J Head Trauma Rehabil

Low Self-Awareness of Individuals With Severe Traumatic Brain Injury Can Lead to Reduced Ability to Take Another Person's Perspective

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Aims of this study were (i) to verify whether a deficit or a lack of self-awareness can lead to difficulties in assuming another person's perspective after a severe traumatic brain injury (TBI); (ii) to verify whether perspective-taking deficits emerge more from performance-based tasks than self-reports; and (iii) to evaluate the possible relationships between perspective-taking difficulties and some clinical, neuropsychological, neuropsychiatric, and neuroimaging variables. The Interpersonal Reactivity Index, Empathy Quotient, first-order false-belief, and faux pas written stories were administered to 28 patients with severe TBI and 28 healthy controls. The Awareness Questionnaire was also administered to TBI patients and their caregivers. Patients were split into 2 groups (impaired self-awareness vs adequate self-awareness) on the basis of the discrepancy Awareness Questionnaire score. Both TBI groups obtained lower scores than healthy controls on the Fantasy subscale of the Interpersonal Reactivity Index, the reality question of the false-belief stories, and the memory questions of the faux pas test. Only impaired self-awareness patients tended to obtain lower scores in first-order false-belief detection. Impaired self-awareness patients also performed significantly worse than both healthy controls and adequate self-awareness patients on the faux pas tasks. The analysis suggests a causal relationship between low self-awareness and perspective-taking difficulties in this population of patients. **Key words:** *empathy*, *self-awareness*, *Theory of Mind*, *traumatic brain injury*

IN HUMANS, social interaction is a prerequisite for adaptive learning and psychological satisfaction. In particular, the ability to reflect on knowledge about the self and to adopt others' perspectives is crucial for understanding others' intentions, beliefs, and feelings and interacting successfully with them.[1] This undoubtedly explains neuroscientists' growing interest in investigating the psychological and neuroanatomical characteristics of the ability to cognitively and emotionally take another person's perspective.

The main current views consider the ability to infer and share the experiences of others as a multidimensional construct, called empathy,[2] which includes both emotional[3–5] and cognitive[6–8] aspects. In particular, *emotional* or *affective* empathy has been defined as an observer's emotional response to another person's affective state[5] and the *cognitive* component of empathy has been included in the concept of Theory of Mind (ToM)[9–11] or mentalizing,[12,13] which specifically refers to the ability to take another person's perspective by "reading" that person's mental states and inferring that person's desires and beliefs.[11,12,14,15]

Some behavioral and neuroimaging data suggest that the cognitive and emotional components of perspective taking rely on different brain networks. In particular, emotional empathy has been linked to limbic and paralimbic structures, such as the anterior insula,[16] rostral anterior cingulate cortex,[17–21] and amygdale;[22] and

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the secondary somatosensory cortices.[23] Instead, cognitive empathy and/or ToM abilities have been related to other neural circuitries, such as the ventromedial prefrontal cortex[18,22,24–33] and the orbitofrontal cortex, middle frontal gyrus, cuneus, and superior temporal gyrus.[22,26,27,30]

From a purely psychological perspective, 2 different approaches have been proposed to explain the nature of ToM processes: (i) "Theory theory"[34,35] and (ii) Simulation theory.[36–39] Basically, the Theory theory approach posits that normal people can read another person's mind by acquiring and deploying a commonsense ToM, something very similar to a scientific theory. In this view, attributing particular mental states to another arises from theoretical reasoning involving tacitly known causal laws. In contrast, according to the Simulation theory, attributors use their mental mechanisms to calculate and predict the mental processes of others. In particular, this view posits that to read another person's mind, subjects should put themselves in that person's shoes and imagine how they would feel in that person's place. The core difference between Theory theory and Simulation theory is that Theory theory considers mind reading as a thoroughly "detached" theoretical activity, whereas Simulation theory considers mind reading as incorporating an attempt to replicate, mimic, or impersonate the mental life of the target agent.[40]

Perspective-taking abilities are frequently impaired after a traumatic brain injury (TBI) (ie, in terms of self-centering or insensitivity to others) and can lead to serious social problems.[41–43]

Patients' difficulty in flexibly changing their point of view could affect their ability to interpret and manage social interactions. This factor, together with other aspects related to TBI, such as negative symptoms (eg, lack of initiation), significant emotional distress (eg, depression, anxiety), and loss of context (work, school), could provoke aversive reactions in others; consequently, TBI patients might withdraw from social relationships.[44] Evidence of a perspective-taking deficit in TBI derives from behavioral studies in which both performance-based and self-report measures were used. *Performance-based* tasks are prototypically those in which patients have to put themselves in the shoes of the main character of a short story and answer specific questions about the character and his or her relationships with the other characters.[7,25,45–47] In contrast, on *self-report* scales, the patient has to answer some questions related to the construct of interest.[4,5,10]

Various authors have reported that individuals with a head injury perform significantly worse than healthy controls on performance-based measures.[48–52] Concurrent findings come from self-report investigations showing that TBI individuals tend to report higher perspective-taking difficulties than controls.[50,51,53–57] However, Muller et al[52] recently reported that perspective taking is not clearly impaired in TBI individuals. In fact, although these authors found reduced performance-based accuracy in TBI patients with respect to healthy controls, they failed in showing any significant difference between the 2 groups on self-report tools. These divergent findings may be due to various factors: (1) the clinical characteristics of the TBI samples recruited as well as the different assessment instruments used across studies; and (2) TBI might mainly affect faux pas performance, as suggested by Martín-Rodríguez and León-Carrión[58] in a recent review.

