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Unawareness of Cognitive Deficits and Daily Functioning Among Persons With Traumatic Brain Injuries

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ABSTRACT

This study examines levels of unawareness of cognitive deficits and their relationship to functional outcome among persons with traumatic brain injury (TBI). Data from 61 persons with TBI and 34 family members consisting of various measures were used. The results suggest that awareness of cognitive deficits is not differentially distributed along a concrete-abstract continuum of cognitive domains. Awareness in this sample was significantly related to psychiatric symptomatology and partially associated with behavior disturbances and daily functioning, but not with vocational outcomes. Persons with TBI who over-estimated their cognitive abilities were found to function worse on most outcome measures, except vocation, than persons who did not overestimate their abilities.

Self awareness has been defined as ''that attribute of the human which not only allows awareness of the self, but also realizes the position of the self within the social milieu'' (Stuss & Benson, 1986), or as ''the capacity to perceive the 'self' in relatively objective terms while maintaining a sense of subjectivity'' (Prigatano, 1991). Both definitions share the inherent duality of self-awareness, as the end product of two, sometimes opposing perceptions – that of the subjective self and that of the objective reality. Self-awareness, an integrative cognitive and emotional construct, is considered to be the highest of all high mental abilities, affecting functioning, quality of life, and psychological well-being in various ways.

The role of self-awareness is of special importance in the psychological and functional adjustment to negative changes in abilities and aptitudes, caused either by abrupt or developmental circumstances such as physical trauma or aging. In such instances deficits in self-awareness comprise three distinct yet inter-linked aspects: unawareness to the mere existence of the disability, unawareness to the functional implications of the disability, and unawareness of the need to consider the disability when setting future goals (Flemming & Strong, 1995). These aspects, commonly termed ''unawareness of deficits'' (Prigatano, 1991), are frequent psychological sequel of brain dysfunction in general, and of traumatic brain injury (TBI) in particular (Sherer, Boake, et al., 1998). It is assumed that self-awareness is mostly related to injuries in the frontal lobes or the tip of the temporal lobes, in which executive functioning is affected (Malec & Moessner, 2000; Ownsworth, McFarland, & McD-Young, 2002; Prigatano, 1991; Stuss, 1991) Unilateral right hemisphere lesions have also been shown to lead to deficits in awareness (Anderson & Tranel, 1989; Sherer, Boake, et al., 1998).

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Alternatively, unawareness of deficits is also seen as a dynamic defense mechanism against the threat caused when facing disability, and as such it is psychologically determined (Langer, 1999). Whether unawareness is an ''organically'' based or a psychologically based phenomenon, it may affect compliance to treatment, motivation for rehabilitation (Prigatano, 1999), and outcome following injury (Flemming & Strong, 1995; Sherer, Bergloff, Levin, et al., 1998).

Four measurement methods of unawareness of deficits have been suggested in the literature (see Flemming, Strong, & Ashton, 1996; Sherer, Bergloff, Boake, et al., 1998; Bogod, Mateer, & Macdonald, 2003, for reviews of these measurement methods). The first method offers to rely on a clinician's evaluation of a person's level of awareness (Ezrachi, Ben Yishay, Kay, & Diller 1991; Sherer, Bergloff, Boake, et al., 1998). The second method uses difference scores between participants' self-evaluations of functioning and evaluations provided by a family member (Cavalo, Kay, & Ezrachi, 1992; Deaton, 1986; Prigatano, et al., 1998; Walker, Blankenship, Ditty, & Lynch, 1987), or a clinician (Fordyce & Roeche, 1986), or neuropsychological tests (Allen & Ruff, 1990; Anderson & Tranel, 1989). Although the fourth method (i.e., difference-scores between self-evaluations and actual performance in objective tests) may be more expensive to use than the other three, it is a more accurate measure of unawareness, as it relies more heavily on scores of objective tests and less so on either family members' (Port, Willmott, & Charlton, 2002) or clinicians' evaluations (Malec & Moessner, 2000; Sherer, Bergloff, Boake, et al., 1998).

