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Version of Record: https://www.sciencedirect.com/science/article/pii/S0028377020303970
Manuscript_fe85bbccc01070949de66411121fcdc7

Contribution of the neuropsychological assessment in concussion

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Contribution of the neuropsychological assessment in concussion

Contribution de l'évaluation neuropsychologique dans les commotions cérébrales

Abstract

The neuropsychological assessment is a cornerstone in the care management of concussion or mild traumatic injury.

Objective: To present the different stages of an exhaustive neuropsychological assessment exploring cognitive and behavioral domains.

Method: Description of the value of the main tests available for behavioral and cognitive assessment. The choice of tests is based on the clinical experience and expertise of the authors.

Results: Questionnaires are mainly used to explore the behavioral sequelae (depression, anxiety or fatigue) and the impact of these potential difficulties in daily life. Four cognitive abilities could be impaired by concussion: attention, memory, visuospatial functions and executive functions. These abilities could be explored with "paper and pencil" tests or with computerized test batteries. While cognitive sequelae in the context of a moderate or a severe traumatic brain injury are consolidated, in the context of concussion, neuropsychological sequelae tend to resolve in a short tiime. As a consequence, several neuropsychological assessments could be conducting in a short period involving some methodological considerations. Moreover, as concussion could be reported in a Whiplash injury from a car crash with forensic consequences, it is crucial to propose tests to be sure that the weak performance obtained into the neuropsychological assessment is not explained by poor effort and/or malingering.

Discussion / Conclusion : This article revises these aspects of a neuropsychological assessment in the specific context of concussion.

Résumé

La réalisation d'une évaluation neuropsychologique est une étape indispensable dans la prise en charge des personnes victimes de commotions cérébrales ou de traumatismes crâniens légers.

Objectif : Présenter les différentes étapes d'une évaluation neuropsychologique exhaustive qui a pour but d'explorer la sphère comportementale ainsi que la sphère cognitive

Méthode : Description de l'intérêt des principaux tests disponibles pour l'évaluation comportementale et cognitive. Le choix des tests reposent sur l'expérience clinique et l'expertise des auteurs.

Résultats :

Les séquelles comportementales (telle que la dépression, l'anxiété ou encore la fatigue) ainsi que leur

répercussion dans la vie quotidienne sont essentiellement explorées à l'aide de questionnaires.
La sphère cognitive est appréhendée à l'aide de tests papier crayon ou d'outils informatisés permettant d'évaluer les quatre capacités altérées dans le cas d'une commotion cérébrale qui sont l'attention, la mémoire, les capacités visuo-spatiales ainsi que les capacités exécutives.
De plus, compte tenu du fait que les commotions cérébrales peuvent avoir lieu dans un contexte médico-légal (notamment suite à un accident de la voie publique avec reconnaissance d'invalidité), des épreuves permettant au psychologue de s'assurer de la participation active de la personne commotionnée à l'examen neuropsychologique sont également analysées.
Discussion / Conclusion : Cet article propose une mise au point concernant la réalisation d'une évaluation neuropsychologique dans le contexte spécifique de la commotion cérébrale.
Keywords : Concussion, Neuropsychology, Cognitive assessment, Behavioral assessment.

Mots-clés : Commotion cérébrale, Neuropsychologie, Evaluation cognitive, Evaluation comportementale

Introduction

Before the 1980s, most brain injury research focused on severe or moderate traumatic brain injury allowing one to describe a now well-known pattern of cognitive and neurological consequences of this kind of brain injury. In contrast, neurological and neuropsychological changes following mild traumatic injury or concussion (commonly used interchangeably [1]) were regarded as minor and inconsequential [2], whereas concussions involve a combination of physical (headache, dizziness…), cognitive and behavioral symptoms [3] provoking sometimes a complaint from patients. The neuropsychological assessment of the cognitive and behavioral symptoms from a concussion could be indispensable in certain contexts. For example, in a context of a rear-end car accidents (inducing a Whiplash injury), legal actions could be undertaken and litigation could involve the presence of cognitive impairment [4]. In a military context (blast injury), as in a sports context (amatory or professional contact sports, i.e. soccer, American football, ice hockey, rugby …), the assessment of cognitive and behavioral sequelae from concussion could be determinant to detect impairments that would hinder a successful return to daily life or to sport. Although, these sequelae are often brief,