A third relevant factor could be low self-awareness, namely, the ability to be aware of one's own thoughts, feelings, and mental states,[59] which implies that one actively identifies, processes, and stores information about the self.[60] Indeed, self-awareness is commonly impaired after a TBI[61–63] and consists of partially or totally reduced ability to recognize problems caused by damaged brain function. Low self-awareness might affect self-report scale scores in a peculiar way; in fact, as poor self-awareness can impair patients' capacity to estimate their own ability, the self-assessment of perspective-taking abilities might also be affected after severe TBI. In this regard, many authors believe that using self-report measures to evaluate perspective-taking abilities in patients with severe TBI is questionable,[52] because these measures require a subjective evaluation of mental and physical states.[64] Thus, it can be argued that if only these measures are used to evaluate perspective-taking deficits in TBI patients with impaired self-awareness, the phenomenon might be underestimated. In fact, it is believed that either collateral information from relatives or systematic behavioral observations are necessary.[64]

Self-awareness has been related to the ability to read another person's mind. Indeed, according to some authors, an individual must be aware of his or her own mental states to infer what another thinks, knows, wants, or intends to do and then model comparable mental experiences of others.[59,65,66] In other words, self-awareness is a prerequisite for assuming another person's perspective: "... if I can think about my thoughts, I should be able to think about your thoughts as well." This hypothesis is in line with the aforementioned Simulation theory view, because it assumes that self-awareness precedes and is the basis of a natural tendency to attribute internal states to others through mental simulation.

The aim of this study was primarily to verify whether reduced self-awareness in patients with severe TBI leads to difficulty in reading another person's mental state. Moreover, as self-report measures may be unreliable for detecting perspective-taking difficulties in individuals with low self-awareness, we used both *self-reports* and *performance-based* tests. In this regard, we expected that perspective-taking deficits would emerge more from performance-based tasks than from self-reports.

Further aims of this study were to evaluate the possible relationships between perspective-taking difficulties and some clinical, neuropsychological, neuropsychiatric, and neuroimaging variables. In particular, we aimed to verify whether TBI patients with low self-awareness had more frontal lobe lesions and, consequently, more executive difficulties and frontal lobe–related neuropsychiatric diseases than those with an adequate level of self-awareness.

METHODS

Participants

Participants included 30 patients with severe TBI consecutively admitted to the Post-Coma Unit of the Santa Lucia Foundation from February 2010 to January 2011. The study was approved by the local ethics committee. The study sample was recruited according to the following *inclusion* criteria: (1) age 18 years or more; (2) diagnosis of severe TBI (Glasgow Coma Scale score $\leq$8); (3) posttraumatic amnesia (PTA) resolution; (4) capacity to undergo formal psychometric evaluation despite cognitive and sensory-motor deficits; (5) absence of aphasia; (6) time interval after consciousness recovery: at least 6 months; and (7) availability of informed consent. *Exclusion* criteria for patients recruited in this study were as follows: (1) history of drug and alcohol addiction; (2) psychiatric diseases; (3) repeated TBI and/or other neurological disorders. After enrolment, 2 patients were excluded because they refused to complete the interview (in both cases because of low frustration tolerance). Thus, the final sample consisted of 28 patients with severe TBI, aged 18 to 63 years. Most patients (n = 25, 89%) had sustained their head injury in a road traffic accident.

To evaluate patients' self-awareness levels according to the discrepancy between their report and that of the caregivers, 28 first-degree relatives (all at least 18 years old) were enrolled: 15 were parents of the patients (54%), 10 were partners (36%), 1 was a child (4%), and 2 were sisters (7%). Only first-degree relatives who were living with patients or at least had daily contact with them were enrolled.

The patients Awareness Questionnaire (AQ) total scores ranged from 27 to 56 (mean = 43.1; SD = 6.2), whereas that for the caregivers ranged from 0 to 62 (mean = 35.8; SD = 12.2). Patients were split into 2 subgroups on the basis of their median value of the AQ discrepancy scores (AQ-DS) (median = 4.5), that is, the difference between the AQ rated by patient himself and the AQ rated by his or her caregiver[65]: (i) patients with lower level of self-awareness ("impaired self-awareness" group: ISA) and (ii) patients with higher level of self-awareness ("adequate self-awareness" group: ASA). Patients with an AQ-DS higher than the median value were placed in the ISA group (mean = 15.8; SD = 12.6; moda = 7; range from 5 to 51) and patients with an AQ-DS lower that the median value were placed in the ASA group (mean = −1.14; SD = 5.2; moda = 1; range from −17 to 4).

All patients were compared with 28 healthy control subjects (21 males and 7 females), comparable for age, gender, and years of formal education. *Exclusion criteria* for participants in the control group were history of drug and alcohol addiction and psychiatric or neurological diseases. Controls were volunteers who were recruited thorough an advisement in our institute.

Measures

Functional assessment

A functional assessment was made using the following scales: the Disability Rating Scale (DRS),[67] the Levels of Cognitive Functioning (LCF),[68] and the Glasgow Outcome Scale (GOS).[69]

Neuropsychological assessment

To determine whether specific cognitive abilities contributed to our TBI patients' level of perspective taking, we administered a variety of neuropsychological tests, namely, the *Wisconsin Card Sorting Test* (WCST)[70,71] and the *Verbal Fluency Test*[72] to assess multiple executive subcomponents, the *Forward* and *Backward Digit Span* tasks[73] to assess verbal short-term memory and working memory, respectively, and the *Prose Memory Test*[72] to assess episodic memory.

Neuropsychiatric assessment

To assess patients' neuropsychiatric disorders, the Neuropsychiatric Inventory (NPI)[74] was administered to TBI patients' relative. The NPI provides a comprehensive assessment of psychopathology in patients with neurological problems; it consists of an informant-based interview that evaluates behavioral changes secondary to a neurological illness. Each NPI subscale assesses a different area: delusions, hallucinations, agitation/aggression, dysphoria/depressed mood, anxiety, euphoria, apathy, disinhibition, irritability/lability, aberrant motor behavior, nighttime disturbances, and appetite/eating disturbances. The score for each neuropsychiatric domain is the product of the frequency and severity subscore for that particular domain (maximum 12), with zero indicating absence of symptoms and 12 indicating higher frequency and severity of symptoms.

