., 2010; Knight, Titov, & Crawford, 2006; Krawczyk et al., 2008; Lutz, 1999; Trudel, Tryon, & Purdum, 1998).

Given the substantial body of evidence recognizing distractibility and inability for blocking out environmental distraction as a key feature of acquired brain injury, it is striking that the formal evaluation of clients’ capacity for managing environmental distractions has not been part of the clinical neuropsychological assessment. In order to obtain a more realistic picture of a client’s cognitive capacities in a real-life situation, it would seem desirable that at least some cognitive functions be tested not only in the quiet, concentrated setting of the standard assessment, but additionally with (controlled) exposure to environmental distraction. The expectation that clients with frontal lobe injuries perform significantly worse with environmental distraction, compared to their achievements in the noise-reduced, standard testing-condition, is investigated in the current study.

Problems with environmental distractibility are reported not only by clients with brain injuries of various causation and severity, but occur frequently in the context of mental health disorders, including depression (American Psychiatric Association, 2000, p. 356). Neuropsychological assessments are increasingly utilized for comprehensively assessing the cognitive impact of a client’s depression, for monitoring the progress of cognitive recovery (Elinson, Houck, Marcus, & Pincus, 2004), and for differential diagnosis between organic changes to the brain and depression (Attix & Welsh-Bohmer, 2005; Sweet, Newman, & Bell, 1992). Meta-analyses of depression-related cognitive impairment highlighted episodic memory and attention (Zakzanis, Leach, & Kaplan, 1999) and frontal lobe functions, encompassing executive functions and concentration/attention which, in turn, influence performance in other areas, such as memory (McClintock, Husain, Greer, & Cullum, 2010). Functional magnetic resonance imaging (fMRI) studies have suggested that these performance problems by clients with MDE are underpinned.
by altered neuronal functioning in the frontal lobe of the brain (Harvey et al., 2005; Hugdahl et al., 2007).

Consistent with tradition, neuro-cognitive assessments for clients with MDE are conducted solely in a quiet setting with minimized environmental distractions. In recognition that the engagement of frontal lobe functions, such as concentration and working memory, were found to be sub-optimum in low stimulation settings (McClintock et al., 2010), the current study examines the possibility for such decreased frontal lobe activation to be temporarily improved by exposure to a powerful environmental distraction during testing, resulting in enhanced performance. The expected effect is already well known in clinical settings. Depression-related rumination interferes with performance on academic tasks (Berman, 2010; Lyubomirsky, Kasri, & Zehm, 2003; Watkins & Brown, 2002). In contrast, task focus and test performance improve when depressed clients get temporarily distracted from thinking about their symptoms and problems (Donaldson & Lam, 2004). Therefore we expect the distraction condition to serve as an incentive for the depressed client to focus on the test task with positive effects on performance.

In analogy to everyday situations, a distraction condition as part of an extended neuropsychological assessment needs to comprise a primary attention task (focus task), preferably with known performance parameters under standard conditions, and a replicable audio-visual stimulation to create interference. Such a formalized distracting condition would be presented as a brief addition to the usual assessment procedure of not more than a few minutes and allow a direct comparison between performances under distraction and under standard conditions.

In summary, the current study had two main objectives. First, to develop a short, replicable, additional test condition that includes standardized auditory/visual distraction-stimuli; second, to examine the effect of this test condition on performance among mTBI and MDE patients and healthy controls.

METHOD

Testing of cognitive performance in a normative distraction condition

Development of an effective distraction condition. For this study we defined environmental distraction settings using two parameters: (1) a demanding primary attention task (focus task) in which the client is fully engaged and tries to remain fully engaged, and (2) a simultaneous, competitive environmental stimulation (distraction) which interferes with processing the primary attention task. The distraction has to be powerful enough to interfere with usual task processing in a measurable way without causing distress to the client. The stimulus has to bear close resemblance to distracting conditions commonly experienced in real-life situations to promote ecological validity (verisimilitude). For reasons of practicality, the distraction condition has to be easily reproducible by other clinicians in various clinical set-ups and short enough to ensure that the overall neuropsychological evaluation does not extend beyond more than 5 minutes in total.

In a pilot study different stimuli and physical set ups were trialed, including different auditory and visual distractions, different volumes, and different
sitting arrangements. Clients rated how the specific test setting matched the experience of a busy environment in their daily lives, and the impact of different set-ups on test performances was analyzed. It quickly became apparent that the condition rated as most “typical” and “natural” for daily life distractions involved auditory distraction by a visible speaker. Most of our initial clients confirmed that the interference imposed was greatest when test material and distraction material were similar. Clients who listened to a set of short stories, such as the “Logical Memory” (LM) stories of the Wechsler Memory Scale [WMS-IV] (Wechsler, 2009), found it most distracting when other prose was read out simultaneously in the background. Correspondingly, while working on number tests such as “Digit Span Forward” (DSF), “Digit Span Total” (DST), or “Letter/Number-Sequencing” (LNS) of the Wechsler Adult Intelligence Scale (WAIS-IV) (Wechsler, 2008), maximum distraction was imposed by presenting numbers in the background.

**Formal characteristics of the distraction condition.** In taking into consideration the clients’ feedback and the impact of different arrangements on test scores, defining parameters for an effective distraction setting were available. The format adhered to in this study is described below.

The seating of client and examiner, as well as other context variables of the test setting such as temperature, light, and sitting arrangement remained identical in the standard condition and the distraction condition. The distraction was provided by playing two specific computerized audio-visual recordings showing a woman reading a news item (“file 1”) and random numbers (“file 2”). The files were played on a laptop computer with a screen sized 365 mm x 205 mm (ø 16.5 inch) with an external speaker providing a sound level of 55 Db (+10 Db) for each file. The distraction story selected was rated as moderately interesting by both men and women without gender bias. The story line featured a non-violent robbery of diamonds narrated in easily understandable English. Readability parameters were broadly comparable to the WMS-IV LM stories, comprising a Flesch Reading Ease score of 50 and Flesch-Kincaid Grade score of 8.5. The laptop was positioned like a third person in an equilateral triangle, with a distance of approximately 1 meter (39 inches) from both client and examiner. After playing “file 1” (story file) for 8 seconds the examiner provided a short lead-in talk, comprising the following sentences (verbatim): “So, you now hear and see our distraction. I will keep talking over her voice for a while so you get used to this background noise. You do not have to look at the screen. You can look at me or somewhere else in the room if you like. When I start reading my story you only listen to my story. Try to ignore this background noise; just listen to me. OK, here is my first story.” The recording was stopped immediately after the examiner finished reading the first story of the WMS-IV LM sub-test. Thereafter the client was asked to report as many items he or she remembered from the story, in accordance with the WMS-IV test manual. After noting the client’s responses, the examiner resumed playing “file 1” in the background while reading out the second LM story. Once the reading was completed the examiner discontinued playing “file 1” and noted the client’s recall of the second story. Using a similar format, the WAIS IV sub-tests Digit Span Forward (DSF), Digit Span Total (DST), and Letter-Number-Sequencing (LNS) were presented. Here, however, “file 2” was played in the background comprising
uninterrupted sequences of random numbers. The distraction procedure was additional to testing under standard conditions. The specified sub-tests of the WMS-IV and WAIS-IV were presented twice, under quiet conditions and with controlled environmental distraction. The order of presentation, standard setting followed by distraction setting, and distraction setting followed by standard setting, was counterbalanced.

**Controlling practice effect when retesting logical memory.** Testing of clients both in the standard condition and the distraction condition essentially constitutes a test/retest setting which can bear the risk of incurring learning effects. This risk is relatively low in the number and number/letter repetition/ordering tests (DSF, DST, LNS), as clients are unlikely to learn and recall multi-digit random numbers after singular exposure. In contrast, the stimulus stories of the LM are easily remembered and require the use of alternative stories (Schnabel, 2012). An alternative set of stimulus stories with high structural and empirical compatibility with the WMS standard stories was recently published by Schnabel (2012) based on a large clinical sample ($N = 240$) of clients with mTBI, MDE, and a Control Group. The current study utilizes the LM standard stories and the alternative stories in the two test conditions to minimize practice effects.

