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Cognitive correlates of narrative impairment in moderate traumatic brain injury

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ABSTRACT

Traumatic brain injuries (TBIs) are often associated with communicative deficits. The incoherent and impoverished language observed in non-aphasic individuals with severe TBI has been linked to a problem in the global organization of information at the text level. The present study aimed to analyze the features of narrative discourse impairment in a group of adults with moderate TBI (modTBI). 10 non-aphasic speakers with modTBI and 20 neurologically intact participants were recruited for the experiment. Their cognitive, linguistic and narrative skills were thoroughly assessed. The persons with modTBI exhibited normal phonological, lexical and grammatical skills. However, their narratives were characterized by lower levels of Lexical Informativeness and more errors of both Local and Global Coherence that, at times, made their narratives vague and ambiguous. Significant correlations were found between these narrative difficulties and the production of both perseverative and non-perseverative errors on the WCST. These disturbances confirm previous findings which suggest a deficit at the interface between cognitive and linguistic processing rather than a specific linguistic disturbance in these patients.

1. Introduction

Traumatic brain injuries (TBIs) are often associated with communicative deficits. Factors such as the seriousness of the trauma and lesion site and extension might alter communicative skills in different ways (Douglas, 2004; Watt and Douglas, 2006). These individuals often experience aphasic symptoms that include phonological, lexical and/or grammatical disturbances. However, even those without aphasic symptomatology might show altered communicative behaviors. Their speech can be incoherent, impoverished (Hartley and Jensen, 1992; Davis and Coelho, 2004), and pragmatically inadequate (e.g., Togher et al., 1997; Bond and Godfrey, 1997; Angeleri et al., 2008; Tu et al., 2011). Such difficulties might be the consequence of a problem in the global organization of information at the macrolinguistic level of discourse processing rather than at the lexical and syntactic (i.e., microlinguistic) level (Brookshire et al., 2000; Coelho, 2002; Body and Perkins, 2004; Le et al., 2011; Marini et al., 2011a; Carlomagno et al., 2011; Galetto et al., 2013). The high-level linguistic skills that guide narrative discourse formulation are mediated by a wide range of cognitive skills (e.g., working memory, attention and executive functions; Sim et al., 2013; Mozeiko et al., 2011) that are usually impaired because of the fronto–temporo-parietal lesions and diffuse axonal damage induced by the brain injury (Stierwalt and Murray, 2002; Mendez et al., 2005; Youse and Coelho, 2005; Scheid et al., 2006; Silver et al., 2009; Erez et al., 2009). Notably, recent evidence suggests that some of these neural networks are implicated also in discourse processing (e.g., Coelho et al., 2012; Marini and Urgesi, 2012). There are unresolved issues at both the clinical and theoretical levels. On the clinical level, the role played by the severity of the trauma on linguistic skills. On the theoretical level, the linguistic abilities of persons with TBI have rarely been the object of a comprehensive micro- and macrolinguistic analysis. On the clinical level, it is not clear yet how the severity of the trauma affects language production skills, as the majority of studies have focused on severe forms of TBI. For example, several studies have shown that persons with severe TBI have major difficulties in narrative production tasks and that in these individuals, story grammar measures correlate with performance on tests assessing executive functions (Coelho et al., 1995; Coelho, 2002; Mozeiko et al., 2011; Marini et al., 2011a; Le et al., 2012). Though interesting, it is unclear whether these findings can be extended to narrative discourse performance in individuals with moderate and mild TBI. To the best of our knowledge, only a few studies have explicitly analyzed this important issue.

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In one such study, Youse and Coelho (2005) reported on the cognitive and linguistic profile of 55 participants with moderate and severe TBI and in both groups, macrolinguistic difficulties on two narrative production tasks (story retelling and story generation) were observed. In a previous study by Biddle et al. (1996), a group of moderate to mild TBI participants produced personal narratives that were less informative than those produced by a group of healthy individuals. The group of patients with moderate TBI could not adequately monitor their narratives and failed to include critical information in their stories. Overall, the few studies that explicitly explored the macrolinguistic skills of persons with moderate TBI point to difficulties in the conceptual and linguistic organizations of their narrative discourse. However, neither of these investigations included accurate micro- and macrolinguistic analyses. Accumulating evidence suggests that multi-level procedures for linguistic analysis provide a unique way to adequately capture the linguistic profile of persons with communication impairments by identifying deficits that are often not detectable by standardized testing (Galski et al., 1998; Snow et al., 1998, 1999; Sherratt, 2007; Jorgensen and Togher, 2009; Marini et al., 2011b). For example, Marini et al. (2011a) analyzed the cognitive and linguistic skills in narratives produced by a group of non-aphasic individuals with severe TBI. Though these individuals showed adequate lexical and grammatical skills, their narrative descriptions were characterized by several violations of cohesion and coherence due to frequent interruptions of ongoing utterances, derailments, and introduction of extraneous utterances. As a result, their narratives were poorly organized, vague and ambiguous. Interestingly, a principal component analysis revealed that a single factor accounted for the violations of Global Coherence, reduced propositional density, and reduced proportion of words that conveyed information. Similarly, Carlomagno et al. (2011) demonstrated that the production of errors in cohesion and coherence in narratives corresponded to reduced informativeness and efficiency. More recently, Galetto and colleagues (2013) analyzed the narrative abilities of a group of 14 mild TBI non-aphasic participants showing that even persons with mild TBI produce more errors of Global Coherence than normal. This finding lends further support to the hypothesis that macrolinguistic difficulties may arise as a consequence of the broad cerebral lesions that characterize traumatic injuries, regardless of the severity of the damage.