Self-awareness assessment

The Awareness Questionnaire Self-awareness level was measured using the AQ,[75] one of the scales adopted most often to assess *metacognitive* self-awareness deficits[76,77] in TBI populations. The AQ consists of 17 items that evaluate patients' current functional abilities compared with their preinjury abilities. The AQ items are rated on a Likert scale ranging from 1 (much worse) to 5 (much better). Scores vary from 17 to 85; a score of 51 indicates that the patient is functioning "about the same" as his or her preinjury level.[63] The degree of the self-awareness deficit is calculated by subtracting family/significant other ratings or clinician ratings from patient self-ratings. These discrepancy scores can range from −68 to 68. Higher discrepancy scores are associated with more severe self-awareness deficits; negative scores are rare and might show a patient's overestimation of his or her impairment,[78,79] possibly due to a high level of emotional distress.[80,81]

Perspective-taking assessment

Self-report measures

Interpersonal Reactivity Index The Interpersonal Reactivity Index (IRI)[10] is a self-report questionnaire that measures cognitive and emotional empathy. It includes 28 items that are broken down into four 7-item subscales, each tapping a different aspect of empathy: (i) the *Perspective-Taking* subscale, which measures the reported tendency to adopt another person's perspective or point of view (eg, "I sometimes try to understand my friends better by imagining how things look from their perspective"); (ii) the *Fantasy* subscale, which measures the tendency to identify with fictional characters in books, movies, or plays (eg, "When I watch a good movie, I can very easily put myself in the place of a leading character"); (iii) the *Personal Distress* subscale, which measures the tendency to experience feelings of discomfort and anxiety in response to others' negative experiences (eg, "I tend to lose control during emergencies"); (iv) the *Emphatic Concern* subscale, which measures feelings of warmth, compassion, and concern for others who are experiencing a negative event (eg, "When I see someone being taken advantage of, I feel kind of protective toward them."). According to Davis,[10] the Perspective-Taking subscale is the most clearly *cognitive* empathy scale whereas the other 3 scales (Fantasy, Emphatic Concern, and Personal Distress) seem more related to *emotional* responsiveness and should therefore display the opposite pattern of relationships with existing empathy measures.[10]

According to the Italian version of the questionnaire, published by Bonino and colleagues,[82] items are rated on a Likert scale ranging from 0 ("never true") to 4 ("always true"). Scores on these scales range from 0 to 112.

Empathy Quotient

The Empathy Quotient (EQ)[5] is a commonly used questionnaire to evaluate empathy. Unlike the IRI, the 40 items on the EQ are not separated into affective and cognitive subcomponents. The questionnaire is based on the assumption that the affective and cognitive components of empathy cannot be separated.[5] Responses are rated on a 4-point Likert scale ranging from "strongly agree" to "strongly disagree" and are scored 2, 1, or 0.

Performance-based measures

To evaluate perspective-taking abilities, we adopted a slightly revised version of an experimental procedure used by one author of this article in a previous study.[33] This procedure was built on the basis of previous ToM paradigms.[46,83] Then, we wrote 18 short stories followed by a series of questions. The stories were composed of 6 first-order false-belief tasks, 6 faux pas recognition tasks, and 6 control stories for the faux pas tasks.[83] Participants were required to read the stories, which were presented in a printed version, and then to answer questions by choosing among different alternatives. There was no time constraint for reading the story. Participants informed the examiner when they were ready and then began to answer the questions.

First-order false-belief tasks

In these stories, one person puts an object somewhere and then he leaves and a second person moves the object while he is away. The questions are related to the inference that someone has a mistaken belief (question 1: The subject is asked to predict where the character will search for the object), the examination of reality (question 2: The subject is asked to indicate where the object is), and memory accuracy (question 3: The subject is asked to indicate where the object was at the beginning of the story).

Faux pas tasks

These stories describe a prior event involving 2 people.[83] Later, the 2 characters meet, and 1 (forgetting the prior event) says something awkward that could offend the other. The questions required the subjects to detect the faux pas (question 1: "Did somebody say something he shouldn't have said?"), to identify who made the faux pas (question 2: "Who said something he shouldn't have said?"), to understand the mental state of the listener (question 3: "Why shouldn't he have said it?"), and to understand the mental state of the speaker (question 4: "Why did he say it?"). Another question was included to determine their recollection of the characters in the story. Control faux pas stories, in which no faux pas occurred between the characters, were also administered. For all first-order false-belief and faux pas stories, accuracy was recorded separately for each question. A score of 1 was assigned to correct answers, and a score of zero to wrong answers. Each subject was administered the stories in one experimental session, which lasted about 60 minutes. The order of story presentation was randomized so that false-belief, faux pas, and control stories were intermixed.

Procedure

The participants met the examiner about 4 times. The first time they met, their relatives were also present. At this time, the experimental procedure was explained and participants' informed consent was obtained. The neuropsychological assessment and administration of perspective-taking and self-awareness tools took place on 3 different days so as not to tire the patients.

A neurologist carried out the functional assessment; a neuropsychologist administered the neuropsychological tests; a psychologist administered each perspective-taking performance-based task; and finally, at the end of the performance-based session, a psychologist gave the patient the self-awareness and perspective-taking self-report instructions and remained in the room to assist them. Likewise, in another room, a psychologist helped the patients' relatives complete the self-awareness self-report measure (caregiver form) and the NPI.

Statistical analyses

Preliminary Student *t* tests were performed to compare the 2 TBI groups on clinical variables (ie, chronicity; time to follow commands; PTA; Glasgow Outcome Scale–Extended; DRS; General Level of Cognitive Functioning).

A general multivariate analysis of variance was performed to compare performance scores obtained by individuals in the 2 TBI groups on the WCST (ie, categories achieved and percentage of perseverative responses), the Forward and Backward Digit Span tasks, the Prose Memory Test, and the Phonological and Semantic Verbal Fluency Test. Then, χ^2 analyses were performed to compare the number of subjects in the 2 groups whose performance was outside the reference range (ie, normality cutoff scores corresponding to a performance ≥95% of the lower tolerance limit of the normal population distribution) on these tests. Analyses of variance (ANOVAs) were also performed to compare the NPI-Total and NPI subscale scores obtained by the individuals in the 2 patient groups. Chi-square analyses were also performed to determine whether there were any between-group differences in the distribution of brain damage, as revealed by the neuroimaging examination.