By applying the above-mentioned measurements it has been repeatedly shown that unawareness of deficits is differentially related to the level of concreteness of the function in question. Individuals tend to be more aware of concrete, physical, and observable deficits than of more abstract, less ''weighable'' disabilities (Anderson & Tranel, 1989; Mckinlay & Brooks, 1984; Prigatano, 1996). Sherer, Boake, et al. (1998) compared self-evaluations of 64 participants with closed head injury to those of their family members. Participants reported more physical disabilities than nonphysical (i.e. cognitive, behavioral), whereas family members reported more nonphysical problems, particularly cognitive and behavioral disabilities. This finding was further supported in a factor analysis of the Awareness Questionnaire, which revealed three distinct factors: Cognitive, Behavioral/affective and Motor/sensory (Sherer, Bergloff, Boake, et al.). Flemming and Strong (1999) compared the responses of 55 participants with TBI on the Patient Competency Rating Scale (PCRS, Prigatano, Altman, & O'Brien, 1990) to the responses of their family members. Self-awareness of simple ADL and memory functions was higher than self-awareness of higher cognitive, social, and emotional functions.

The concrete-abstract hypothesis is based on the comparison of full domains, that is, behavioral, affective, and cognitive functioning. However, distinct cognitive abilities have not been examined in this context. Several neuropsychological models propose that cognitive processes are hierarchically ordered, with more complex and abstract processes at the top of the hierarchy and more simple and concrete ones at the bottom (Mapou, 1992; Shalice & Burgess, 1991; Whyte, 1986). The question arises as to whether awareness of cognitive abilities is affected by the concrete-abstract or complexity continuum, that is, whether a person will be more unaware of abstract processes than of concrete ones. In order to examine this question, we propose to compare the degree of awareness of three cognitive abilities: attention, memory, and verbal comprehension. Based on the above-mentioned cognitive models we assume that in the concrete-abstract continuum, memory and attention lie at the more concrete end and verbal comprehension lie at the more abstract end. If unawareness is indeed sensitive to this continuum, then specific cognitive deficits may be differentially affected, with more awareness to attention and memory problems, and least awareness to verbal comprehension.

A further crucial issue is whether the relationship between unawareness of deficits and compliance to treatment, motivation, and eventual outcome is indeed as consistent as is commonly assumed in clinical settings. Flemming and Strong (1995) review eight studies that examined the relationship between unawareness of deficits

and functional outcome following TBI. They found that in six studies there were no significant associations between unawareness of deficits and functional outcome in various groups of persons with TBI. In a later study Fleming, Strong, and Ashton (1996) also report that while persons with higher awareness were more motivated for rehabilitation, they were also more distressed than the less aware participants, and their overall functioning was no better than that of the less aware participants.

On the other hand, Sherer, Bergloff, Levin, et al. (1998) argue that in addition to measures of awareness, demographic data and injury severity play a major role in predicting employment outcome. Consequently, awareness and employment outcome may not be directly or causally related, but their relationship may instead be mediated by other factors, such as cognitive abilities and readiness for change. In order to better understand the role of awareness in functional outcome following TBI, it is suggested here to look at awareness of specific cognitive disabilities rather than at awareness of intellectual ability as a whole. We assume that if awareness of specific cognitive abilities is differentially distributed across a concrete-abstract continuum, then its association with outcome will also show a differential pattern of correlations. If persons with TBI tend to show more awareness of a certain cognitive disability, then this level of awareness should be more closely related to outcome than the level of awareness of another cognitive disability.

Several methodological issues are also of concern when studying unawareness. Unawareness has been mostly studied with the use of difference scores between participants' self-evaluations and those of family members or clinicians. To the best of our knowledge only two studies (Allen & Ruff, 1990; Anderson & Tranel, 1989) examined unawareness among persons with TBI by comparing participants' self-evaluations to neuropsychological test scores, thus overcoming the limitation of subjectively biased evaluations of family relatives or clinicians. However, the latter two studies focused on the associations between unawareness of deficits and either structural locations of injury (Anderson & Tranel) or severity of injury and chronicity (Allen & Ruff), but did not examine different levels of awareness or their association with outcome. Studies of persons with HIV infection (Hinkin, Van-Gorp, Satz, & Marcote, 1996; Rourke, Halman, & Bassel, 1999) have looked at the correlation between self-awareness of memory ability on the one hand and depression or neuropsychological abilities on the other hand. Yet, functional outcomes have not been investigated. Hence, following previous studies and recommendations (Sherer, Bergloff, Boake, et al., 1998; Malec & Moessner, 2000), in the current study unawareness of cognitive deficits and its relation to outcome were examined by comparing participants' self-evaluations to their performance on neuropsychological tests.

In addition, difference scores of self-awareness derived by comparing participants' evaluations either to test scores or to evaluations given by family members and clinicians have resulted in a classification into three distinct levels of awareness/unawareness. Over estimation of ability, that is, subjective evaluation greater than objective evaluation; Good awareness, that is, subjective evaluation similar to objective evaluation and finally under estimation, that is, subjective evaluations lower than objective evaluation (Prigatano & Altman, 1990; Hinkin et al., 1996).