they tend to resolve within 7-10 days in a sport-related concussion, or after 2 or 3 months in the context of a whiplash [5]. In a number of patients, the complaints still exist six months after the accident, resulting in a fairly high disability rate [6]. Accordingly, in front of any cognitive and/or behavioral complaint after concussion, a neuropsychological assessment has to be proposed. Moreover, as there is a consensus in the literature [7] indicating that persistent symptoms from a concussion are related to anxiety and stress rather than cognitive impairment, the recommended neuropsychological assessment needs to include a battery of tests designed to assess a wide range of domains, with the aim of providing specific information regarding behavioral and cognitive status [8].

Method

The objective of this article is to propose a comprehensive overview and description of the value of the main tests available for behavioral and cognitive assessment. As this is neither a meta-analysis nor an extensive review of all previously published papers, the choice of tests is based on the clinical experience and expertise of the authors. This work aims to highlight the tests that appear to be the most suitable and reliable in their design and practicality to explore the different cognitive and behavioral effects of concussions.

Results

1. Behavioral Assessment

The behavioral semiology combines mood lability, irritability, insomnia, anxiety and depression with, sometimes, some personality changes [1]. None of these signs are specific or pathognomonic. To catch these symptoms as their impact in daily life, the neuropsychological assessment shall include the Rivermead Post-Concussion Symptoms Questionnaire [9] or the Profil of Mood Stats (POMS) [10], and also questionnaires to apprehend depressive

symptoms (BDI – II, [11]), anxiety symptoms (STAI, [12]) and fatigue (Multidimensional Fatigue Inventory, MFI – 20 [13, 14]).

The Rivermead Post-Concussion Symptoms Questionnaire [9] is the questionnaire the most commonly used; it can be self-administered or given by an interviewer. Participants are asked to rate how severe each of the 16 symptoms has been over the past 24 hours. In each case, the symptom is compared with how severe it was before the injury occurred. The 16 symptoms are: headaches, dizziness, nausea, hyperacusis (or noise sensitivity), sleep disturbance, fatigue, irritability, feeling depressed, feeling frustrated, poor memory, poor concentration, taking longer to think, blurred vision, light sensitivity, double vision and restlessness.

The POMS [10] exists in several versions. The most commonly used is the POMS 2, which is available for adults aged 18 years and older and is available as full-length (65 items) or short versions (35 items). This questionnaire contains a series of descriptive words/statements that describe feelings people have. Subjects self-report on each of these areas using a 5-point Likert scale.

The BDI-II [11], STAI [12] and MFI-20 [13, 14] are specific to a behavioral sphere and less focused on the functional impact. The BDI – II [11] is a 21-question multiple-choice self-report inventory, one of the most widely used psychometric tests for measuring the severity of depression. Each answer is scored on a scale value of 0 to 3. Higher total scores indicate more severe depressive symptoms. The standardized cutoffs are: 0-13 minimal depression, 14-19 mild depression, 20-28 moderate depression and a score higher to 29 severe depression.

The STAI [12] is a psychological inventory based on a 4-point Likert scale and consists of 40 questions on a self-report basis. It measures two types of anxiety – state anxiety (or anxiety about an event), and trait anxiety (or anxiety level as a personal characteristic). The multidimensional fatigue inventory (MFI-20) [13, 14] is a self-assessment instrument with 20 items including five dimensions of fatigue: General fatigue, Physical fatigue, two scales

covering reduction in activities and lack of motivation to start an activity (Reduced activities and Reduced motivation) and Cognitive fatigue.

2. Cognitive Assessment

The cognitive semiology of a concussion is characterized at first by a mental fogginess, the patient experiences a subjective sensation of mental clouding described as feeling "foggy" and highlighted by poor performance on diverse tasks, in various degrees, and affecting different cognitive fields [5]. Main cognitive sequelae from a concussion concern four cognitive spheres: attention, memory, visuospatial functions and executive functions [15]. The integrated operation of these spheres could be explored as well as with “paper and pencil” tests or with computerized test batteries.