**Participants**

A total of 240 clients were recruited for the present study, comprising 80 clients with mTBI and 80 clients with a current diagnosis of MDE who were referred to a community-based Psychological Assessment and Rehabilitation Centre in Auckland, and a sample of 80 healthy volunteers (control group) recruited informally.

Clients were included in the mTBI sample when referred with this diagnosis made by a multi-disciplinary team, based on standard diagnostic parameters (Carroll et al., 2004; Ruff et al., 2009). The criteria comprise traumatic disruption of brain function, as manifested by at least one of the following: any loss of consciousness, any loss of memory for events immediately before or after the accident, any alteration in mental state at the time of the accident, and focal neurologic deficit(s) that may or may not be transient. The diagnostic parameters further include that the injury-related loss of consciousness does not exceed 30 minutes; an initial Glasgow Coma Scale score of 13–15 needs to be obtained after 30 minutes, and post-traumatic amnesia of less than 24 hours needs to be documented. For 74 clients of the mTBI sample comprehensive medical records were available, which noted GCS scores between 10 and 15 upon arrival in hospital\(^1\) (mean 14.2, $SD = 1.3$); all clients suffered LOC, with estimations ranging from 3 to 30 minutes (mean 9 minutes, $SD = 6$ minutes). Length of PTA was formally documented only for 62 clients, and was less than 24 hours in all cases. A total of 59 clients received a CT brain scan, 27 for whom changes were identified on imaging which were treated conservatively. None of the mTBI clients had a pre-existing history of epilepsy, although eight clients suffered epileptic

\(^{1}\) In nine cases GCS scores below 13 were documented upon admission which improved in A&E upon medical stabilization within 30 minutes.
seizures either at the scene of the injury (six clients) or within 1 month following the injury (two clients). A total of 31 clients had previous concussions or minor mTBI, but none of these injuries had resulted in significant or prolonged symptoms. For all clients, post-injury headaches, dizziness, fatigue, and concentration problems were recorded on file; these symptoms were confirmed as ongoing concerns at the time of the assessment. All mTBI clients were between 54 to 129 days (mean 88 days, SD 21 days) post-injury at the time of assessment. None of the mTBI clients had a formal psychiatric history or a history of acquired brain injury, including previous significant TBI, cerebral vascular accident, tumor, neurotoxic exposure, HIV, dementia, or other diagnosed cerebral conditions. The assessment was undertaken in the context of rehabilitation planning and not as part of a medico-legal dispute. All mTBI clients had an established claim with the national Accident Compensation Corporation and about one third had additional claims with private insurance companies and cover decisions that were pending. The Test of Memory Malingering [TOMM] (Tombaugh, 2003) and additional clinical and psychometric measures for appraising test effort was presented to all participants; 11 mTBI clients failed the TOMM cut-off criterion (fewer than 45 recognitions on Trial 2) by a wide margin (means 34, 39, and 31, respectively for sub-tests) and were therefore not included in the sample. Recruiting continued until a target sample size of \( n = 80 \) was reached. The mean TOMM scores for the mTBI sample were 49.6, 50, and 50, respectively. Within the scope of mTBI definition, the sample recruited would rank in the middle to upper end of severity, with at least one third of the sample presenting with formal complications (prolonged LOC, low initial GCS, seizures, abnormalities on CT imaging). It is also important to highlight that the study sample was selected from the minority of clients with mTBI in the community, who presented to hospital-based emergency services and who continued to experience neuro-cognitive changes for longer than a few weeks post injury.

Clients with MDE were included in the study upon referral under such diagnosis according to DSM-IV TR criteria (American Psychiatric Association, 2000), assessed by the client’s general practitioner (general medical officer) and confirmed separately by a psychiatrist. For 52.5% of clients selected for the study this was their first formally diagnosed depressive episode; for the remaining 47.5% the current episode was a relapse of symptoms in the context of a major depressive disorder. The sample did not include clients in the depressive cycle of a diagnosed bipolar disorder. About 13% of clients had a previous anxiety disorder diagnosis. None of the clients had a history of psychosis or a diagnosed personality disorder. Participating MDE clients had no history of acquired brain injury, including brain trauma, or other diagnosed cerebral conditions. All MDE clients had an established claim with an insurance company, covering loss of income due to medical incapacity (“income protection insurance”), and the assessment was conducted solely for the purpose of rehabilitation planning.

Inclusion criteria for the control group were absence of current or past mental health disorders (of any type), and absence of current or past acquired brain injury, other than trivial concussions. All members of the control group and of the MDE group met the TOMM criteria for sufficient test effort. Participants from either group had not been previously exposed to comprehensive neuro-cognitive testing.
Design and procedure

Three sub-tests of the WAIS-IV (DSF, DST, and LNS) and one sub-test of the WMS-IV (LM) were chosen for presentation with and without distraction. The common link of the selected sub-tests is a working memory component which was expected to be affected by distraction. DSF and DST are overlapping measures; DSF is a fully integrated sub-task (singularity) of the DST, a comprehensive compound test, which additionally includes Digit Span Backwards and Ascending Digit Span. While not independent measures, DSF, DST, and LNS represent increasing levels of complexity, ranging from simple, to mixed simple and complex, to very complex. The current research project presented the above measures, with and without distraction, to clients with mTBI, with MDE and a control sample. Each client was tested twice, in the distraction condition and in the standard condition. The order in which the conditions were presented was counterbalanced, whereby the first client took part first in the distraction setting followed by the standard setting, and the second client was first presented with standard testing, followed by distraction testing. Within the four sub-tests the order was not varied; LM was always followed by DSF, DST, and LNS. Alternative test stimuli and standard test stimuli for LM were presented in a randomized counterbalanced order, using a random-generation website (Haahr, 2002).

No significant amount of time elapsed between standard testing and distraction testing. Both raw scores and scaled scores were calculated. The conversion of raw scores into scaled scores was undertaken based on the client’s age at the time of the assessment and the WMS-IV/WAIS-IV conversion tables. Subjective levels of distress imposed by the standard and distraction condition were obtained immediately after each condition was completed, using a 10 point Visual Analogue Scale (VAS). Scores on the Beck Depression Inventory 2nd edition (BDI-II) (Beck, Steer, & Brown, 1996) were obtained for all clients prior to commencing testing.

Statistical methods

Biases in the distribution of gender, age, ethnicity and education in the sample were explored using chi square analysis. A mixed-model ANOVA was used to explore the within-participants (standard vs distraction condition) and between-participants relationships (MDE, mTBI, Controls), separately for each test (LM, DSF, DST, LNS). Both raw and scaled scores were analyzed. Independent sample T-tests were used to analyze the impact of education, age, and gender on change of performance in the experimental condition for all sub-tests. Independent sample T-tests were also employed to investigate whether the order of testing conditions (standard setting followed by distraction setting, or distraction setting followed by standard setting) had an impact on the scores obtained. T-tests were also used to explore differences in the story presentation (first standard stories followed by alternative stories, or first alternative stories followed by standard stories). Furthermore it was investigated whether practice effects had occurred by comparing the means of performance in the first presentation with the means of the second presentation. Pearson correlations explored the relationship between
BDI-II scores and the change in test performance under the distraction condition. All analyses were performed using PASW/SPSS version 18 (IBM Corporation, New York, USA).

RESULTS

Consistent with the higher prevalence of depression among women (American Psychiatric Association, 2000), 60% of the MDE sample was female. Equally consistent with the epidemiological distribution of mTBI (Rickels, von Wild, & Wenzlaff, 2010; Tagliaferri, Compagnone, Korsic, Servadei, & Kraus, 2006) is the higher proportion of male clients in the mTBI group (61%). The control group was selected to have equal gender balance. Maori/Pacific-Islanders were over-represented in the mTBI sample (25%), consistent with the elevated incidence-rate of mTBI in these ethnic groups in New Zealand (New Zealand Guidelines Group, 2006). The control group is consistent with the ethnic distribution of the New Zealand population (Statistics New Zealand, 2010) (see Table 1).

Baseline testing of the different study groups in the controlled condition revealed overall similar achievements in most tests for all three groups, apart from LNS where MDE clients held an advantage over mTBI clients. The distraction condition impacted markedly on achievements of both mTBI and MDE clients.

