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BEHAVIORAL AND COGNITIVE FUNCTIONING AFTER TRAUMATIC BRAIN INJURY

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ABSTRACT:

Background: Behavioral and cognitive disorders often occur after Traumatic Brain Injury (TBI). Controversial results about the relation between these outcomes are reported.

Aims: We aimed: explore: 1) to explore the relation between different aspects of behavioral functioning of TBI patients; 2) to explore the cognitive functioning of patients with behavioral disorders compared to patients without behavioral disorders; 3) to correlate the behavioral and cognitive functioning for both groups.

Methods: A group of 74 severe TBI patients admitted in the Neuropsychological Rehabilitation Unit of our Hospital took part in our study [inclusion criteria: LCF $\geq$ 6; time post-injury $\leq$ 9 years; no history of neurological or psychiatric disorders]. We assessed the patients' cognitive functioning with tests commonly used in clinical neuropsychology and the behavioral functioning with the Functional Assessment Measure.

Results: 1) We found significant correlation between "emotional controls", "interpersonal relationships" and "awareness"; 2) patients with behavioral disorders compared to patients without behavioral disorders show a worse performance in tests for attention and executive functions and a different relation between cognitive and behavioral functioning; 3) the behavioral functioning significantly correlates with attention and executive function only for patients without behavioral disorders, underlying a diffuse disorganization of these cognitive processes for patients with behavioral disorders.

KEYWORDS: behavioral functioning, neuropsychological functioning, traumatic brain-injury

INTRODUCTION

Traumatic Brain Injury (TBI) often leads to cognitive and behavioral disorders and it is a leading cause of disability. During the acute phase, behavioral disorders may be determined by organic factors such as severity of the trauma, but later in post-acute phase they can persist and be aggravated by environmental and social factors, too (Franulic et al., 2000).

Research has suggested that emotional and behavioral difficulties are the most common complaints

5 years post-injury, regardless of patients' age (Skell et al., 2000; Deb and Burns, 2007) and may be the most critical factor determining the quality of long-term recovery (Warrier et al., 2003).

Several studies have explored the association between different aspects of behavioral functioning in TBI patients. However, it must be noted that they differ in sample size, severity of trauma, time interval between trauma and assessment, assessment and disorder classification procedures, so they cannot be compared.

Two different results about the relation between self-awareness and emotional control have been recently reported:

1. Sawhchyn et al. (2005) administered to patients and relatives the Patient Competency Rating Scale (PCRS) (Prigatano et al., 1986), and the Katz Adjustment Scale-Revised (Jackson et al., 1992). Both scales refer to self-awareness and cognitive, behavioral and emotional functioning. They found less awareness of deficit in patients with emotional adjustment difficulties.
2. Malec et al. (2007) found a direct relation between self-awareness and depression measured with the Neurobehavioral Functioning Inventory (NFI) Depression Scale (Kreutzer et al., 1999). They conceptualized that impaired self-awareness may serve as a barrier to the development of depression.

A different research issue concerns the association between behavioral and cognitive functioning. Some recent studies reported that behavioral functioning is related with executive functions and attention:

1. Hart et al. (2005) combined eight clinical measures of executive functions in a composite score, the Executive Composite (EC). They found that a worse EC score was associated with impaired self-awareness of behavior and attention deficits, estimated using self and significant other questionnaires.
2. Krpan et al. (2007) reported that a lower executive performance was related to the use of "emotion focused coping" in interpersonal relationships, considered more maladaptive compared to "problem focused coping".
3. Baddeley et al. (1997) shared out patients without behavioral disorders from patients with dysexecutive behavioral disorders, estimated with questionnaires administered to patients and caregivers. They found a lower ability of divided attention in patients with behavioral disorders.

To investigates the behavioral and cognitive functioning after TBI, we shared out patients in two group, depending on their behavioral functioning level:

- "Low functioning" group (if at least one of the behavioral F.A.M. item was ≤ 5)
- "High functioning" group (if every behavioral F.A.M. item was 6 or 7).