To compare the scores obtained by participants on the IRI, a mixed ANOVA with group as between factor (ISA vs ASA vs healthy control subjects) and IRI subscales (Emphatic Concern vs Personal Distress vs Perspective Taking vs Fantasy) as within factor was executed. Instead, to determine whether there were any EQ score differences between the 2 groups, a 1-way ANOVA was performed with group as independent factor and EQ total score as dependent variable. Accuracy on first-order false-belief stories was compared by means of mixed ANOVA, with group (ISA vs ASA vs healthy control subjects) as between factor and questions (question 1 vs question 2 vs question 3) as within factor. To compare the performance scores on the faux pas stories, first, a mixed ANOVA with group as between factor (ISA vs ASA vs healthy control subjects) and story (faux pas–detection of faux pas question vs control story–correct rejections) as within factor were executed to detect any between-group differences in ability to detect the faux pas as compared with ability to comprehend the "neutral" story. Then, as in previous studies,[29,84] a composite score was computed for the faux pas by summing the scores a subject obtained on the 4 ToM questions and the control story questions. Finally, the total score was divided by 30 (ie, the number of questions). A final 1-way ANOVA was performed to compare performance of the 3 experimental groups on the faux pas memory question. To qualify significant main effects and interactions, we performed post hoc analyses using the Tukey HSD test. And, to better estimate the amplitude of a statistical effect, we computed Cohen *d* effect sizes.[85] Finally, to determine whether there was a relationship between TBI patients' scores on perspective-taking measures (for which between-group differences were found) and clinical, neuropsychiatric (NPI score), and neuropsychological variables, a series of Pearson correlations were carried out.

RESULTS

Table 1 shows the distribution of demographic, clinical, and functional data of the 3 groups examined.

Comparison of TBI groups with reference to clinical, neuropsychological, neuropsychiatric, and neuroimaging data

Clinical variables

As shown in Table 1, with respect to ASA patients, ISA patients obtained higher DRS and lower LCF scores ($P < .05$ in both cases) and tended to have longer PTA duration ($P = .056$). No other significant

TABLE 1 *Distribution of demographic, clinical, and functional data*

	Mean (SD)			
	ISA Group	**ASA Group**	**HC Group**	***P***
Gender	M = 12 F = 2	M = 9 F = 5	M = 21 F = 7	
Age	37.2 (13.3)	30.6 (8.9)	34.5 (9.9)	NS
Education level, y	11.6 (4.2)	12.6 (3.6)	13.0 (3.4)	NS
Chronicity, d	831 (772)	782 (627)		NS
Time to follow commands, d	32.4 (28.1)	25.2 (23.1)		NS
Posttraumatic amnesia, d	150 (127)	67.7 (55)		.056 (NS)
GOS	3.9 (0.73)	4.4 (0.76)		NS
DRS	7.2 (2.5)	3.8 (2.5)		.013
LCF	7.0 (0.8)	7.6 (0.5)		.015

Abbreviations: ASA, adequate self-awareness; DRS, Disability Rating Scale; GOS, Glasgow Outcome Scale; HC, healthy control; ISA, impaired self-awareness; LCF, Level of Cognitive Functioning; NS, nonsignificant.

between-group differences emerged (all *P* values consistently >.05).

Neuropsychological tests

In Table 2, average scores on tests of the neuropsychological battery are reported for both ISA and ASA individuals. Results of general multivariate analysis of variance evidenced no significant main group effect (Wilks $\lambda = 0.67$; $df = 7$; $P > .20$). This finding documents the absence of a significant between-group difference in global cognitive functioning. In fact, a series of subsequent χ^2 analyses showed only a trend toward statistical significance for the *categories achieved* and the percentage of *perseverative responses* on the WCST (with $\chi^2 = 3.28$ and $P = .07$ in both cases). In particular, 6 of 13 patients (1 patient was excluded because his scores were borderline) in the ISA group obtained pathological scores on both measures compared with 2 of 14 of the ASA patients. The *P* level did not approach statistical significance (*P* consistently >.10) in any other test.

Comparison of NPI subscale scores obtained by the 2 TBI groups

A significant effect was found in the NPI-Total score (ISA group: mean = 25.45; SD = 19.8; ASA group: mean = 11.1; SD = 11.9; $F_{1,26} = 5.33$; $P < .05$; Cohen $d = 0.87$). The univariate analyses performed on each individual subscale score showed that ISA patients on average obtained significantly higher scores than ASA patients only on the *Apathy* subscale (ISA group: mean = 5.57; SD = 5.4; ASA group: mean = 1.0; SD = 3.2; $F_{1,26} = 7.35$; $P = .012$; Cohen $d = 1.02$); and no significant difference was found for any other subscale investigated ($F_{1,26} = 0.02$-3.28; all *P*s >.08).

Neuroimaging data

Computed axial tomography or 1.5-T magnetic resonance imaging (model Siemens Vision Magnetom, Milano, Italy) was performed for each subject with TBI, according to the compatibility and compliance of

TABLE 2 *Average performance on the tests of the neuropsychological battery reported for both ISA and ASA individuals*

		Mean (SD)	
Cognitive domain	**Neuropsychological tests**	**ISA Group**	**ASA Group**
Declarative memory	Prose Memory	8.2 (3.7)	7.1 (3.0)
Short-term memory	Digit Span Forward	5.2 (1.9)	6.1 (1.9)
	Digit Span Backward	4.8 (1.7)	5.6 (2.5)
Executive functions	WCST: categories achieved	3.4 (2.8)	5.2 (1.8)
	WCST: perseverative responses (%)	26.6 (23.7)	10.8 (7.0)
	Phonemic fluency	11.4 (10.5)	24.3 (16.2)
Language	Semantic fluency	7.1 (6.0)	12.7 (6.6)

Abbreviations: ASA, adequate self-awareness; ISA, impaired self-awareness; WCST, Wisconsin Card Sorting Test.

the patients, except for 2 patients in the ASA group and 1 patient in the ISA group. As shown in Table 3, the neuroimaging examination revealed a homogeneous diffuse axonal injury across the 2 TBI groups ($N = 9$ in both groups). No between-group differences were found in the distribution of posterior cortical lesions ($x_1^2 = 0.52$; $P > .40$). Nevertheless, the 2 groups were significantly different regarding the involvement of the frontal cortical regions. Indeed, 7 of 13 patients in the ISA group, but no patient in the ASA group, showed frontal damage ($x_1^2 = 8.97$; $P < .01$).

Comparison of TBI groups for perspective-taking performance in relation to self-awareness level

Self-report measures

As for the IRI (see Figure 1A), both the main effects (group: $F_{2,53} = 7.59$; $P = .013$; IRI subscales: $F_{3,159} = 56.4$; $P < .001$) and the group × IRI subscale interaction ($F_{6,159} = 2.24$; $P < .05$) reached statistical significance. Post hoc analyses showed that the significant interaction was due to the fact that both ISA and ASA patients obtained lower average scores than healthy controls only on the Fantasy subscale ($P < .05$; Cohen $d = 1.37$ and $P < .05$; Cohen $d = 1.42$) where there were no other significant between-group differences (all P values consistently $>.10$). Instead, no significant between-group difference was found for the EQ total score ($F_{2,53} = 1.57$; $P > .20$; Fig 1B).