Table 1. Participants’ sociodemographic characteristics by study group

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Study group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MDE (n = 80)</td>
</tr>
<tr>
<td>Age (mean ± SD)</td>
<td>44.7 ± 9.3*</td>
</tr>
<tr>
<td>Age (min/max)</td>
<td>23–60</td>
</tr>
<tr>
<td>Gender (n, %)</td>
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</tr>
<tr>
<td>Female</td>
<td>48 (60.0)**</td>
</tr>
<tr>
<td>Male</td>
<td>32 (40.0)</td>
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<tr>
<td>Years of education (n, %)</td>
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<tr>
<td>&lt;8</td>
<td>0 (0)</td>
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<tr>
<td>9 to 11</td>
<td>6 (7.5)</td>
</tr>
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<td>12</td>
<td>26 (32.5)</td>
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<tr>
<td>13 to 15</td>
<td>27 (33.8)</td>
</tr>
<tr>
<td>≥16</td>
<td>21 (26.3)</td>
</tr>
<tr>
<td>min/max</td>
<td>10–27</td>
</tr>
<tr>
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<td>Caucasian</td>
<td>69 (86.3)</td>
</tr>
<tr>
<td>Maori/Pacific</td>
<td>6 (7.5)</td>
</tr>
<tr>
<td>Asian</td>
<td>5 (6.3)</td>
</tr>
<tr>
<td>Other</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

MDE = Major depressive episode.
mTBI = Mild traumatic brain injury.
*p < .05; MDE group older than mTBI group.
**p < .05; Female over-represented in MDE group, male over-represented in mTBI group.
***p < .05; Maori/Pacific over-represented in mTBI group.
whereby, on a within-participants comparison, a significant deterioration of performance was noted with mTBI and a significant improvement was documented with MDE. For control participants no significant change of test performance was noted in the distraction condition. The described changes were demonstrated equally for raw scores and for scaled scores (see Table 2).

Significant differences between study groups were documented in the distraction setting, with MDE clients performing best, followed by Control and mTBI groups (Figure 1). A mixed-model ANOVA showed significant differences ($p < .001$) and medium to large effect sizes ($\eta^2$ values between 0.07 and 0.49) on

<table>
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<tr>
<th>Tests by study group</th>
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<tr>
<td>n</td>
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<td>SD</td>
<td>MDE</td>
<td>mTBI</td>
<td>Control</td>
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<td>MDE</td>
<td>mTBI</td>
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<tr>
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<td>5.57</td>
<td>-</td>
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<td>.40</td>
<td>80</td>
<td>29.63</td>
<td>5.15</td>
<td>-</td>
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<td>.33</td>
<td>.72</td>
<td>80</td>
<td>11.85</td>
<td>1.42</td>
<td>-</td>
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<td>.17</td>
<td>80</td>
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<td>.01</td>
<td>64</td>
<td>19.94</td>
<td>3.19</td>
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<td>.04</td>
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<td>.34</td>
<td>80</td>
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<td>.74</td>
<td>.34</td>
<td>80</td>
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<td>-</td>
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<td>80</td>
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<td>.01</td>
<td>64</td>
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<td>-</td>
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<td>.06</td>
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<td>-</td>
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<td>mTBI (Scaled Scores)</td>
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<tr>
<td>Logical Memory</td>
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<td>9.18</td>
<td>2.24</td>
<td>-</td>
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<td>9.09</td>
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<tr>
<td>Control (Raw Scores)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Logical Memory</td>
<td>80</td>
<td>27.36</td>
<td>5.92</td>
<td>-</td>
<td>&lt;.01</td>
<td>-</td>
<td>80</td>
<td>25.96</td>
<td>6.25</td>
<td>-</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Digit Span Forward</td>
<td>80</td>
<td>10.55</td>
<td>1.93</td>
<td>-</td>
<td>.72</td>
<td>.23</td>
<td>80</td>
<td>10.45</td>
<td>2.05</td>
<td>-</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Digit Span Total</td>
<td>80</td>
<td>27.48</td>
<td>5.19</td>
<td>-</td>
<td>&lt;.01</td>
<td>.02</td>
<td>80</td>
<td>26.91</td>
<td>5.48</td>
<td>-</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Letter-Number-Sequ.</td>
<td>76</td>
<td>19.94</td>
<td>2.98</td>
<td>-</td>
<td>&lt;.01</td>
<td>-</td>
<td>35</td>
<td>18.46</td>
<td>3.48</td>
<td>.04</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Control (Scaled Scores)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Logical Memory</td>
<td>80</td>
<td>10.24</td>
<td>2.54</td>
<td>-</td>
<td>&lt;.01</td>
<td>-</td>
<td>80</td>
<td>10.21</td>
<td>2.49</td>
<td>-</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Digit Span Forward</td>
<td>80</td>
<td>10.19</td>
<td>2.36</td>
<td>-</td>
<td>.34</td>
<td>.24</td>
<td>80</td>
<td>10.01</td>
<td>2.55</td>
<td>-</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Digit Span Total</td>
<td>80</td>
<td>9.99</td>
<td>2.55</td>
<td>-</td>
<td>&lt;.01</td>
<td>-</td>
<td>80</td>
<td>9.70</td>
<td>2.69</td>
<td>-</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Letter-Number-Sequ.</td>
<td>76</td>
<td>10.31</td>
<td>2.69</td>
<td>-</td>
<td>&lt;.01</td>
<td>-</td>
<td>35</td>
<td>9.37</td>
<td>2.61</td>
<td>.06</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

MDE = Major depressive episode.
mTBI = Mild traumatic brain injury.
*p Difference between study groups in standard condition.
**p Difference between study groups in distraction condition.
***p Intra-participant difference between standard condition and distraction condition.

Table 2. Test scores derived from standard and distraction setting by study group
within-participants comparison of performances in the two testing conditions. In comparing performances of different study groups (between-participants comparison), significant differences ($p < .001$) and large effect sizes (eta$^2$ values between 0.23 and 0.38) were obtained. Each comparison of the performances of the study groups found that the cognitive tests differ in usefulness and differential power. LM and DST produced the largest changes of performances in the distraction setting (raw score: eta$^2 = 0.12$ and 0.17; mean differences $= 3.03 \pm 3.83$ and $2.49 \pm 2.83$, respectively). The within-participants performance on DSF still varied significantly with distraction, albeit to a lesser degree (eta$^2 = 0.07$; mean differences $= 1.40 \pm 1.20$) (see Table 3). The highly demanding LNS test did not provide useful measurements: a substantial number of clients (20% MDE, 54% mTBI, 56% Control) abandoned working on the LNS test in distraction setting, as they felt overwhelmed. The significant drop-out rate for LNS makes this sub-test not a viable option for distraction testing. LNS scores were subsequently excluded from further analysis.

Consistent with expectations, BDI-II scores differed significantly between the three study groups, with MDE clients scoring in the “moderately-severe” range (mean 27.25 ± 5.99), mTBI$^2$ clients in the “mild” range (mean 16.61 ± 6.92), and control participants in the minimal range (mean 3.48 ± 3.25). In the MDE group clients with higher BDI-II scores were found to achieve greater improvement in the distraction condition ($r = .32$ for LM, $r = .44$ for DSF). No significant correlation

$^2$It is important to note the overlap between PCS symptoms and the BDI-II questions, including ambiguous items such as “concentration difficulties”, “problems with decision-making”, “low energy”, “fatigue”, “irritability” etc. MTBI clients inevitably score in the “mild symptom range” on the BDI-II when they endorse common PCS symptoms.
between BDI-II scores and change in performance was documented for the mTBI and Control group (see Table 4). Subjective Levels of Stress (VAS) under the distraction condition were explored for different sub-groups. In contrast to their actual performance, MDE clients considered the distraction setting significantly more distressing than the mTBI clients. No significant gender differences were noted.
in the appraisal of stress in all clinical groups. In comparing the stress levels of clients who abandoned the LNS tasks under the distraction condition with clients who completed this task, greater stress was reported by those clients who had continued exposure (see Table 5).

With regard to the order of test conditions (standard setting followed by distraction setting, or distraction setting followed by standard setting), no significant differences were found. Equally no significant differences were found between means of performance in the first presentation with the means of the second presentation of test stimuli of either sub-test, suggesting that no significant practice effects had occurred (Table 6).