AIMS AND HYPOTHESIS:

- **Aim 1:** to further explore the relation between different aspects of behavioral functioning for the two groups.

Hypothesis 1: a direct correlation between interpersonal relationships, emotional control and awareness (behavioral F.A.M. items) for both groups is expected.

- **Aim 2:** to explore the differences in demographic (age, educational level) and clinical data (GCS, coma duration, PTA duration, time post-injury, total F.A.M.) between the two group.

Hypothesis 2: no difference between groups is expected.

- **Aim 3:** to explore the differences in cognitive functioning between the two groups. **Hypothesis 3:** a lower performance in attention and executive function abilities is expected for patients with behavioral disorders.
- **Aim 4:** To correlate the behavioral and cognitive functioning for the two groups.

Hypothesis 4: for both groups, a direct correlation of the behavioral F.A.M. items with attention and executive functions abilities is expected.

METHODS

SUBJECTS

We identified 74 TBI patients (58 males, 16 females) admitted to our Hospital between 2000 and 2008. All patients had a severe TBI in accordance to Glasgow Coma Scale (GCS), coma duration and Post-Traumatic Amnesia (PTA) duration. Inclusion criteria were:

- not younger than 15 and not older than 80 years;
- Level of Cognitive Functioning ≥ 6;
- no linguistic disorders;
- no motor, visual and auditory disorders which could prevent the neuropsychological tests' administration;
- no history of previous neurological disease;
- no history of alcoholism, drug assumption, psychiatric disorders and mental retardation.

Demographic and clinical data of the two groups are shown in Table I.

	Group	M	SD	Range	Sig. (p =)
Age	Low F.	32.06	14.53	15- 73	.806
	High F.	31.16	15.48	16- 72	
Ed. level	Low F.	11.24	3.10	5 - 18	.265
	High F.	12.16	3.70	8 - 20	
GCS	Low F.	6.05	3.17	3 - 14	.907
	High F.	5.94	2.35	3 - 13	
Coma duration	Low F.	30.33	30.34	1 - 120	.171
	High F.	16.18	15.61	1 - 45	
PTA duration	Low F.	11.96	7.50	1 - 28	.727
	High F.	11.06	8.58	1 - 30	
F.A.M.	Low F.	177.08	30.83	75 - 210	.484
	High F.	182.24	27.64	115 - 210	
Time post-injury	Low F.	13.96	23.68	1 - 180	.177
	High F.	7.36	6.42	2 - 28	

TAB. I. Demographic and clinical data of the two groups.

ASSESSMENT OF BEHAVIORAL FUNCTIONING

F.A.M. is a 30 items, seven levels ordinal scale used in the rehabilitation of any neurological, musculoskeletal and other disorders to assess areas of dysfunction in everyday activities. It is administered by the rehabilitation team in collaboration with the patients and his family. Items are classified in motor functions (16 items related to self-care, sphincter control, mobility, locomotion) and cognitive functions (14 items related to communication, psychosocial adjustment, cognitive functioning) (Hall et al., 2001; Tesio e Cantagallo, 1998).

The general coding is:

7 = Complete independence (timely, safely);
6 = Modified independence (extra time, device);
5 = Supervision;
4 = Minimal assist (independence in >75% of task);
3 = Moderate assist (independence in 50-75% of task);

2 = Maximal assist (independence in 25-50% of task);
1 = Total assist (independence in < 25% of task).