Performance-based tasks

False-belief tasks

Figure 2 presents performance of the subjects in the 3 groups on the false-belief stories. The main effects of group and question were significant ($F_{2,53} = 9.84$; $P < .001$ and $F_{2,106} = 4.52$; $P = .01$, respectively). The group × question interaction also reached statistical significance ($F_{4,106} = 3.01$; $P < .05$). Post hoc analyses revealed that, with respect to healthy controls, ISA patients tended to obtain lower scores on false-belief detection (question 1: $P = .06$; Cohen $d = 0.71$) and achieved poorer scores on the reality question (question 2: $P < .01$; Cohen $d = 0.96$) whereas the ASA group performed worse than healthy controls only on the reality question ($P < .001$; Cohen $d = 1.31$). No significant difference

TABLE 3 *Distribution of neuroimaging data*

Subjects	Age	Gender	Brain lesions	Self-awareness level
1	40	M	Diffuse axonal injury	ISA group
2	60	M	Frontal (*bilateral*) + diffuse axonal injury	
3	33	M	Diffuse axonal injury+ parietal (*right*)	
4	24	M	Frontal (*bilateral*) + temporal (*left*) + diffuse axonal injury	
5	33	M	Frontal (*bilateral*) + temporal *(right)*	
6	30	M	Diffuse axonal injury	
7	45	M	Frontal (*left*)	
8	23	F	Temporal-parietal (*left*)	
9	18	M	Diffuse axonal injury+ frontal (*right*)	
10	42	M	Diffuse axonal injury	
11	38	M	Frontal (*bilateral*) + parietal (*left*)	
12	63	F	Frontal (*bilateral*) + diffuse axonal injury	
13	27	M	Diffuse axonal injury	
14	46	M	*Not available*	
1	34	F	Diffuse axonal injury	ASA group
2	25	M	Diffuse axonal injury	
3	26	M	Diffuse axonal injury	
4	42	M	Diffuse axonal injury	
5	36	M	Diffuse axonal injury	
6	50	M	Diffuse axonal injury	
7	18	M	*Not available*	
8	21	M	Temporal (*right*)	
9	22	M	Diffuse axonal injury	
10	24	F	Diffuse axonal injury	
11	32	F	Temporal (*left*)	
12	30	F	*Not available*	
13	32	M	Temporal (*bilateral*)	
14	33	F	Diffuse axonal injury	

Abbreviations: ASA, adequate self-awareness; ISA, impaired self-awareness.

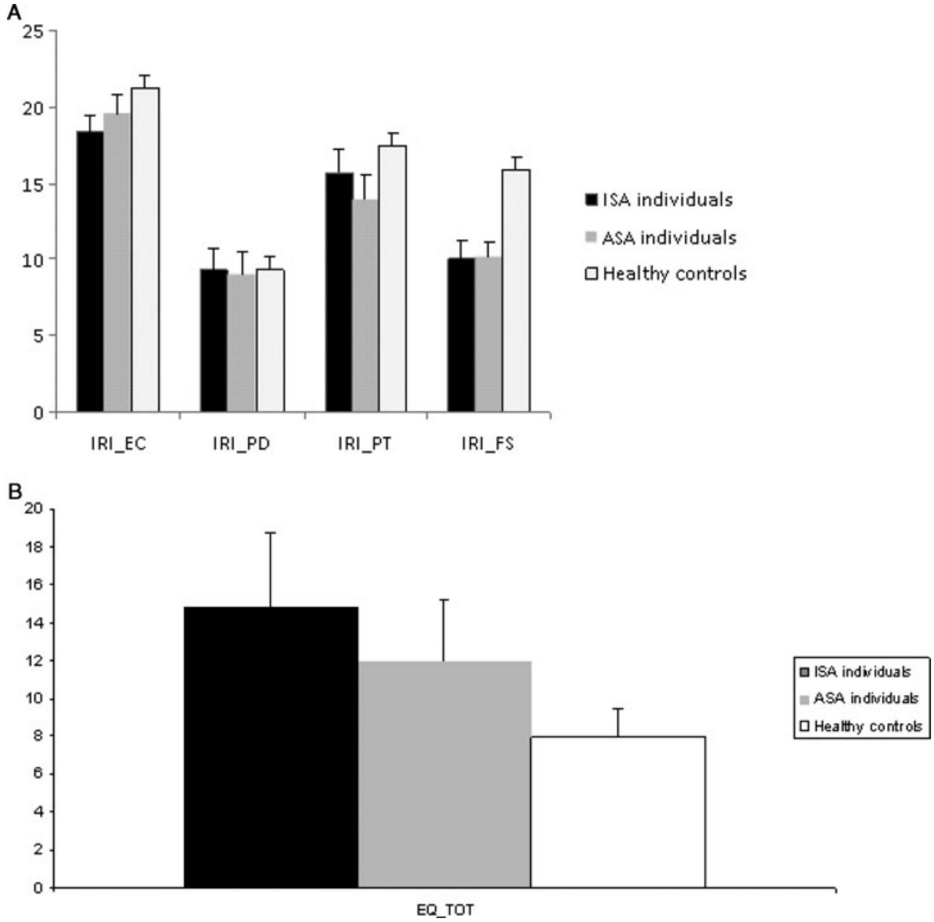

Figure 1. Comparisons between TBI groups on self-report measures. A. Interpersonal Reactivity Index. B. Empathy Quotient. ASA indicates adequate self-awareness; IRI, Interpersonal Reactivity Index; EQ_TOT, Empathy Quotient total score; IRI_EC, Emphatic Concern IRI subscale; IRI_FS: Fantasy IRI subscale; ISA: impaired self-awareness; IRI_PD, Personal Distress IRI subscale; IRI_PT, Perspective-Taking IRI subscale.

was found between the 2 TBI patient groups (all *P* values consistently >.10).