According to Prigatano and Altman (1990), the three awareness/unawareness categories may be differentially associated with neuropsychological and psychiatric outcomes. However, Prigatano and Altman, as well as other authors (e.g., Flemming & Strong, 1996, 1999), have found only partial evidence to support this assumption. The authors note that it is possible that methodological issues have led to this result, as participants in these studies were assigned to one of the three awareness categories according to the most frequent ratio in the their responses, ignoring the magnitude of the difference. Thus, they recommend that future studies of awareness/unawareness typology relate to size of differences rather than to the direction of the difference alone. Following their recommendation, levels of awareness will be determined in this study on the basis of the direction as well as the size of the difference between self-evaluations of cognitive

abilities and neuropsychological measures of the same abilities. It is hypothesized that such a division will be helpful in predicting psychiatric symptomatology, behavioral disturbances, and outcomes in terms of activities of daily living and vocation.

In summary, the present study aims to examine the hypotheses that awareness of distinct cognitive abilities is distributed along a concrete-abstract continuum and that it is related to outcome. Awareness is measured with the use of difference scores between self-evaluations and actual performance on neuropsychological tests, and the participants are assigned to awareness groups by the magnitude as well as the direction of that difference. Three cognitive domains will be examined: attention, memory, and comprehension. The relations between unawareness of cognitive deficits and outcome will be examined by comparing three levels of awareness/unawareness: Under estimation of ability, good awareness and over estimation of ability, on four outcome measures: Psychiatric symptomatology, behavior, extended ADL, and vocation.

METHOD

Participants

Sixty-one participants with severe TBI and 34 of their family members (9 parents and 25 spouses) participated in the study. This group was part of a larger group of 99 participants who were evaluated extensively in a long-term outcome study, with an average of more than 14 years postinjury (Hoofien, Gilboa, Vakil, & Donovick, 2001). The original group of 99 participants was drawn from a pool of 321 individuals who were referred to the 'National Institute for the Rehabilitation of the Brain-Injured' in Israel for outpatient neuropsychological rehabilitation. Referrals from a period of 16 years prior to the study were included, consisting of persons with TBI or other suspected disorders of the central nervous system, at various levels of functional and mental disabilities, excluding severe psychiatric problems, substance abuse, and persons younger than the age of 18 or older than the age of 55. One hundred and ninety-eight (62%) of the original 321 individuals suffered from acquired brain injuries of various aetiologies. Ninety-nine of them (50%) were not available for the long-term outcome study, mainly due to changes of address, immigration to other countries, or death. No refusals to participate in the outcome study were encountered. In addition, many of the original 198 referred individuals were not fully diagnosed at the initial rehabilitation period, making it difficult to examine specific differences between those who were located for the outcome study and those who were not. Of the remaining group of 99 persons, 61 participants with medically documented TBI, for whom all the measures needed for the current study were available, were included in the present analysis.

Participation of family members depended on availability and on the consent obtained from both the participant and his or her family member to participate in this study. The 34 participants whose family relatives participated in the study did not differ in terms of age, education, severity of the injury, mental status, awareness of deficits and outcome measures from those who had no available family member or did not give consent for their participation in the study. Table 1 presents the demographic and injury-related data of the 61 participants. Demographic data were collected from the patients' initial referral files at the Institute. Medical and injury related data, including length of coma, were

Table 1. Demographic and Injury-Related Data of the Participants.

	M	*SD*	Range	*N*	%
Age at injury	25.2	7.9	33.0	61	100
Age at study	39.0	8.7	40.0	61	100
Years since injury	13.8	5.8	20.0	61	100
Education (in years)	12.0	2.5	18.0	61	100
Gender					
Male				51	83.6
Female				10	16.4
Dominant hand					
Right				54	88.5
Left				7	11.5
Etiologies of brain injury					
Motor vehicle accidents				39	63.9
War injuries				16	26.3
Work accidents				6	9.8
Type of brain injury					
Cerebral cranial injury				40	65.6
Closed head injury				21	34.4
Length of coma					
30 days and more				20	32.8
8–30 days				19	31.1
1–7 days				11	18.0
Less than 24 hr				5	8.2
No coma				3	4.9
No available data				3	4.9

collected from medical reports of the institutions in which the patients were hospitalized during the acute phases of trauma.

Procedure and Design

Each participant was examined and interviewed at home or at the institute by a psychology graduate student, for about 7 hr in two or three separate sessions. These interviews were part of an extensive outcome study and they included, among other things, neuropsychological test scores, self-evaluations of cognitive disabilities, outcome measures in terms of psychiatric, behavioral, ADL and vocational functioning, and measures of awareness of cognitive deficits.