We assessed the patient's behavioral functioning with 3 cognitive F.A.M. items concerning behavior: "emotional control", "interpersonal relationships", and "awareness". They respectively refers to:

- **Emotional control**: frequency and severity of depression, anxiety, frustration, apathy, agitation episodes; effect of these episodes on everyday activities; patient's ability to cope with his emotional behavior.
- **Interpersonal relationships:** ability to interact with other people in clinical and social context and to integrate individual needs with other people needs; inappropriate behaviors refer to yell out, to use a scurrilous language, to react aggressively, to show excessive laugh or crying and to show changeable attitudes or inability to get in touch with others.
- **Awareness:** awareness and acceptance of disability, motivation to learn compensatory strategies; to take appropriate safety measures and to have realistic expectations about the future.

ASSESSMENT OF COGNITIVE FUNCTIONING

Attention

- Visual Scanning (Matrices) (Spinnler and Tognoni, 1987), to assess selective attention and visual search ability: execution time and number of errors are recorded.
- Trail Making Test (TMT), subtest A e B (Giovagnoli et al., 1996), to assess the cognitive flexibility implied in the execution of two alternating tasks: time execution in part A and B and the difference between the two have been analyzed.
- Verbal span (disyllabic words) (Spinnler and Tognoni, 1987), to assess verbal short-term memory;
- Spatial Span (Corsi) (Spinnler and Tognoni, 1987), to assess visual-spatial short-term memory;
- Immediate Visual Memory (IVM) (Caltagirone et al, 1995).

Executive Functions

- Wisconsin Card Sorting Test (WCST) (Heaton et al., 2000), to assess the ability to formulate abstract concepts and to flexibly modify strategies depending on environmental modifications. Global Score, Perseverative Response, Non-Perseverative Errors and Failure to maintain a set have been analyzed;
- Behavioral Assessment of Dysexecutive Syndrome (BADS) (Wilson et al., 1996), to assess the ability of actions and routes planning, temporal judgments and cognitive flexibility; we analyzed each subtest's score (Rule shift card, Action program, Key search, Temporal judgment, Zoo map, Modified six elements);
- Raven Progressive Matrices (38) (Spinnler and Tognoni, 1987), to assess the abstract reasoning ability.

Memory and Learning

- Verbal selective reminding test (Buschke-Fuld) (Spinnler and Tognoni, 1987), to explore whether learned verbal stimuli are stored in short-term or long-term memory (coding and recovery LT processes). We analyzed the following scores: Total recall, Consistent recall and Delayed recall;
- Spatial Sovra-Span (Spinnler and Tognoni, 1987), to assess visual-spatial learning;
- Prose memory (Capitani et al., 1994), to assess both the ability to recall the text regardless of the items' significance (No hierarchic score) and the ability to recall the more important events (Hierarchic score).

STATISTICAL ANALYSIS

An oneway ANOVA was carried out to explore if the two groups were different in relation to:

- Demographic data: age, educational level;
- Clinical data of both the acute phase (GCS, coma duration, PTA duration) and post-acute phase (time post-injury, total F.A.M.);
- Performance in neuropsychological tests.

For the two group**s,** Spearman's rank correlation was computed:

- Between behavioral F.A.M. behavioral items;
- Between behavioral functioning (behavioral F.A.M items) and cognitive functioning (performance in neuropsychological tests).

Alpha < 0.05 was taken as significance level.

RESULTS

Hypothesis 1 confirmed: A Significant correlations between interpersonal relationships, emotional control and awareness (behavioral F.A.M). items resulted for both groups, as shown in Table II.

	Interpersonal relationships		**Emotional control**	
	Low F.	High F.	Low F.	High F.
Emotional control	.691**	.611**		
Awareness	.550**	.695**	.554**	.792**

Significant two-tailed correlations are pointed up with asterisks (* for significant value at the .01 level, ** for significant value at the .05 level).

TAB. II. Correlations between the behavioral F.A.M. items for the two groups.

Hypothesis 2 confirmed: Any significant differences between groups was found in demographic and clinical data (see Tab. I).

Hypothesis 3 confirmed: The Low functioning group had a worse performance compared to the High functioning group in neuropsychological tests assessing attention and executive function, as Table III reported. Specifically, they seem to have less ability to select attention on target stimuli, to shifting of attention between two alternating tasks and to plan the execution of a complex action sequence within a specific time interval.