The “paper and pencil” tests usually applied in the cognitive assessment design to evaluate the consequences of a concussion are those used to assess cognitive deficit after a mild or a severe brain injury. To assess attention, the Paced auditory serial addition test (PASAT) [16], D-2 test [17], the Symbol Digit Modalities Test (SDMT) [18] are commonly used.

The PASAT [16] is used to assess sustained and divided attention. It is a very challenging task that involves working memory, auditory information processing speed, flexibility and calculation abilities. In this task, patients are given a number every 3 seconds and are asked to add the number they just heard to the number they heard just before.

The D2 test [17] is also used to assess selective and sustained attention and involves as well visual scanning speed. This test asks participants to cross out any letter *d* with two marks around above it or below it in any order. The surrounding distractors are usually similar to the target stimulus, for example a *p* with two marks or a *d* with one or three marks.

The SDMT [18] is a brief test which involves a simple substitution task. Using a reference key, the examinee has 90 seconds to pair specific numbers with given geometric figures. This

task involves only geometric figures and numbers, the SDMT is relatively culture free as well, and can also be administered to illiterate individuals.

To assess memory, one could choose the Digit Span [19] (forward and backward) for short-term memory and the Rey auditory verbal learning test [20], the Hopkins Verbal learning test [21], or the California Verbal learning Test (CVLT) [22] for the verbal episodic aspects of long-term memory (semantic and procedural memories are usually not altered in the context of concussion). The digit span test [19] is a measure of the working memory. Working memory is a cognitive system with a limited capacity that is responsible for temporarily holding information available for a processing (as a calculation). This ability is important for reasoning and the guidance of decision-making. Working memory is often used synonymously with the term: short term memory. This digit span task determines the longest list of items that a person can repeat back in a correct order (forward or backward according to the instruction) immediately after presentation. It is a common measure of short-term memory and refers to the ability of an individual to reproduce immediately, after one presentation, a series of discrete stimuli. The Rey auditory verbal learning test [20], the Hopkins Verbal learning test [21] and the California Verbal Learning Test [22] are three tests assessing verbal long-term memory based on the recall of a list of words. In the California Verbal Learning Test, these words share semantic links. These three tests allow clinicians to assess processing of encoding, storage and restitution of information in verbal long-term memory.

To assess the visuospatial function, the most frequently mentioned “paper and pencil” tests are the Hooper visual organization test [23] and the Benton judgement of line orientation test [24]. The Hooper Visual Organization Test is known to be a measure of visual integration whereas the Benton judgement of line orientation test was developed to be a measure of visual reasoning and visuo-constructive abilities.

The executive functions are apprehended with the Trail Making Test (A and B) [25] which tests mental flexibility and shifting abilities, the Stroop test [25] which involved inhibitory processing and the Controlled Oral Word Association Test (COWAT) [26], a test of verbal fluency [4-5, 15].

More recently, some computerized neuropsychological batteries have been developed to assess these four cognitive spheres. The best-known computerized battery to assess attention was proposed by Zimmermann and Fimm [27]. In sport-related concussion, several computerized batteries have been developed such as the Automated Neuropsychological Assessment Metrics (ANAM) [28], CogState [29], Headminder Concussion Resolution Index [30] or ImPACT (Immediate Post-Concussion Cognitive Assessment and Testing) [31]. These computerized batteries, assessing the four cognitive spheres affected by a concussion, were developed for English native speakers.