No significant gender bias was demonstrated with regard to performance of most sub-tests under distraction (DSF and DST $p > .15$; LM $p = .05$ and .02). In addition the effect of distraction did not differ between older clients (43 years or older) and younger clients ($<43$ years old) ($p > .16$). Highly educated clients (more than 12 years of education) were equally affected by the distraction setting as less educated clients (12 or less years of education) ($p > .27$). This was demonstrated for all measures (LM, DSD, DST), both for raw scores and scaled scores (Table 7).

**DISCUSSION**

Although environmental distractibility is a well-known, often debilitating, feature of acquired brain injury the standard neuropsychological assessment investigates cognitive performance solely in a distraction-free environment. Traditionally clients’ abilities to manage environmental distractions have remained untested. The current study presents a short, standardized, and easily replicable distraction procedure which allows the examiner to study a client’s test performance with exposure to environmental distraction. The performances under the distraction condition and under the traditional, quiet condition can directly be compared. For a sample of mTBI clients, with injuries at the higher end of the mild category, significant decline was demonstrated in the distraction condition for working memory, including simple concentration (WAIS-IV DSF) and mixed simple/complex concentration (WAIS-IV DST) (overlapping with DSF), and for

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**Table 5. Differences in stress levels under Distraction condition for different groups**

<table>
<thead>
<tr>
<th>Groups</th>
<th>MDE</th>
<th>mTBI</th>
<th>Female</th>
<th>Male</th>
<th>Complete LNS</th>
<th>Incomplete LNS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stress levels</td>
<td>n=80</td>
<td>n=80</td>
<td>n=128</td>
<td>n=132</td>
<td>n=142</td>
<td>n=108</td>
</tr>
<tr>
<td>(VAS)</td>
<td>mean $\pm$ SD</td>
<td>mean $\pm$ SD</td>
<td>mean $\pm$ SD</td>
<td>mean $\pm$ SD</td>
<td>mean $\pm$ SD</td>
<td>mean $\pm$ SD</td>
</tr>
<tr>
<td></td>
<td>6.58 $\pm$ 1.56</td>
<td>5.23 $\pm$ 1.64</td>
<td>5.36 $\pm$ 1.74</td>
<td>5.45 $\pm$ 2.05</td>
<td>5.82 $\pm$ 1.83</td>
<td>4.86 $\pm$ 1.87</td>
</tr>
<tr>
<td>Mean difference</td>
<td>1.35*</td>
<td>.09</td>
<td>.96*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < .001 (2-tailed).

MDE = Major depressive episode.

mTBI = Mild traumatic brain injury.

LNS = Letter-Number-Sequencing Test.

VAS = Visual Analogue Scale.
<table>
<thead>
<tr>
<th>LM (Raw Scores)</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>p</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>p</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>p</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>p</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Standard then Distraction condition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WMS then Schnabel</td>
<td>60</td>
<td>25.23</td>
<td>6.07</td>
<td>0.84</td>
<td>60</td>
<td>23.97</td>
<td>6.99</td>
<td>0.78</td>
<td>60</td>
<td>25.80</td>
<td>5.30</td>
<td>0.72</td>
<td>60</td>
<td>24.27</td>
<td>8.82</td>
<td>0.91</td>
<td>0.60</td>
</tr>
<tr>
<td>Schnabel then WMS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Distraction then Standard condition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WMS then Schnabel</td>
<td>60</td>
<td>25.47</td>
<td>6.53</td>
<td>0.55</td>
<td>60</td>
<td>23.56</td>
<td>9.13</td>
<td>0.55</td>
<td>60</td>
<td>26.17</td>
<td>5.54</td>
<td>0.55</td>
<td>60</td>
<td>24.44</td>
<td>7.23</td>
<td>0.55</td>
<td>0.58</td>
</tr>
<tr>
<td>Schnabel then WMS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

*p Difference between order of condition.

**p Difference between order of stories in Standard condition.

***p Difference between order of stories in Distraction condition.
Table 7. Change of performance (Standard vs. Distraction condition) by Education, Gender, and Age

<table>
<thead>
<tr>
<th>Tests</th>
<th>Years of education</th>
<th>Gender</th>
<th>Age</th>
<th>Order of test setting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤12 years (n=129)</td>
<td>&gt;12 years (n=111)</td>
<td>Male (n=121)</td>
<td>Female (n=119)</td>
</tr>
<tr>
<td>Changes in LM (Raw Scores)</td>
<td>1.96 (4.87)</td>
<td>1.14 (6.65)</td>
<td>.27 (2.31)</td>
<td>.35 (6.35)</td>
</tr>
<tr>
<td>Changes in DSF (Raw Scores)</td>
<td>.38 (.83)</td>
<td>.40 (2.47)</td>
<td>.95 (.59)</td>
<td>.39 (2.39)</td>
</tr>
<tr>
<td>Changes in DST (Raw Scores)</td>
<td>1.57 (4.35)</td>
<td>1.22 (5.19)</td>
<td>.57 (1.57)</td>
<td>.49 (4.97)</td>
</tr>
<tr>
<td>Changes in LM (Scaled Scores)</td>
<td>.00 (.60)</td>
<td>.54 (2.87)</td>
<td>.86 (.96)</td>
<td>.27 (2.73)</td>
</tr>
<tr>
<td>Changes in DSF (Scaled Scores)</td>
<td>.49 (2.36)</td>
<td>.40 (2.57)</td>
<td>.77 (.66)</td>
<td>.26 (2.60)</td>
</tr>
<tr>
<td>Changes in DST (Scaled Scores)</td>
<td>.80 (2.17)</td>
<td>.62 (2.64)</td>
<td>.57 (.82)</td>
<td>.25 (2.55)</td>
</tr>
</tbody>
</table>

LM = Logical Memory I  
DSF = Digit Span Forward  
DST = Digit Span Total
logical memory (WMS-IV LM). No gender, education, or age biases were demonstrated. Motivational factors, including malingering, were excluded by employing clinical and psychometric procedures to establish the validity of the data obtained.

In contrast, participants from the control group did not present with significant changes of their test performance in the distraction condition. In full command of their regular cognitive capacities, healthy clients were able to “block out” the distracting stimuli without experiencing distress or decline in performance. It appears the specifics of the distraction setting and the WAIS-IV/WMS-IV sub-tests LM, DSF, and DST have struck the right balance to be sufficiently challenging for impacting on the performance in mTBI clients, but to be manageable enough for healthy clients to achieve essentially unchanged results. Such balance was not attained in the sub-test LNS which turned out to be unachievable in the distraction setting for both healthy and brain-injured clients, producing an unacceptable dropout rate.

Significantly, depressed clients were shown to improve in the distraction condition on three measures: LM, DSF, and DST. An investigation of stress levels experienced by MDE clients in the distraction setting demonstrated significantly higher stress levels compared to the other groups. Although the additional challenge of environmental distraction caused rising stress levels in all study groups, the increase of distress was greatest for the MDE group. Qualitatively, clients with depression described the distraction condition as “unbearable” and “terrible”, and often became tearful, despite their substantial improvement in test achievements. It appears that the distraction condition provided a “boost” and temporary lifted performance close to pre-morbid capacities, albeit at great costs for the client in terms of personal exertion and frustration. Of course these findings do not suggest that MDE clients would be able to sustain their improved cognitive performance for longer periods of time under such challenging distracting circumstances. Given the degree of distress and frustration with this setting and the high efforts required, it is likely that MDE clients would “burn out” after a relatively short time and return to the levels of cognitive functioning documented in standard testing conditions. MTBI clients, in contrast, reported only moderately increased emotional distress. On qualitative appraisal, clients with mTBI described “dizziness”, “headaches”, and “feeling puzzled” rather than emotional distress by the distraction, confirming that the decline in cognitive performance is not affect-related, according to clinical indicators.

The specific procedure of distraction-testing developed for this study appears to differentiate between clients with MDE, mTBI, and healthy controls, based on the changes in performances under distraction. This may be of clinical relevance for differential diagnosis between these groups, as well as for appraising the state of recovery of a client with either of the clinical diagnoses. Based on the data obtained, it would be indicative of substantial remission of the cognitive effects of either MDE or mTBI when the distraction condition no longer imposes significant changes of performance (in either direction) compared to the standard condition. Such unchanged performance would be characteristic for healthy control participants and suggest recovery. On the other hand, significant change of performance in the distraction condition would suggest that further rehabilitation needs to occur before
a client can successfully or sustainably return to an occupational role with complex attention demands.