	Group	M	SD	Range	Sig. (p=)
Matrices	Low F. High F.	38.33 42.85	8.66 7.61	15.25 - 51. 75 29.25 - 56. 25	.034
TMT A	Low F. High F.	64.65 52.36	23.11 15.87	30 - 143 24 - 85	.02
TMT B	Low F. High F.	168.93 139.65	54.54 50.98	50 - 280 42 - 303	.038
TMT B-A	Low F. High F.	111.31 86.57	45.54 40.92	27 - 227 14 - 220	.034
BADS (6 elements)	Low F. High F.	83.39 106.04	20.12 9.39	46.6 - 108.87 77.73 - 108.87	.001

TAB. III. Significant differences between groups in the cognitive functioning.

No difference between groups was found in other tests.

Hypothesis 4 partially confirmed: As shown in Table IV, behavioral F.A.M. items correlates with tests assessing attention and executive functions almost only for patients with high behavioral functioning.

	Interpersonal relationships		Emotional control		Awareness	
	Low F.	High F.	Low F.	High F.	Low F.	High F.
TMT A	.152	-.552**	.227	-.603**	.025	-.589**
TMT B	.129	-.499*	-.034	-.588**	-.077	-.699**
TMT B-A	.048	-.479*	-.25	-.540**	-.191	-.659**
BADS (Rule)	.247	.787**	.337	.664*	.444*	.885**
Raven ('38)	-.086	.501*	-.167	.569**	.039	.647**

Significant two-tailed correlations are pointed up with asterisks (* for significant value at the .01 level, ** for significant value at the .05 level).

TAB. IV. Significant correlations between behavioral and cognitive functioning for the two groups.

DISCUSSION AND CONCLUSIONS

Aim 1: The strong correlation between awareness, interpersonal relationships and emotional resulted for both groups, suggest that a single, comprehensive process is responsible for all the F.A.M. items

concerning behavioral functioning. Our results is in accordance with Sawhchyn et al. (2005) and Malec et al. (2007) findings.

Aim 2: Behavioral disorders in TBI patients seemed not related either to demographic data, clinical data of the acute-phase and clinical data of the post-acute phase. As proposed by Franulic et al. 2000, it would be useful to consider the role held by environmental and social factor in the development of behavioral disorders.

Aim 3: In accordance with other author's results (Hart et al., 2005; Krpan et al., 2007; Baddeley et al., 1997), patients with behavioral disorders perform worse compared to patients without behavioral disorders in test for attention and executive functions. Further research is needed to determine whether the behavioral functioning contribute in a causal fashion to attention and executive functions abilities.

Aim 4: Behavioral functioning correlates with attention and executive functions almost only for patients with high behavioral functioning, suggesting that behavioral disorders are related with a diffuse disorganization of these cognitive processes. It would be useful to explore if some aspects of emotional control, interpersonal relationships, awareness are more responsible than others for supporting cognitive functioning.

Our findings support that a rehabilitative approach focalizing on both cognitive and behavioral functioning would be useful for TBI patients. Nevertheless, only few studies are reported about this issue. Rath et al. (2003) proposed an innovative group treatment for the problem-solving deficits. It incorporated strategies for addressing underlying emotional self-regulation and logical thinking/reasoning deficits, focalizing on both motivational, attitudinal and affective processes and problem-solving skills in patients with TBI. Results showed an improvement in problem solving as assessed using a variety of measures, including (1) executive function (2) problem-solving self-appraisal, (3) self-appraised emotional self-regulation and clear thinking, (4) objective observer ratings of role-played scenarios. An adaptation of this protocol to the Italian context is in progress, (Cantagallo et al., in progress) expecting it could improve behavioral functioning and executive functions abilities in TBI patients.

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