Consequently, the current study was designed to analyze the narrative and linguistic skills of a group of persons with moderate TBI with no sign of aphasic symptoms by adopting a multi-level procedure for discourse analysis. We hypothesized that this narrative analysis would reveal the linguistic impairments not captured by traditional aphasia testing. Furthermore, since the multilevel procedure for discourse analysis allows clinicians to explore the complex interactions between the different levels of linguistic processing (e.g., between verb processing, argument structure generation, sentence production, and inter-utterance integration), we expected to find significant correlations between measures assessing these different levels. Finally, we hypothesized that these patients would experience difficulty with tasks assessing executive function and attention and that performance on these tasks correlate with the ability to produce coherent and informative narrative samples.

Table 1
Means (and standard deviations) of demographic and clinical characteristics of the groups of Traumatic Brain Injured and Healthy Control participants.

	Traumatic Brain Injured			Healthy Controls		
	Mean	(SD)	(Range)	Mean	(SD)	(Range)
Age	36.6	(10.8)	(22–55)	35.7	(9.5)	(21–55)
Formal education (years)*	11.0	(2.6)	(8–13)	14.7	(2.9)	(8–18)
Time after injury (months)	22.4	(7.2)	(12–32)	–		
GCS (maximum score: 15)	10.8	(.8)	(9–13)	–		

GCS: Glasgow Coma Scale.

* When the group-related difference is significant.

2. Methods

2.1. Participants

Thirty Italian-speaking participants formed two age matched groups (Table 1). The experimental group consisted of 10 patients suffering from moderate traumatic brain injury (modTBI). Criteria for the selection of TBI participants included symptom stability, Glasgow Coma Scale score ranging from 9 to 13, and normal to near-normal performance on the Aachener Aphasie Test (AAT, Italian version, Luzzatti et al., 1991) (see Tables 1 and 3). Although all participants were living at home at the time of the study, none were completely independent and all had caregivers. Three of the participants were employed, four were unemployed, and three were university students at the time of their participation. After hospital discharge, participants underwent extensive neuropsychological rehabilitation aimed at recovering those cognitive functions most affected by brain injury (i.e., attention, memory, executive functions, and communicative skills). The treatment, lasting for 6 months, consisted of individual and group sessions. The aim of each individual session was treatment of specific cognitive deficits, through a series of focused exercises. In the group sessions, the focus was mainly on social and communicative skills. All participants also received language therapy in their post-acute phase.

The control group consisted of 20 neurologically Healthy Controls (see Table 1). Inclusion criteria for admission in the control group was normal performance on Raven's progressive matrices (Raven, 1938) and on a selection of neuropsychological tests assessing the functionality of different areas of cognition linked to language processing (see Section 2.2.1 and Table 2). None of them had a known history of psychiatric or neurological illness, learning disabilities, or hearing or visual loss.

Two independent samples *t*-tests were conducted to compare the age and the level of formal education in the two groups. There was no significant difference in age ($t\,(28)=-.246$; $p=.530$) but the two groups differed in the level of formal education ($t\,(28)=3.787$; $p<.001$). For this reason, this variable was included as covariate in the analyses (see later).

All participants gave their written informed consent to participate in the study after all procedures had been fully explained. Approval for the study was obtained from the local ethics committee.

2.2. Procedures

2.2.1. Neuropsychological assessment

The cognitive profile of the participants was obtained by administering tests aimed at assessing those abilities (attentional and learning skills, long-term memory, and executive functions) which may affect narrative performance (see Table 2): This included tests of phonological and semantic verbal fluency, verbal memory (Rey's 15-word Immediate Recall and Delayed Recall), executive functioning (Wisconsin Card Sorting Test, WCST perseverative and non-perseverative errors; Heaton et al., 1993), and the Trail Making Test (Parts A and B; Reitan, 1992). The linguistic skills of the TBI group were investigated by administering the AAT (see Table 3).

Table 2
Means (and standard deviations) of the neuropsychological performance of the groups of Traumatic Brain Injured and Healthy Control participants.

	Traumatic Brain Injured	Healthy Controls	*p*-value	Eta-squared
TMT-A (seconds)	39.2 (14.2)	54.6 (12.6)	.099	.098
TMT-B (seconds)	123.3 (89.4)	115.4 (32.3)	.105	.094
Phonemic fluency	27.1 (11.2)	35.4 (8.3)	.199	.060
Semantic fluency	17.2 (5.7)	24.1 (4.8)	.047	.138
WCST (pers err)*	6.4 (6.5)	.5 (.2)	.001	.402
WCST (non-pers err)*	18.1 (10.3)	.2 (.4)	.001	.608
Rey's 15-word immediate recall	43.4 (12.9)	45.6 (6.6)	.649	.008
Rey's 15-word delayed recall	8.6 (4)	10 (1.8)	.211	.057

TMT-A: Trail Making Test, Part A; TMT-B: Trail Making Test, Part B; WCST (pers err): Wisconsin Card Sorting Test, perseverative errors; WCST (non-pers err): Wisconsin Card Sorting Test, non-perseverative errors.

* When the group-related performance was significantly different after Bonferroni correction ($p<.006$).