The distraction procedure also controlled for practice effects, based on alternative test stimuli which can be used for retesting LM in the distraction condition. Although learning of test material (stimulus learning) is the most obvious pitfall, practice effects can occur as a result of decreasing test anxiety, having greater familiarity with the test settings, procedural learning, and improvement in test-taking strategy (Goldberg et al., 2010). This was investigated and no practice effects were found.

The distraction procedure was validated as a short and practical addition to the standard neuropsychological assessment, adding less than 5 minutes to the testing time. The procedure is standardized, comprising objective parameters of setting and distraction stimuli which can be replicated easily in different clinical and research settings.

Further validation is needed to confirm the effectiveness of the distraction setting with additional diagnostic groups, such as severe TBI, dementia, HIV, toxicity, and other medical conditions with cerebral impact. As these groups often present with changes to frontal lobe functioning, significant enough to be evident on standard testing, an even greater incapacity to perform in the distraction condition is expected, compared to the mTBI sample of our study. Vice versa, mTBI clients who suffered relatively trivial injury with subsequent fast and uncomplicated recovery (representing the majority of mTBI) are expected to pass the distraction setting without significant changes, as no significant frontal lobe damage has occurred. Further investigations into different types of background distractions and variable time spans are also needed to determine parameters for improving or declining performance in different clinical groups.

Limitations of this study include the use of a solely New Zealand test population which may reduce the generalizability of results. It should also be considered that scaled scores were calculated based on the WMS-IV and WAIS-IV normative samples (Wechsler, 2008, 2009). There are insufficient data to assert that raw scores obtained in the distraction condition will universally correspond to the score distribution provided by the WMS-IV/WAIS-IV normative sample for the standard condition. Furthermore, the MDE sample did not include clients younger than 23 years or older than 60 years; the mTBI sample only had clients aged between 18 and 64, suggesting that additional validation efforts be undertaken for younger and older age groups.

Consistent with the epidemiological gender distribution of mTBI and MDE men were over-represented in the mTBI and under-represented in the MDE sample. As women performed slightly better than men on LM in the distraction condition, the possibility cannot be ruled out that gender differences drive some of the observed findings. Accordingly, future research may take an interest in gender specific responses to environmental distraction.

Future research might consider the involvement of fMRI imaging in studies on distraction, given the promising data presented in recent years about the recruitment of additional brain resources with exposure to auditory distraction (Campbell, 2005; Gisselgård, Petersson, Baddeley, & Ingvar, 2003; Gisselgård, Petersson, & Ingvar, 2004). For future research endeavors a validated
environmental distraction procedure is herewith available, comprising objective parameters of test setting and distraction stimuli which can be replicated easily in different clinical and research settings with minimum impact on total assessment time.

REFERENCES


DISTRACTIBILITY IN MTBI AND DEPRESSION


5. Discussion

Although environmental distractibility is a well-known, often debilitating feature of acquired brain injury, the standard neuropsychological assessment investigates cognitive performance solely in a distraction-free environment. Traditionally, clients’ abilities to manage environmental distractions have remained untested. This research project had two main objectives: First, to develop a short, standardised, replicable, additional test condition which includes normative auditory/visual distraction stimuli; second, to examine the effect of this test condition on the performances of patients with TBI and MDE, and healthy controls. These objectives required that two independent, major empirical studies had to be conducted: the first for developing a set of new test stimuli to allow re-testing without incurring practice effects (1st study and publication); the second for examining the effects of distraction on different client groups (2nd study and publication).

The results of the first study (n=240) demonstrated that the newly developed test stimuli have compatible structural and statistical properties comparable with the established WMS-IV stimuli. Consistently high levels of compatibility were demonstrated for different clinical groups, including MDE (n=80), mTBI (n=80), and healthy control subjects (n=80), representing focal areas of neuropsychological interest. Compatibility was also shown for different points of recall, that is, immediate recall and delayed recall of the newly acquired verbal (logical) information. Very high levels of correlation in raw scores and scaled scores were demonstrated between standard stories and new stories for the three groups and two points of assessment. Analysing raw and scaled scores, there were no significant differences between the standard and new stories, irrespective of whether recall was assessed immediately or after a 30-minute delay, within any of the study groups.

Limitations of the first study included a possible socio-economic bias of the MDE group with a disproportionately high representation of Caucasian and well-educated subjects. While the mTBI and control group were comparatively well-matched to their respective reference populations with regard to ethnicity and education, the use of a solely New Zealand test population may reduce the generalizability of the results. Furthermore, the clinical samples did not include clients aged 16-21 years or older than 65 years, suggesting that additional validation efforts ought to be undertaken for these age groups. Accordingly, clinicians should not derive demographically adjusted norms (e.g. correcting for education, gender, and ethnicity) for the new logical memory stimuli using the Advanced Clinical Solutions (NCS Pearson, 2009) normative information. Further validation of equivalence of standard and new stimuli within additional clinical and non-clinical samples is needed. In this context is worth noting that even excellent alternative test stimuli provide no blanket
protection against practice effects. Although learning of test stimuli is the most obvious pitfall, Goldberg et al. (2010) pointed out that practice effects can also occur as a result of decreasing test-anxiety, having greater familiarity with the test-settings, procedural learning, and improvement in test-taking strategy. In the second study, this concern was specifically investigated and it was documented that no such practice effects had occurred.

The second study (n=240) presented a short, normative, and easily replicable distraction procedure that allows the examiner to study a client’s test performance with exposure to environmental distraction. Three equally sized client groups were examined, mTBI, MDE and a healthy control group applying the same inclusion/exclusion criteria for participant selection as in the first study. The performances under the distraction condition and under the traditional, quiet condition can directly be compared. For a sample of 80 mTBI clients significant decline was demonstrated in the distraction condition. Distraction-related decline of performance was demonstrated for working memory, including one-dimensional concentration (WMS-IV DSF) and complex concentration (WMS-IV DST), and for Auditory Semantic Memory (WMS-IV LM). These findings confirmed the research hypotheses for this clinical group (Table 7, H10 to H15) and highlighted an important shortcoming of the standard neuropsychological test setting that, conducted solely in a quiet condition, would have failed to identify this significant and functionally highly relevant incapacity. No gender bias was demonstrated: male and female clients with brain injury were equally affected by the distraction condition. Neither age, education, nor ethnicity was found to mitigate the impact of distraction. A specific investigation of stress levels experienced by brain injury clients in the distraction setting suggested slightly rising but by no means overwhelming distress. On qualitative appraisal, clients with mTBI described “dizziness,” “headaches,” and “feeling puzzled” rather than emotional distress during the distraction, confirming that the marked decline in cognitive performance is not affect-related, according to clinical indicators. Motivational factors including malingering were equally excluded by employing comprehensive clinical and psychometric procedures to establish the validity of the data obtained. The inability to effectively block out environmental distraction appears to be a brain organic feature in mTBI clients. It can be suspected that this effect may be observed in other diagnostic groups with fronto-cerebral changes, such as moderate/severe brain trauma, CVA, degenerative disorders, cerebral vascular diseases, HIV, or toxicity, to the degree as the frontal lobes of their brains have suffered structural damage. The distraction test measures a key frontal-temporal brain function; neuronal damage to the frontal-temporal lobes is expected to impact on related functions, irrespective of the cause for such damage. Specific research with additional clinical groups may be required to validate the merits of the distraction test for different clinical populations.
The result of the second study also confirmed that clients with depression respond in a specific way to the distraction setting. “Activated” by the challenging test setting, MDE-clients temporarily dedicated their full attention to the actual test task: significant improvement of test scores was documented, compared to their performance in standard conditions. Significant distraction-related improvement of test achievements in the distraction condition was demonstrated for working memory, including one-dimensional concentration (WMS-IV DSF) and complex concentration (WMS-IV DST), and for Auditory Semantic Memory (WMS-IV LM). These findings confirm the research hypotheses for this clinical group (Table 7, H1 to H6).