Faux pas tasks

The scores obtained on the faux pas and control stories are shown in Figure 3. The analysis carried out to examine between-group differences in the ability to detect faux pas in the faux pas stories and to correctly reject the presence of a faux pas in the neutral stories showed a significant main effect of group ($F_{2,53} = 17.4$; $P < .001$) and story ($F_{1,53} = 46.6$; $P < .001$). Also in this case, the interaction was statistically significant ($F_{2,53} = 15.4$; $P < .001$). The Tukey HSD analysis performed to qualify this interaction showed that although ISA patients were significantly less accurate in detecting faux pas (ie, question 1 of faux pas stories) than healthy controls ($P < .001$; Cohen $d = 2.01$) and ASA patients ($P < .001$; Cohen $d = 1.47$), their performance on the control stories was not significantly different from that of the other 2 groups (vs healthy control: $P > .80$; Cohen $d = 0.14$; vs ASA patients: $P > .40$; Cohen $d = 0.63$). ASA individuals, however, scored as accurately as healthy controls on both faux pas and control stories ($P > .70$; Cohen $d = 0.52$, and $P > .30$; Cohen $d = 0.76$, respectively). Moreover, in the ISA group, the accuracy score obtained in the control stories was significantly higher than that obtained on the faux pas stories ($P < .001$), whereas in the other 2 groups, no significant between-story differences were found (both *P* values consistently >.10).

The second analysis performed to compare the composite score obtained by the individuals in the 3 groups showed a significant effect ($F_{2,53} = 21.2$; $P < .0001$). Post hoc analysis showed that ISA patients' composite score (mean = 0.36; SD = 0.22) was significantly lower than that of both healthy control participants (mean = 0.75; SD = 0.15; $P < .001$; Cohen $d = 2.07$) and ASA patients (mean = 0.61; SD = 0.19; $P < .01$; Cohen $d = 1.21$). However, no significant difference was found between the ASA patients and healthy controls ($P > .09$; Cohen $d = 0.82$). Moreover, we also performed a Pearson

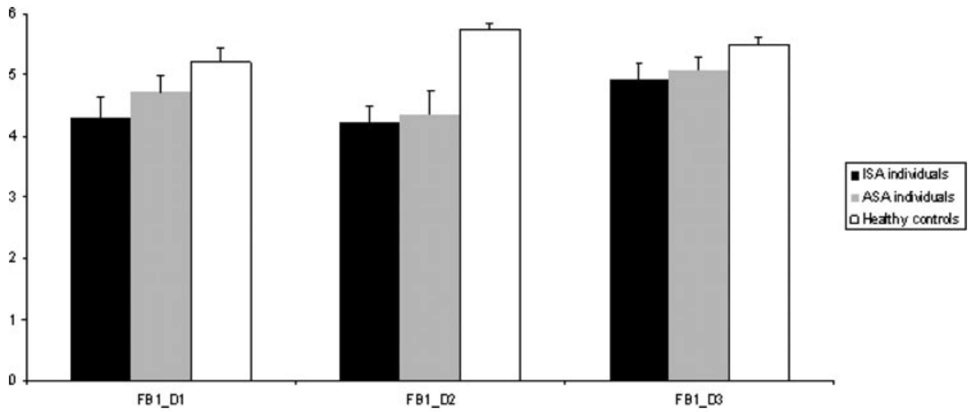

Figure 2. Comparisons between TBI groups on *false-belief* tasks. ASA indicates adequate self-awareness; FB1_D1: False-belief detection (question 1); FB1_D2: False-belief reality question (question 2); FB1_D3: False-belief memory accuracy (question 3); ISA, impaired self-awareness.

correlation analysis between continuous AQ-DS and ToM composite scores. As expected, results provide a significant negative correlation between AQ and ToM composite scores ($r = -0.46$; $P = .014$), confirming that higher level of self-awareness are associated with better ToM performance. As for scores obtained on the memory question, the 1-way ANOVA revealed a significant between-group difference ($F_{2,53} = 17.3$; $P < .001$). The Tukey HSD test showed that the performance of both ISA (mean = 3.2; SD = 1.4) and ASA (mean = 3.8; SD = 1.0) patients was worse than that of healthy controls (mean = 5.2; SD = 0.9; with $P < .001$; Cohen $d = 1.69$ and $P < .01$; Cohen $d = 1.47$, respectively), whereas the difference between the 2 TBI groups did not approach statistical significance (P consistently >.20; Cohen $d = 0.49$).

Correlations among TBI groups' Perspective-Taking scores, clinical variables, and performance on neuropsychological tests

For these analyses, the 2 TBI groups were considered as a whole.

Correlations between Perspective-Taking scores and clinical variables

To avoid the risk of *alpha* inflation (ie, considering a correlation significant when it is not), the number of correlations was reduced to include only those clinical parameters for which a significant difference between the 2 TBI groups was observed, namely, DRS and LCF scores and PTA duration. For the same reason, we included the Fantasy IRI subscale score and the faux pas tasks score (ie, composite score) among the perspective-taking measures. Analysis of the results revealed a positive correlation between PTA duration and Fantasy IRI subscale score ($r = -0.41$; $P < .05$) and a trend toward statistical significance of a positive correlation between LCF and the faux pas composite score ($r = 0.38$; $P = .059$); the DRS score was not correlated with any of the perspective-taking variables included (all P values consistently >.09).

Correlation between Perspective-Taking and NPI subscale scores

The NPI-Total score and the Apathy subscale score were included in these analyses. In this case, Pearson correlations revealed no significant effect (r ranged from -0.13 to 0.29; all P values consistently >.10).

Correlation between Perspective-Taking scores and neuropsychological variables

Here, we applied Bonferroni correction to avoid the risk of alpha inflation. Furthermore, with 7 neuropsychological tests to analyze the minimum P level to consider a correlation significant was set at 0.007 (ie, 0.05/7). The results of these analyses show that the number of categories achieved on the WCST and the faux pas composite score tended to be positively correlated ($r = 0.47$; $P = .012$). No other correlations approached statistical significance (in all cases, $P > .02$).

DISCUSSION

This research was aimed at investigating the relationship between self-awareness and perspective-taking difficulties in individuals with severe closed-head injury. The main result of our study is that perspective-taking ability is impaired in individuals with low self-awareness. Indeed, patients with ISA were significantly less accurate in performing the faux pas task than both healthy controls and patients with ASA. It is unlikely that reduced global cognitive functioning accounts for this finding because the neuropsychological test performance of the 2 TBI groups was not significantly different.