(A) **Neuropsychological test scores** were collected in three cognitive domains:

Attention was measured by the attention-concentration index of the Wehcsler Adult Intelligence Scale – Revised (WAIS–R, Wechsler, 1981, Hebrew version), which is the mean of the Digit Span and Arithmetic scaled scores (Spreen & Strauss, 1998).

Memory was measured by the immediate recall section of the Logical Memory sub-test of the Wechsler Memory Test (WMS–R, Wechsler, 1987, Hebrew version).

Comprehension was measured by the scaled score of the Comprehension sub-test of the WAIS–R.

(B) **Self-evaluations of cognitive disabilities** were measured by a questionnaire devised in the National Institute for the Rehabilitation of the Brain Injured in Israel (see Hoofien, et al., 2001). Participants were asked to rate their cognitive functioning on a scale of 0 ('Not at all') to 5 ('Very much'). The questionnaire included 18 questions on attention, memory, and comprehension. Scores for each domain were calculated as the average of the ratings participants gave to items that referred to that domain, thus yielding a range of 0–5 points for each sub-scale. Examples of the questions are: ''To what degree do you suffer today of problems in concentration?'' and ''To what degree do memory problems interfere with your daily functioning?'' The questionnaire was found to have good internal consistency and reliability (Alpha Cronbach = 0.87; Gutman split half = 0.81).

(C) **Outcome measures** in terms of psychiatric, behavioral, ADL and vocational functioning.

Psychiatric outcome was measured by the Symptom-Checklist-90 – Revised (SCL-90–R; Derogatis, 1977). This is a 90-item psychiatric symptoms checklist that produces nine psychopathology scores and a Global Severity Index (GSI) that reflects the clinical severity of all symptoms and is used in the present study as an indicator of mental health.

Behavioral outcome was measured by the Behavior Evaluation Checklist (Hoofien, et al., 2001). This is a 15-item checklist, filled by a family member, which addresses the frequency of occurrence of five types of behavioral disturbances: impulsiveness, rigidity, dullness, low frustration level, and aggressiveness. Questions are answered on a scale of 0 ('Not at all') to 5 ('Very frequently'), with 5 indicating a high level of behavioral disturbances as perceived by a family member, The total score ranges from 0 to 75. Examples of the questions are: ''To what extent does the participant exhibit physical violence?'' or ''To what extent is the participant unable to modulate his or her behavior with regard to changing circumstances?''

ADL outcome was measured by the Extended Activities of Daily Living Questionnaire (Melamed, Heruti, & Shiloh, 1999; Melamed, Ring, & Najenson, 1985). This is a 33-item questionnaire, filled by a family member, which assesses daily functioning and independence at home, within the family, in social settings, and in terms of mobility. Answers are scored on a 1 ('Not at all') to 5 ('Very frequent') scale, with 5 indicating a high level of functioning as perceived by the family member. The total score is the average of the scores of all the items in the scale. Examples of questions are: ''Does he or she cook by him/herself?'', ''Does he or she take part in the family's decisions?'', ''Does he or she entertain friends at home?'', ''Does he or she travel by him/herself to work?''

Vocational outcome was measured by two indices:

(1) Employed/Unemployed Index. An Employed score was assigned to participants who, at the time of the study, and for at least 3 months prior to it, were employed either in regular employment in the open market, in a family business, in a sheltered employment or as volunteers. Hence an Unemployed score was assigned to those who manifested no occupational activity whatsoever.
(2) Index of Stability at Work: This index was calculated as the function of the potential work period (PWP) available to the participant since discharge from hospital (in months), the actual time (AT) spent at various jobs, and the number of jobs (NJ) held during that period. The index was computed by the following formula: (AT/NJ)/PWP and ranged from 0.0 to 1.0, with 1.0 indicating maximum stability.

(D) **Awareness of cognitive deficits** was measured by calculating the difference between participants' self evaluations of their cognitive disabilities in attention, memory, and comprehension and their actual neuropsychological test scores in the same domains, thus yielding three ''Cognitive Awareness'' scores for each participant.

In order to use the same type of scores when calculating these differences, the self-evaluations scores were transformed to normalized percentiles by ranking participants and assigning them a normalized propor-

tional percentile score, using Tukey's proportion estimate formula. The percentile scores of neuropsychological test scores were computed from the normative data of each subtest, thus yielding three standardized percentile cognitive-ability scores for each subject. An awareness score in each of the three cognitive domains was then computed by subtracting the self-evaluation percentile score in the specific domain from the actual-performance percentile score in that domain. A Mean Awareness Score was also computed by averaging the three scores of each participant.