No significant gender bias was demonstrated: male and female clients with MDE equally improved under the distraction condition. Neither age nor levels of education were found to mitigate the impact of distraction for the MDE group. An investigation of stress levels experienced by MDE clients in the distraction setting demonstrated a substantial increase of stress levels during the distraction setting. Although the additional challenge of environmental distraction increased the stress levels in all clinical groups, the increase of distress for the MDE group was significantly greater than for any other group. Qualitatively, clients with depression described the distraction condition as “unbearable” and “terrible,” and often became tearful, despite their substantial improvement in test achievements.

These findings of course do not suggest that MDE clients would be able to sustain their improved cognitive performance for longer periods of time under such challenging distracting circumstances. Given the degree of distress and frustration with this setting and the high efforts required, it is likely that clients would ‘burn-out’ after a relatively short time and return to the decreased levels of cognitive functioning documented in standard testing conditions. The distraction condition provides only a very temporary lift of performance for MDE clients, which comes at great costs for the client in terms of personal exertion and frustration, but it offers considerable diagnostic benefits in appraising pre-morbid levels of functioning (based on the level of cognitive functioning in the distraction condition), in judging severity of depression (measured by the difference of performances in standard vs. distraction condition) and in clarifying differential diagnosis (based on improvement of scores under distraction condition). Future research may further investigate different types of background distractions and variable time spans to determine parameters for performance-enhancing distraction for this clinical group.

Inevitably there will be clients amongst those referred under a mTBI diagnosis who will achieve largely unimpaired scores under the distraction condition. MTBI is a confounded clinical population in which the prognosis for substantial recovery from the initial injury is optimistic and the likelihood for arising mood disorders is high. Previous chapters highlighted that a proportion of these
clients have effectively recovered from the neurocognitive sequelae of their injury, but that symptoms persist due to an emerging mental health disorder. Those clients have been notoriously difficult to differentiate due to their overlapping physical symptoms (e.g. fatigue, headaches, irritability, mood swings) and due to a similar cognitive profile on standard cognitive testing. The distraction procedure is a novel approach to differential diagnosis. Unlike traditional tests of the neuropsychological test repertoire, the distraction test appears to differentiate between clients with organic brain damage, who were found to deteriorate, and clients with depression, who were found to improve.

Participants from the control group did not present with significant changes of their test performance in the distraction condition. The research hypotheses for this group (Table 7, H18 to H22) were confirmed.

The tests with the greatest power of differentiation were the WAIS-IV/WMS-IV sub-tests LM, DSF and DS. It appears the specifics of the distraction setting and these sub-tests have struck the right balance between providing a sufficiently challenging distraction for impacting on the performance in mTBI clients and remaining manageable enough for healthy participants to achieve essentially unchanged results. Such balance was not attained in the sub-test LNS, which turned out to be unachievable in the distraction setting for all study groups, producing an unacceptable drop-out rate. Accordingly, no further statistical analysis was conducted for LNS. Related hypotheses (Table 7; H7, H8, H16, H17, H24, H25) were therefore not tested.

The specific procedure of distraction-testing developed for this study appears to differentiate between clients with MDE, mTBI, and healthy controls based on the changes in performances under distraction. This may be of clinical relevance for differential diagnosis between these groups, as well as for appraising the state of recovery of a client with either of the clinical diagnoses. Based on the data obtained, it would be an indicator that substantial remission of the cognitive effects of either MDE or mTBI has occurred when the distraction condition does no longer impose significant changes of performance (in either direction) compared to the standard condition. Such unchanged performance would be characteristic for healthy control subjects and suggest recovery. Vice versa, significant change of performance in the distraction condition would suggest, that further rehabilitation is needed before a client can successfully or sustainably return to an occupational role with complex attention demands.
<table>
<thead>
<tr>
<th>Research Hypotheses by Study Group</th>
<th>N</th>
<th>p (H0)</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Depression Group</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H1: mean Logical Memory (standard condition, raw scores) &lt; mean Logical Memory (distraction condition, raw scores)</td>
<td>80</td>
<td>p (Equality) &lt;.001</td>
<td>Accept H1</td>
</tr>
<tr>
<td>H2: mean Logical Memory (standard condition, scaled scores) &lt; mean Logical Memory (distraction condition, scaled scores)</td>
<td>80</td>
<td>p (Equality) &lt;.001</td>
<td>Accept H2</td>
</tr>
<tr>
<td>H3: mean Digit Span Forward (standard condition, raw scores) &lt; mean Digit Span Forward recall (distraction condition, raw scores)</td>
<td>80</td>
<td>p (Equality) &lt;.001</td>
<td>Accept H3</td>
</tr>
<tr>
<td>H4: mean Digit Span Forward (standard condition, scaled scores) &lt; mean Digit Span Forward recall (distraction condition, scaled scores)</td>
<td>80</td>
<td>p (Equality) &lt;.001</td>
<td>Accept H4</td>
</tr>
<tr>
<td>H5: mean Digit Span Total (standard condition, raw scores) &lt; mean Digit Span Total recall (distraction condition, raw scores)</td>
<td>80</td>
<td>p (Equality) &lt;.001</td>
<td>Accept H5</td>
</tr>
<tr>
<td>H6: mean Digit Span Total (standard condition, scaled scores) &lt; mean Digit Span Total recall (distraction condition, scaled scores)</td>
<td>80</td>
<td>p (Equality) &lt;.001</td>
<td>Accept H6</td>
</tr>
<tr>
<td>H7: mean Letter/Number Sequencing (standard condition, raw scores) &lt; mean Letter/Number Sequencing (distraction condition, raw scores)</td>
<td>64</td>
<td>test abandoned due to high drop-out rate</td>
<td></td>
</tr>
<tr>
<td>H8: mean Letter/Number Sequencing (standard condition, scaled scores) &lt; mean Letter/Number Sequencing (distraction condition, scaled scores)</td>
<td></td>
<td>Not applicable</td>
<td></td>
</tr>
<tr>
<td>H9: mean stress (distraction condition, visual analogue scale) &gt; mean stress (distraction condition, visual analogue scale) [mTBI group]</td>
<td>80</td>
<td>p (Equality) &lt;.001</td>
<td>Accept H9</td>
</tr>
<tr>
<td><strong>Brain Injury Group</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H10: mean Logical Memory (standard condition, raw scores) &gt; mean Logical Memory (distraction condition, raw scores)</td>
<td>80</td>
<td>p (Equality) &lt;.001</td>
<td>Accept H10</td>
</tr>
<tr>
<td>H11: mean Logical Memory (standard condition, scaled scores) &gt; mean Logical Memory (distraction condition, scaled scores)</td>
<td>80</td>
<td>p (Equality) &lt;.001</td>
<td>Accept H11</td>
</tr>
<tr>
<td>H12: mean Digit Span Forward (standard condition, raw scores) &gt; mean Digit Span Forward recall (distraction condition, raw scores)</td>
<td>80</td>
<td>p (Equality) &lt;.001</td>
<td>Accept H12</td>
</tr>
<tr>
<td>H13: mean Digit Span Forward (standard condition, scaled scores) &gt; mean Digit Span Forward recall (distraction condition, scaled scores)</td>
<td>80</td>
<td>p (Equality) &lt;.001</td>
<td>Accept H13</td>
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<tr>
<td>H14: mean Digit Span Total (standard condition, raw scores) &gt; mean Digit Span Total recall (distraction condition, raw scores)</td>
<td>80</td>
<td>p (Equality) &lt;.001</td>
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<tr>
<td>H15: mean Digit Span Total (standard condition, scaled scores) &gt; mean Digit Span Total recall (distraction condition, scaled scores)</td>
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<td>p (Equality) &lt;.001</td>
<td>Accept H15</td>
</tr>
<tr>
<td>H16: mean Letter/Number Sequencing (standard condition, raw scores) &gt; mean Letter/Number Sequencing (distraction condition, raw scores)</td>
<td>37</td>
<td>test abandoned due to high drop-out rate</td>
<td></td>
</tr>
<tr>
<td>H17: mean Letter/Number Sequencing (standard condition, scaled scores) &gt; mean Letter/Number Sequencing (distraction condition, scaled scores)</td>
<td></td>
<td>Not applicable</td>
<td></td>
</tr>
</tbody>
</table>
The neuropsychological assessors of this study were not blind to the diagnoses of their participants. This of course is well in line with the standard clinical assessment which considers comprehensive clinical background information (via medical reports provided with the referral) and actively investigates symptoms of mood disorder and injury parameters as part of the clinical interview. From a purely experimental viewpoint this might be considered a source of assessment bias. However, the nature of the neurocognitive evaluation would act to mitigate this. As outlined in the introductory chapters, highly regulated, normative, and objective parameters apply with regards to the assessment setting, test instruction, scoring, and interpretation of data obtained, which do not rely on the assessor’s personal perspective or interpretation.