Instead, our data suggest a strong association between low self-awareness and reduced perspective-taking abilities. Indeed, this relationship was predicted on the basis of the assumption of the Simulation theory approach, namely, that to take another person's perspective, one has to put himself or herself in that person's shoes and imagine how he or she would feel in that person's place.[36–39] This implies that the individual is able to correctly evaluate his or her own inner emotional and cognitive states and to differentiate between his or her own states and another person's.[59] In fact, a patient who suffers from low self-awareness after a severe TBI loses the ability to make a real examination of his or her emotional, cognitive, and behavioral changes, which he or she often underestimates. Therefore, it can be argued that low self-awareness first affects the ability to take another person's perspective because it impairs the ability "to put himself or herself in that person's shoes." We can also speculate that the perspective-taking difficulties experienced by TBI individuals with low self-awareness might, in turn, be an obstacle for improving their self-awareness. In fact, it is likely that the patient's difficulty in taking another person's perspective can lead to reduced ability to use social feedback that could facilitate his or her examination of reality, especially in cases of behavioral changes that usually have greater impact at a social level.

Further clues for interpreting our findings can be found in the recent review of Aboulafia-Brakha and colleagues,[86] which shows that ToM abilities are closely associated with executive functioning. Some authors specifically suggest that the inability to take another person's perspective could be a result of cognitive inflexibility[41,43] related to frontal lobe dysfunction.[43,87,88] In fact, some evidence from the present study seems to indicate a relationship between

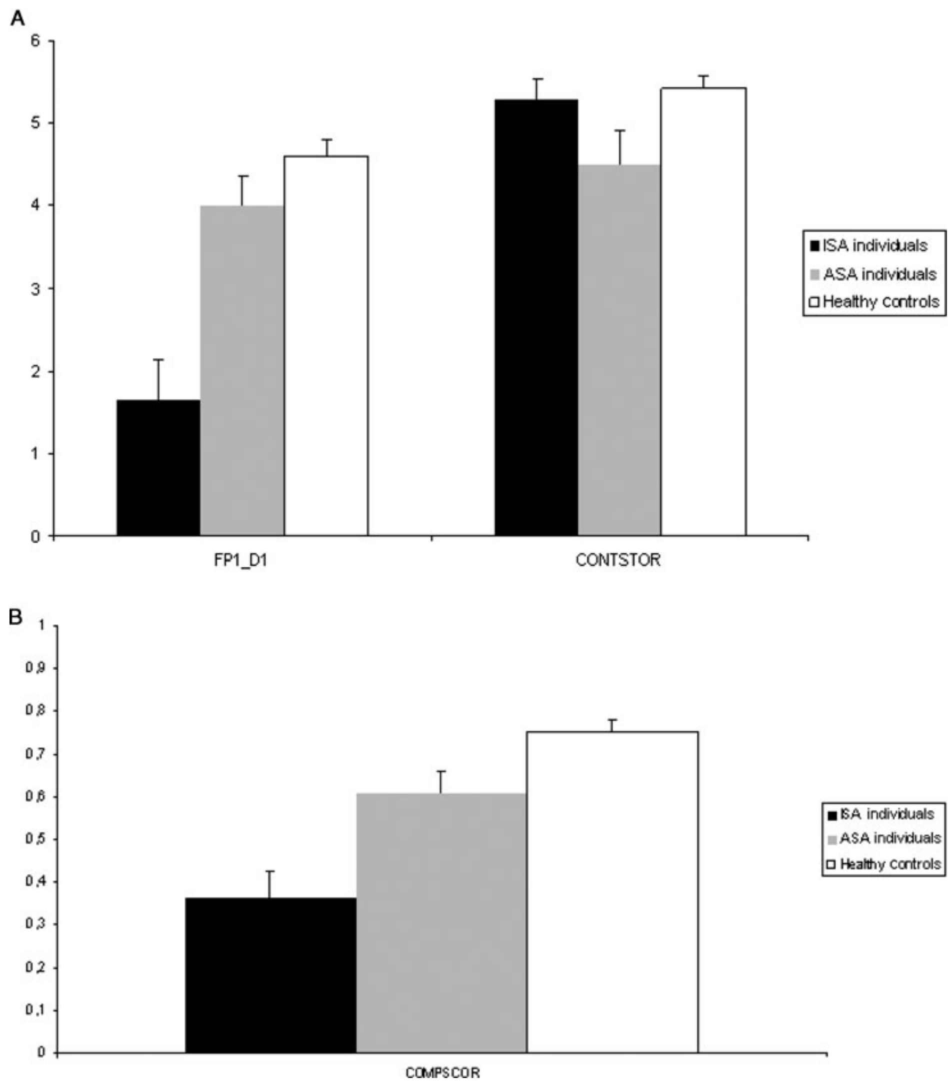

Figure 3. Comparisons between TBI groups on *faux pas* tasks. ASA indicates adequate self-awareness; CONTSTOR, faux pas control stories; COPSCOR, faux pas composite score; FP1_D1, faux pas detection (question 1); ISA, impaired self-awareness.

altered frontal functioning and the perspective-taking impairment in ISA patients. First, analysis of the neuroimaging data reveals a significantly higher frequency of cortical frontal damage in ISA patients (7/13 cases) than in ASA patients (0/12 cases). Second, congruently with neuroimaging findings, ISA patients tended to perform worse than ASA patients on the WCST (ie, they achieved fewer categories and made more perseverative responses) and scores on this test also tended to correlate with ToM faux pas scores in the whole TBI sample. Indeed, it is generally held that the WCST taps problem-solving and cognitive flexibility, which strongly depend on integrity of the prefrontal cortex.[89] Third, as revealed by NPI scores, ISA patients were significantly more apathetic than ASA patients. In fact, several studies document that apathy, a frequent sequela of TBI,[90] is highly associated with altered functioning of the frontal lobes.[91–94]

From a more properly clinical point of view, it should be noted that, overall, ISA patients seem more severely affected than ASA patients. In fact, the former have significantly higher DRS and lower LCF scores than the latter and tend to have longer PTA duration. In the literature, the relationship between self-awareness and clinical indexes is not linear. Some studies reported that severity of acquired brain injury is correlated with some measures of impaired self-awareness,[79,95] whereas others found no significant association.[76,96–100] These differences are likely due to methodological factors, such as sampling, testing instrument, or indexes used for classifying TBI severity. To summarize, our finding that head injury results in more severe sequelae in ISA patients than in ASA patients (which is documented by some neuropsychological, neuropsychiatric, and clinical measures) could justify the reduced perspective-taking abilities of the former.

