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Original article

Neurobehavioral and self-awareness changes after traumatic brain injury: Towards new multidimensional approaches

A. Arnould [a,*,b,c], E. Dromer [a,c], L. Rochat [b,d], M. Van der Linden [b,d,e], P. Azouvi [a,c]

[a] Service de médecine physique et de réadaptation, hôpital Raymond-Poincaré, AP–HP, 104, boulevard Raymond-Poincaré, 92380 Garches, France
[b] Unité de psychopathologie et de neuropsychologie cognitive, université de Genève, Genève, Switzerland
[c] EA 4047, HANDIReSP, université de Versailles-Saint-Quentin-en-Yvelines, 78000 Versailles, France
[d] Swiss centre for affective sciences, université de Genève, Genève, Switzerland
[e] Unité de psychopathologie cognitive, université de Liège, Liège, Belgium

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ABSTRACT

Neurobehavioral and self-awareness changes are frequently observed following traumatic brain injury (TBI). These disturbances have been related to negative consequences on functional outcomes, caregiver distress and social reintegration, representing therefore a challenge for clinical research. Some studies have recently been conducted to specifically explore apathetic and impulsive manifestations, as well as self-awareness impairments in patients with TBI. These findings underlined the heterogeneity of clinical manifestations for each behavioral disturbance and the diversity of psychological processes involved. In this context, new multidimensional approaches taking into account the various processes at play have been proposed to better understand and apprehend the complexity and dynamic nature of these problematic behaviors. In addition, the involvement of social and environmental factors as well as premorbid personality traits have increasingly been addressed. These new multidimensional frameworks have the potential to ensure targeted and effective rehabilitation by allowing a better identification and therefore consideration of the various mechanisms involved in the onset of problematic behaviors. In this context, the main objective of this position paper was to demonstrate the interest of multidimensional approaches in the understanding and rehabilitation of problematic behaviors in patients with TBI.

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1. Introduction

In order to illustrate the multidimensional aspect of behavioral changes following traumatic brain injury (TBI), this literature review focused on the manifestations of apathy, impulsivity and anosognosia, which constitute the most common behavioral changes associated with a TBI. This article presents a brief descriptive introduction of each problematic behavior followed by a synthesis of the most recent studies that have investigated the nature of these behaviors. Regarding the methodology for articles search, authors focused on these three main behavioral changes, which represented the most published studies reporting the psychological processes involved. Then, in PubMed, authors selected the original articles in order to illustrate the first studies and original definitions, followed by a selection of the most recent and significant articles describing the multidimensional nature of these manifestations.

Changes in behaviors and emotional attitudes are common symptoms often described in persons with TBI, regardless of its severity. These manifestations can be quite diverse such as irritability, apathy, impulsivity or intolerance to change, and they often represent the biggest barrier to rehabilitation in the acute phase as well as to socioprofessional reintegration on the long term. [1]. Furthermore, these problematic behaviors are most often associated to manifestations of anosognosia, which makes care management as well as social, professional and familial reintegration even more difficult. Moreover, these changes have been related to negative consequences on the quality of life of patients but also of their closed ones. Indeed, behavioral and emotional changes exhibited by patients are better predictors of the subjective caregiver burden than injury severity or cognitive impairments [2].

Recently, Ciurli et al. [3] sought to characterize neurobehavioral changes among a group of 120 individuals with severe TBI. Using the Neuropsychiatric Inventory [4], the authors found that family

* Corresponding author. Tel.: +33 1 47 10 44 57; fax: +33 1 47 10 70 73.
E-mail address: annabelle.arnould@rpc.aphp.fr (A. Arnould).

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caregivers reported a wide range of neuropsychiatric symptoms such as: apathy (42%), irritability (37%), dysphoria/depression (29%), disinhibition (28%), eating disorders (27%), agitation/aggressiveness (24%), sleep disorders (15%), delusions (14%), euphoria and mania (13%), aberrant motor behaviors (9%), hallucinations (8%), and anxiety (8%). These data highlight the important proportion of problematic behaviors post-TBI, as well as the diversity of these manifestations. In clinical practice, these manifestations are most often related to executive function impairments due to brain damage, but increasingly data from the literature report that these manifestations are underpinned by a variety of mechanisms related in part to the brain damage (i.e. cognitive, psychoaffective impairments) but also to the patient's personality traits and its environment. A precise identification and consideration of these multiple mechanisms are much needed to promote adapted and effective care management for these patients.

The objective of this article was to illustrate the multidimensional aspect of these behavioral changes through two types of manifestations: apathy and impulsivity. Furthermore, anosognosia, which is often associated to these problematic behaviors in patients with TBI, can be expressed in different ways, suggesting here also the involvement of multiple processes.