The present study was undertaken in a clinically realistic and pragmatic framework. The results of the study may therefore be confined to a clinical context. Future research options may include laboratory-based, blinded study designs, possibly involving computerised assessment options.

Members of the MDE-group had been commenced on a stable regime of anti-depressant medication, either on SSRI, SNRI, or combined SSRI/TCA. It cannot be excluded that some of the ‘hypofrontality’ in their clinical presentation and the subsequent performance-enhancing effects of the distraction setting may be mitigated by pharmaceutical effects. This would need to be explored in future studies.
At this place the case examples presented in the preceding chapters can be re-visited.

Case Study 1 involved Mr K.F. who sustained complicated mTBI. After spending 3 months in a relatively quiet environment, rehabilitating from his orthopaedic injuries, he attempted to return to his previous work role in a busy, noisy environment with countless attention demands and distractions. In this environment, he encountered significant cognitive problems, involving concentration difficulties, problems with memory, and fatigue with tension headaches. A neuropsychological assessment was conducted in the traditional distraction-free setting which did not demonstrate cognitive decline or incapacity. The functional problems experienced by Mr K.F. were attributed to causes unrelated to the injury ("likely depression") and he lost cover for treatment and compensation. A neuropsychological re-assessment was undertaken. This time Mr K.F.’s performance was observed both in the standard setting and under normative environmental distraction. As expected, Mr K.F had severe performance problems in the distraction condition. He could no longer concentrate on the focus task and thus only remembered a small amount of the information presented. His scores on WMS-IV LM and WAIS-IV DSF, DST decreased on average by about 1.5 standard deviations. Upon identification and validation of Mr K.F.’s profound problem with blocking out distractions, specific changes were undertaken both to his task profile and to the work environment. He was placed in a separate workshop area, detached from the busy main factory hall; his supervisory role was delegated to a foreman. Mr K.F. did not attend to clerical tasks, including computer-based work or talking on the phone in the work office, during usual business hours. Instead, he had three mornings per week scheduled to undertake these tasks from a newly established home office. Mr K.F noted that in this environment, he could successfully undertake quite complex tasks, such as project costing or filing tax returns, as already identified in the initial standard neuropsychological assessment. Mr K.F. reported significant improvement of work performance and job satisfaction following these changes.

Case Study 2 presented Mrs C.D., who was diagnosed with a major depressive episode. She had been unable to work in her managerial role for 11 months when she was referred for neuropsychological assessment to investigate ongoing cognitive problems. Testing in the distraction-free standard setting documented cognitive decline, consistent with marked depression (BDI-II 34/63), involving working memory, logical memory, verbal pairs, processing speed and specific, attention-based executive functions. Consistent with expectations, the distraction condition provided a powerful incentive to temporarily suspend negative self-evaluation, memories, or future worries and to dedicate her full concentration instead to the actual test task. This resulted in
considerable improvement of her performance in the above measures, on average by about 1 standard deviation. The test achievements under distraction were close to pre-morbid levels of cognitive functioning, as established by biographical information and by her performance on a specific test for estimating pre-morbid abilities (NART). This improvement, of course, was achieved with extreme effort and would not have been sustained for longer than a few minutes. Mrs C.D. described the distraction condition as a “nightmare scenario.” In Mrs C.D.’s case, distraction testing confirmed the findings of the standard assessment that considerable further improvement of depression is required and intensive rehabilitation efforts need to be extended before a return to her work role can be considered.

Case Study 3 introduced Mr P.M. and his 4-year-long history of PCS, following a mild/trivial head injury. Mr P.M. did not present with significant symptoms of depression. Encouragingly, Mr P.M. achieved good results on formal cognitive tests, obtaining scores in the average to high-average range (10 to 13 on both Wechsler batteries, 50 to 58 percentile in tests for executive functioning). Mr P.M.’s performance remained unchanged in the standard and in the distraction condition. On these grounds, it was concluded, that, cognitively, Mr P.M. had attained pre-injury cognitive capacities, which had been estimated based on his academic and vocational history and performances on decline-resistant holding tests. Given his unchanged test achievements under the distraction condition, Mr P.M.’s performance was consistent with the healthy control group. From a clinical perspective, these findings would suggest a change in the direction of Mr P.M.’s rehabilitation. Rather than fostering strict activity limitation and symptom avoidance, as established under the PCS-diagnosis, recommendations for future rehabilitation could include a programme of physical activation and re-engagement with meaningful life-roles and activities.

The three case studies exemplify clinical applications and relevance of the distraction condition. These examples also show how distraction testing could be an integrated part of the neuropsychological investigation. The distraction procedure was validated as a short and practical addition to the standard neuropsychological assessment, adding less than 5 minutes to the testing time. The procedure is normative, comprising objective parameters of setting and distraction stimuli. The distraction procedure also controlled practice effects effectively, based on alternative test-stimuli which can be used for re-testing logical memory in the distraction condition.

Further validation is needed to confirm the effectiveness of the distraction setting with additional diagnostic groups, such as severe TBI, Dementia, HIV, Toxicity, and other medical conditions with cerebral impact. Further investigations into different types of background
distracting and variable time spans are also needed to determine parameters for improving or declining performance in different clinical groups.

Analogue to the limitations identified for the first study, the second study also relies on a solely New Zealand test population, which may reduce the generalizability of results. As in the first study, it should be considered that scaled scores for the second study were calculated based on the WMS-IV and WAIS-IV normative samples (Wechsler, 2008, 2009). There are insufficient data to assert that raw scores obtained in the distraction condition will universally correspond to the score distribution provided by the WMS-IV/WAIS-IV normative sample for the standard condition. In the second study, the MDE sample did not include clients younger than 23 years or older than 60 years. The mTBI sample only had clients aged between 18 and 64, suggesting that additional validation efforts be undertaken for younger and older age groups. Future research may consider the involvement of fMRI imaging in studies on distraction, given the promising data presented in recent years about the recruitment of additional brain resources during exposure to auditory distraction (Campbell, 2005; Gisselgård, et al., 2003; Gisselgård, et al., 2004). Future studies may also seek to establish veridicality of the extended Neuropsychological Assessment by comparing clients’ performances on distraction testing with their levels of functioning in real-life settings at home or at work. There is also scope for exploring distractibility in a laboratory environment, e.g. for computerised assessments. Performance norms would need to be obtained for additional reference populations, including for other conditions with cerebral impact, and for norm-control groups pertaining to different counties and social or ethnic sub-groups.

For future research endeavours, a validated environmental distraction procedure is herewith available, comprising objective parameters of test setting and distraction stimuli, which can be replicated easily in different clinical and research settings with minimum impact on total assessment time. For clinical evaluation, a practical tool was presented to enhance ecological validity of the neuropsychological assessment by specifically testing a cognitive function crucial for operating in a real-life environment. For differential diagnosis, an additional measure was introduced with validated differential power for the clinical populations investigated. The research project succeeded as per its intention set out in the introductory chapter to contribute in a relevant manner to neuropsychological research and “hands-on” clinical practice.

Summary

The importance of additional distraction testing as part of a neuropsychological assessment was demonstrated. Only in the formalised distraction setting did the problems with managing environmental distractions experienced by clients with mTBI become apparent. The distraction condition proved to be an effective tool for differential diagnosis. Unlike
traditional tests for frontal lobe functions, the distraction test clearly differentiated mTBI, MDE, and healthy control participants. In addition to proving relevant insight into the particular clinical groups selected for this study, distraction testing was shown to be a practical procedure, replicable in clinical practice and in research. The procedure may invite further research with additional clinical groups and contribute to improving ecological validity of the cognitive assessment.
6. References


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3 The substantial bodies of references for Publication 1 and Publication 2 are integrated parts of the respective journal article. These references are therefore presented at the end of each publication (first and second “insertion chapter”). The references included in Chapter 6 solely refer to research directly referred to in the “regular” chapters 1 to 5.