Computerized neuropsychological assessments seem to be more sensitives to subtleties of recovery, notably because they are based on the analyze of reaction time measures. However, Randolph et al. [32] highlighted some methodological weakness of the computerized batteries. According to these authors, no or very few peer-reviewed papers have studied computerized batteries, their psychometric properties such as their reliability and validity. Test reliability refers to the degree to which a test is consistent and stable in measuring what it is intended to measure. Test validity refers to the degree to which the test actually measures what it claims to measure and the extent to which inferences, conclusions and decisions made on the basis of test scores are appropriate and meaningful. Hence, before carrying out routinely these computerized batteries, some additional studies are needed and even more since some studies demonstrated the importance to use appropriate normative data in the assessment of sport-related concussion [8]. Indeed, the use of normative data is a hallmark of the neuropsychological assessment process to be able to identify changes in cognitive

functioning after a concussion and to attribute these changes to head injury. However, it could not be always adapted to use currently available normative data of tests. The normative data are established from a large panel of participants aged from 19 to 89-years-old with variants in their level of academic education. Appropriate normative data are needed because athletes or soldiers are generally young, some of them could have a history of a previous head injury or learning disorders or even hyperactivity disorders [8].

3. Supplementary Assessment

In the specific context of a Whiplash injury from a car crash, there is at least one supplementary test to carry out during the neuropsychological assessment. Indeed, in this context, legal actions could be undertaken with the aim of identifying a handicap based on cognitive or behavioral sequelae [4]. The detection of poor effort and/or malingering shall be crucial in clinical neuropsychological practice in order to make accurate diagnoses, prognoses, and referrals. The criteria proposed by Slick, Sherman, and Iverson [33] for Malingering Neurocognitive Dysfunction (MND) described in Table 1 constitute an interesting reference to guide the neuropsychologist to appreciate if a patient's performance during an evaluation is or is not really associated to his pathological condition (e.g. neurological, psychiatric).

Some neuropsychological tests could be carried out in support of these criteria, such as, in the field of memory, the 15-items Rey [34], the test of Memory Malingering (TOMM) [35], Amsterdam Short-Term Memory Test (ASTMT) [36] or the 21-items Test [37]. These tests are based on two conditions – free recall and – recognition. The usual patterns of responses of malingering patients is characterized by inconsistent errors in the recognition tasks with a normal free recall of the same items which is counterintuitive and the very opposite to amnesic patients' pattern of memory performance.

_____Insert here Table 1_____

Discussion / Conclusion

Neuropsychological examination is the established method of assessing cognitive and emotional status following a concussion. According to Moser et al. [38], neuropsychologists possess the background knowledge and training to understand brain-behavior relationship. A neuropsychological assessment is indispensable during the subacute period of recovery following a concussion. Although the use of multiple task computerized battery seems to be attractive, it remains more prudent to use a computerized single task developed for a specific purpose, such as the measure of reaction time in the aim to study proceeding speed.

To achieve its objectives, a neuropsychological assessment needs time to be completed successfully namely exploring behavior and cognition without forgetting a possible exaggeration of symptoms. According to the concussion context (car accident, falls, sport and so on) to objective behavioral and cognitive sequelae is important in the management of the patients and to guide them towards a return to work or to a sport practice in a safe way. To ensure a correct return to a daily life, some psychological therapy based on cognitive-behavioral therapy or on neuropsychological therapy could be proposed.

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Table 1. Summary of the of Slick et al. (1999) criteria for Malingered Neurocognitive Dysfunction

A. Presence of substantial external incentive
B. Evidence from neuropsychological testing
    1. Definite negative response bias
    2. Probable response bias
    3. Discrepancy between test data and known patterns of brain functioning
    4. Discrepancy between test data and observed behavior
    5. Discrepancy between test data and reliable collateral reports
    6. Discrepancy between test data and documented background history
C. Evidence from self-report
    1. Self-reported history is discrepant with documented history
    2. Self-reported symptoms are discrepant with known patterns of brain functioning
    3. Self-reported symptoms are discrepant with behavioral observations
    4. Self-reported symptoms are discrepant with information obtained from collateral informants
    5. Evidence from exaggerated or fabricated psychological dysfunction
D. Behaviors meeting necessary criteria from groups B and C are not fully accounted for by psychiatric, neurological, or developmental factors

Definite	Meets criterion A **AND** criterion B1 **AND** criterion D.
Probable	Meets criterion A **AND** two or more B criteria (excluding B1); or, meets one B criterion (excluding B1) **AND** one or more C criteria.
Possible	Meets criterion A **AND** one or more C Criteria **but NOT** Criterion D; or, meets all criteria for Definite or Probable **but DOES NOT** meet criterion D