2. Manifestations of apathy

Apathetic manifestations are commonly described after TBI [5] and have been associated with major negative consequences, especially regarding patients' participation in rehabilitation [6,7], family life [8] and later social reintegration [9]. The complaint from patients or family members is often "a lack of initiative, some passivity, disinterest towards oneself and others, lack of spontaneous conversation or even emotional blunting". Conceptually, there is some agreement within the literature that apathy refers to a set of behavioral, cognitive and emotional features. More precisely, disorders of interest, action initiation and emotional reactivity are all dimensions of apathy and diminished goal-directed behavior is at the core of the disorder [10]. However, current conceptions of apathy are based on descriptive and categorical approaches, without taking into account the several processes involved in each apathy manifestation as well as the interactions between these manifestations [11]. Thus, according to the definition proposed by Mulin et al. [12], a diagnosis of apathy can be made in the presence of diminished motivation in comparison to the patient's previous level of functioning, and at least two of the three following domains of apathy, which must be present for at least 4 weeks:

- diminished goal-directed behavior;
- diminished goal-directed cognitive activity;
- diminished emotions.

However, different studies have underlined significant relationships between the different dimensions of apathy, and specifically between lack of goal-directed behaviors (i.e. lack of initiative) and lack of goal-directed cognitive activity (i.e. lack of interest) [13–15]. These data are not surprising since a lack of interest is closely related to a lack of initiative and on the other hand, a lack of initiated actions may gradually lead to a lack of interest. More specifically, a recent study [16] conducted in 68 patients with TBI showed the heterogeneity of apathetic manifestations, by using the caregiver version of the Apathy Inventory [17]. Cluster analyses precisely identified four subgroups of patients: a group with high scores on all apathy dimensions, a group with low scores on all dimensions, a group with major emotional blunting and a group with high scores on lack of initiative and lack of interest. These data clearly indicate that apathy is not an accumulation of isolated symptoms but rather a dynamic concept with various associations and dissociations between the symptoms.

Furthermore, recent studies have shown the implication of different psychological mechanisms in the various facets of apathy. Thus, in elderly subjects, lack of initiative has been associated with difficulties in the ability to run multiple tasks simultaneously ("multitasking") [18], difficulties in prospective memory [14] and also low self-efficacy beliefs [19]. To be more precise, Esposito et al. [18] showed that the number of rules breaks on the modified Six Elements Test [20] was a significant predictor of lack of initiative in persons with a diagnosis of Alzheimer's disease. In addition, the multitude of mechanisms involved in apathetic manifestations is supported by the diversity of brain structures related to apathy in persons with TBI. A literature review reported the implication of a number of cortical and subcortical brain structures in the occurrence of apathetic behaviors such as the ventromedial prefrontal cortex, the lateral prefrontal cortex, basal ganglia, anterior cingulate cortex, insula and amygdala [11]. Based on all these data, a multidimensional and integrative concept of apathy was recently proposed, taking into account on the one hand the diverse mechanisms involved in the various dimensions of apathy, including cognitive factors (e.g. executive functions), motivational factors (e.g. effort mobilization), emotional factors (e.g. negative mood), aspects related to the personal identity (e.g. self-esteem) and on the other hand, the direct relations (at a symptomatic level) between the different manifestations of apathy [11].

3. Manifestations of impulsivity

Impulsivity, generally defined as the tendency to express spontaneous and excessive behaviors, has been commonly described in persons with TBI [21]. One of the significant conceptual advances should be attributed to the work of Whiteside and Lynam [22]. On the basis of a factorial analysis performed on the data of 400 students who were administered several impulsivity assessments tools, they identified four dimensions of impulsivity: urgency (the tendency to experience strong reactions, frequently under conditions of negative affects), the lack of premeditation (the difficulty to think and reflect on the consequences of an act before engaging in that act), lack of perseverance (the difficulty to remain focused on a task that may be boring or difficult) and sensation seeking (the tendency to enjoy and pursue activities that are exciting and openness to trying new experiences). This multidimensional model of impulsivity has recently been confirmed in a sample of patients with TBI with a short form of the UPPS Impulsive Behaviour Scale, which was specifically designed by Rochat et al. [23–25] to assess impulsivity changes after TBI. This scale includes 16 items (4 items per dimension) with a pre- and post-TBI evaluation for each item in order to evaluate impulsivity changes since the head injury. Results from validation studies have shown that the dimensions "urgency", "lack of premeditation" and "lack of perseverance" increased significantly after TBI, whereas the dimension "sensation-seeking" decreased significantly according to the patients' significant others.

In terms of psychological processes, sensation-seeking has been associated with motivational processes, whereas the other three impulsivity dimensions (urgency, lack of premeditation, lack of perseverance) were more related to self-control processes [26,27]. Thus, Rochat et al. [25] showed that the urgency dimension was significantly associated with dominant response inhibition difficulties in patients with TBI. The more patients had dominant response inhibition difficulties, the more they exhibited

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