Rieger, K. (1888). *Beschreibung der Intelligenzstörungen in Folge einer Hirnverletzung nebst einem Entwurf zu einer allgemein anwendbaren Methode der Intelligenzprüfung*. Würzburg: Stahel


### 7. Appendices

#### 7.1. Test Stimuli

**7.1.1. Set of alternative stories for logical memory**

**Logical Memory Story A**

<table>
<thead>
<tr>
<th>Item</th>
<th>Criteria</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Maria or variation of name</td>
<td>0</td>
</tr>
<tr>
<td>2.</td>
<td>Anderson or variation of name</td>
<td>0</td>
</tr>
<tr>
<td>3.</td>
<td>Indication being a student/scholar of law</td>
<td>0</td>
</tr>
<tr>
<td>4.</td>
<td>Otago University or University in Dunedin</td>
<td>0</td>
</tr>
<tr>
<td>5.</td>
<td>Indication two other people joined her</td>
<td>0</td>
</tr>
<tr>
<td>6.</td>
<td>Anna or variation of name</td>
<td>0</td>
</tr>
<tr>
<td>7.</td>
<td>Michael or variation of name</td>
<td>0</td>
</tr>
<tr>
<td>8.</td>
<td>Indication of any type of snow sport</td>
<td>0</td>
</tr>
<tr>
<td>9.</td>
<td>Queenstown required</td>
<td>0</td>
</tr>
<tr>
<td>10.</td>
<td>Indication of any type of vacation in the cold season</td>
<td>0</td>
</tr>
<tr>
<td>11.</td>
<td>Indication of arrival in the afternoon</td>
<td>0</td>
</tr>
<tr>
<td>12.</td>
<td>Indication of going to hotel</td>
<td>0</td>
</tr>
<tr>
<td>13.</td>
<td>Indication of going out for an evening meal</td>
<td>0</td>
</tr>
<tr>
<td>14.</td>
<td>Indication that it happened on the day of arrival</td>
<td>0</td>
</tr>
<tr>
<td>15.</td>
<td>Indication of illness</td>
<td>0</td>
</tr>
<tr>
<td>16.</td>
<td>Indication of elevated body temperature</td>
<td>0</td>
</tr>
<tr>
<td>17.</td>
<td>Indication of nausea of any type</td>
<td>0</td>
</tr>
<tr>
<td>18.</td>
<td>Indication of pain/ache affecting the head</td>
<td>0</td>
</tr>
<tr>
<td>19.</td>
<td>Indication of stomach cramps or pain</td>
<td>0</td>
</tr>
<tr>
<td>20.</td>
<td>Indication of medical attention</td>
<td>0</td>
</tr>
<tr>
<td>21.</td>
<td>Indication of bed-rest</td>
<td>0</td>
</tr>
<tr>
<td>22.</td>
<td>Two days required</td>
<td>0</td>
</tr>
<tr>
<td>23.</td>
<td>Indication of drinking tea</td>
<td>0</td>
</tr>
<tr>
<td>24.</td>
<td>Indication of timely recovery</td>
<td>0</td>
</tr>
<tr>
<td>25.</td>
<td>Indication of successful continuation of holiday</td>
<td>0</td>
</tr>
</tbody>
</table>

**Logical Memory Story B**

<table>
<thead>
<tr>
<th>Item</th>
<th>Criteria</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Amanda or variation of name</td>
<td>0</td>
</tr>
<tr>
<td>2.</td>
<td>Wright required</td>
<td>0</td>
</tr>
<tr>
<td>3.</td>
<td>Indication of driving</td>
<td>0</td>
</tr>
<tr>
<td>4.</td>
<td>Indication of shopping-related destination</td>
<td>0</td>
</tr>
<tr>
<td>5.</td>
<td>Blue required</td>
<td>0</td>
</tr>
<tr>
<td>6.</td>
<td>Toyota required</td>
<td>0</td>
</tr>
<tr>
<td>7.</td>
<td>Church Road required</td>
<td>0</td>
</tr>
<tr>
<td>8.</td>
<td>Indication of noticing visually</td>
<td>0</td>
</tr>
<tr>
<td>9.</td>
<td>White required</td>
<td>0</td>
</tr>
<tr>
<td>10.</td>
<td>Indication of stretch-vehicle</td>
<td>0</td>
</tr>
<tr>
<td>11.</td>
<td>Indication of emotional arousal</td>
<td>0</td>
</tr>
<tr>
<td>12.</td>
<td>Indication of famous person</td>
<td>0</td>
</tr>
<tr>
<td>13.</td>
<td>Indication of temporary visit</td>
<td>0</td>
</tr>
<tr>
<td>14.</td>
<td>Indication of public performance</td>
<td>0</td>
</tr>
<tr>
<td>15.</td>
<td>Indication of slowing her car</td>
<td>0</td>
</tr>
<tr>
<td>16.</td>
<td>Indication of trying to see celebrity</td>
<td>0</td>
</tr>
<tr>
<td>17.</td>
<td>Indication of simultaneous event</td>
<td>0</td>
</tr>
<tr>
<td>18.</td>
<td>Two required</td>
<td>0</td>
</tr>
<tr>
<td>19.</td>
<td>Indication of youth</td>
<td>0</td>
</tr>
<tr>
<td>20.</td>
<td>Indication of children</td>
<td>0</td>
</tr>
<tr>
<td>21.</td>
<td>Indication of back seat or back of the car</td>
<td>0</td>
</tr>
<tr>
<td>22.</td>
<td>Indication of quarrel, or becoming noisy</td>
<td>0</td>
</tr>
<tr>
<td>23.</td>
<td>Indication of Amanda verbally attending to her children</td>
<td>0</td>
</tr>
<tr>
<td>24.</td>
<td>Indication of request to behave</td>
<td>0</td>
</tr>
<tr>
<td>25.</td>
<td>Indication of continuation of trip</td>
<td>0</td>
</tr>
</tbody>
</table>
7.1.2. Auditory Distraction Stimulus A (story)

Gang of five sought in $99 million jewellery heist

London
British police believe a 40 million pounds ($99 million) raid on Graff Diamonds in Mayfair was a well-planned robbery that involved at least five people.

Detectives believe the two main raiders targeted the most expensive items in the London store. One officer said: “They knew exactly what they were looking for and we suspect they already have a market for the jewels.”

The suspects’ details have been circulated but police believe they would have organised an escape route and may already have left the country.

It is thought to be the biggest gems heist in British history.

Scotland Yard has issued CCTV images of two men dressed in suits who escaped with 43 rings, bracelets, necklaces and watches last week.

They approached staff at Graff’s claiming to be armed, and got away in a series of cars.

The extent of the haul had been kept secret but police have now disclosed that the items stolen had a retail value of 40 million pounds. Britain’s previous biggest diamond jewellery robbery is believed to be a 23 million pounds raid, which also took place at Graff’s, in 2003.

The two men, thought to be Londoners, arrived in a taxi on August 7 and were only in the New Bond St jewellers for a matter of minutes.

After being let in through the security doors both robbers selected 43 items and placed them into a bag before briefly seizing a woman employee as a hostage.

She was taken outside but released when the raiders made their getaway in a blue BMW.

Their escape was nearly foiled when the car crashed into a black cab in Dover Street, as a bystander from a nearby shop gave chase. The men then switched to a silver Mercedes and later again into a black vehicle, possibly a Ford Galaxy or VW Sharan.

It is suspected that the jewels, meanwhile, were transferred to a waiting motorcyclist who was able to escape quickly.

Police believe there were at least two other men who were acting as getaway drivers for three cars.
7.1.3. Auditory Distraction Stimulus B (random numbers)

<table>
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<th>5</th>
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7.1.4. Visual Analogue Scale

How **stressful** was it for you, working with this distraction?

(please tick √ )
7.2. Example for the Value of the “Lateral View” in Medical Diagnostics

Figure 4
X-ray study
Two views of a femur fracture in which the frontal view shows the bone apparently intact but the lateral clearly shows a displaced fracture

Images by Dr Antony Doyle, Auckland (private collection) with kind permission