A second result of our study is that faux pas tasks are more sensitive than first-order false-belief tasks in detecting perspective-taking difficulties in patients with low self-awareness. Indeed, ISA patients performed significantly worse than ASA patients on the faux pas tasks but not on the false-belief tasks. Our findings are in line with previous data revealing poor performance of severe TBI on faux pas tasks[50–52,58,86] and normal performance on first-order false-belief tasks[52] (but see the Bibby and McDonalds study[48] for partially divergent results). The different level of complexity involved in false-belief and faux pas tasks could account for this finding. Indeed, 3- to 4-year-old children are reported to understand that another person may hold a mistaken belief, namely, a first-order false belief.[101] Conversely, understanding that a faux pas has occurred requires the ability to represent 2 mental states: that the person saying the faux pas does not know he should not say it (ie, *cognitive* representation) and that the person hearing it should feel insulted or hurt (ie, *affective* representation). Consequently, compared with the false-belief tasks, the faux pas tasks involve both cognitive and affective components of perspective taking,[18,97] that is, complex social skills that first appear between 9 and 11 of age.[83] Therefore, considering that ISA patients were more severely affected by TBI than ASA patients, we could hypothesize that the faux pas task was more sensitive than the first-order false-belief task because the participants had to adopt more complex cognitive processes to perform.[25] Finally, it is worth noting that in both first-order false-belief and faux pas tasks, regardless of self-awareness levels, all TBI patients performed significantly worse than healthy controls on both the reality and the memory questions, respectively. As more than half of the patients in our sample (17/28; 61%) performed pathologically on the Prose Memory Test, it is reasonable to assume that these differences were due to memory difficulties present in both groups of patients but not in healthy controls.

Our findings partially overlap those of a previous study that failed to find any statistical difference between TBI patients and controls on the IRI.[52] The same findings are in contrast with previous data that showed a deficit in emotional empathy in a TBI population by means of the Balanced Emotional Empathy Scale.[4,56,57,64] This contrasting evidence may be due to various factors. First, we used 2 different self-report tools (the IRI and EQ instead of the Balanced Emotional Empathy Scale). As no study has yet assessed the concurrent validity of these tools, their different internal structure and characteristics might justify our different findings. Furthermore, Wood and Williams[56,64] enrolled a less severely impaired TBI population (moderate TBI, according to their Glasgow Coma Scale scores, instead of the patients with severe TBI enrolled in our study), and in the de Sousa and colleagues study,[57] the average length of time postinjury (chronicity) was considerably longer than in ours' (11.9 vs 2.2 years, respectively). Considering that self-awareness is positively correlated with chronicity,[98,99,102,103] in both of these cases, the TBI patients probably had a better level of self-awareness than our patients with severe TBI.

Therefore, our findings suggest that *self-report* measures are not sensitive enough to detect perspective-taking problems in an individual with severe TBI and low self-awareness. Indeed, it might seem paradoxical to attempt to investigate perspective-taking problems in an individual who is unaware of the problem by means of *explicit questions about that problem.* Therefore, the use of only self-report questionnaires to assess perspective taking should be avoided.

One limitation of our study is related to the execution of a relatively large number of statistical tests with a small experimental sample. Another limit is that we compared different kinds of tools to assess perspective-taking abilities: *self-report* scales, commonly used to assess empathy, and *performance-based* tasks, commonly used to assess ToM. We aimed to analyze the possible influence of self-awareness on perspective-taking abilities, and, in fact, a methodological comparison of both kinds of measures went well beyond the aims of this study but could certainly be carried out in future studies.

CONCLUSIONS

This article shows that patients with severe TBI with low self-awareness but without diffuse cognitive impairment have significant difficulty in taking another person's perspective. From a clinical point of view, the cognitive, neuropsychiatric, and perspective-taking residual complaints identified in our TBI sample with ISA could be responsible for the marital problems and difficulties in social integration commonly observed after a moderate-severe TBI.[41–43] In fact, the awareness that our behavior can affect the other (ie, when it is offensive, humiliating, or aggressive) requires adequate perspective-taking abilities. Therefore, because of their perspective-taking deficit, individuals with TBI can impinge on another person's well-being and, consequently, without understanding feedback about the social unacceptability of their behavior, they can end up socially withdrawn and isolated.[49] Because of these observations and the fact that perspective-taking disorders may adversely affect rehabilitative interventions and social outcomes,[10,57] it would be useful to include an accurate investigation of self-awareness and perspective-taking abilities in the neuropsychological and neuropsychiatric standard assessment of TBI individuals. In fact, our data clearly indicate that an integrated approach, including both self-report and performance-based measures, is the most reliable one. This is also to plan adequate treatment options for ToM disorders. In particular, our results suggest the usefulness to address perspective-taking difficulty in patients with severe TBI through a self-evaluation of patients' inner states, educating them to differentiate their own inner states from those of another person, and then evaluating other person's states; in fact, this might be a useful approach to treat perspective-taking disorders already from the post–acute rehabilitation phase.

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APPENDIX

An Example of Faux pas Story

Clara bought her friend Mark an ancient flowerpot. About 3 years later, Clara was over one night at Mark's party. During the party, Clara hit the flowerpot, and the flowerpot shattered. Clara regretted for the happening, and Mark told her that there was no problem because he never liked it anyway.

Question 1: Did somebody say something he shouldn't have said?
Possible answers:
- *yes*
- *not*

Question 2: Who said something he shouldn't have said?
- *Mark*
- *Clara*

Question 3: Why shouldn't he have said it?
- *Not to offend Clara*
- *Not to intrigue Clara*

Question 4: Why did he say it?
- *Because he was irritated by the incident*
- *Because it was his favorite flowerpot*
- *Because he did not remember that the flowerpot was a gift from Clara*

Question 5: Which of the following characters were in the story?
- *Mark*
- *John*
- *Clara*
- *Alfred*