These scores were used in two analyses. The first one correlated self-evaluation percentile scores in each domain with the performance percentile scores in the same domains. This method was used to examine whether participants' self-evaluations were differentially related to actual performance, depending on the type of cognitive domain under study. The second analysis compared the means of the differences, in absolute numbers, between self-evaluations and actual performance scores, across the three cognitive domains. The purpose of that method was to examine whether subjects were more accurate in predicting their level of functioning in any of the three cognitive domains, that is, whether they demonstrated better awareness in any of the domains.

The four cognitive awareness scores – one for each domain and one consisting of the mean of the other three – ranged from −100 indicating an extreme under-estimation of the ability to +100, indicating an extreme over-estimation of the ability. A score of zero or close to it indicates good awareness.

Following Prigatano and Altman (1990), participants were assigned to one of the three awareness groups in each cognitive domain. The middle group (Good Awareness) comprised of the participants whose awareness scores in the particular cognitive domain fell within the range of −0.5–+0.5 standard deviations from the mean. The Under-Estimation group comprised of participants whose awareness score was lower than −0.5 standard deviations from the mean. The Over-Estimation group comprised of participants whose awareness scores were higher than +0.5 standard deviations from the mean. Descriptive statistics of the three awareness groups, according to each cognitive domain, are presented in Table 2.

Table 2. Means of Awareness Scores and Descriptive Statistics of the Three Awareness Groups According to the Three Cognitive Domains.

	Attention	Memory	Comprehension	Mean
Group 1: Over-estimation				
N	18	21	16	16
Mean	−29.0	−28.7	−52.2	−30.5
SD	22.3	16.8	17.6	16.2
Min	−79	−56	−80	−61
Max	−7	−9	−21	−11
Group 2: Good-awareness				
N	24	15	24	23
Mean	13.3	13.0	4.8	11.6
SD	10.2	12.7	13.9	9.4
Min	−3	−8	−15	−8
Max	32	31	28	28
Group 3: Under-estimation				
N	17	18	19	13
Mean	63.3	59.1	58.2	58.0
SD	20.6	16.2	22.06	19.4
Min	35	34	31	31
Max	95	92	96	89
Whole sample				
N	59	54	59	52
Mean	14.8	12.2	6.5	10.2
SD	39.8	40.5	46.2	36.1
Min	−79	−56	−80	−61
Max	95	92	96	89

RESULTS

Does awareness of cognitive deficits depend on the cognitive domain under study? In order to answer this question, self-evaluations and actual performance in each cognitive domain were entered into a correlational analysis. A low, yet significant correlation ($r = .34$ $p < .05$) was found between participants' self-evaluations of their memory ability and their performance on memory tests. In the attention and comprehension domains these correlations were not significant (Attention: $r = .18$, $p > .05$, Comprehension: $r = .23$, $p > .05$).

The correlation between objective memory scores and subjective evaluations of that domain ($r = .34$, $p < .05$) was higher than the correlation between memory scores and evaluations of the other two domains (Attention: $r = .16$, $p > .05$, Comprehension: $r = .16$, $p > .05$). In the attention and comprehension domains, the correlations between self-evaluation and actual performance were significant neither within each domain nor across domains. Note also that the objective measures of attention, memory, and comprehension were all moderately yet significantly related with each other ($r = .52$, $p < .001$ between attention and comprehension; $r = .35$, $p < .01$ between attention and memory; and $r = .36$, $p < .01$ between memory and comprehension). A similar pattern of correlations was found between the three measures of subjective evaluations. Attention and comprehension were strongly related ($r = .71$, $p < .001$), while memory was more moderately, yet significantly, related to both (Attention: $r = .51$, $p < .001$, Comprehension: $r = .45$, $p < .001$).

In addition to the associations between self-evaluations and objective measures, the accuracy of self-evaluations was also examined. This accuracy was measured by the absolute differences between the percentile scores of self-evaluations and the percentile scores of the neuropsychological tests in the three cognitive domains. Results show no significant differences between the absolute difference scores across the cognitive domains (Attention: $M = 32.6$, $SD = 27.0$; Memory: $M = 34.9$, $SD = 23.4$ and Comprehension: $M = 37.9$, $SD = 23.4$; Paired t-test analyses were not significant). Note also that the three mean scores fall within the range of 30–40 percentiles. On average the participants either over-estimated or under-estimated their ability by 29.1 percentiles ($SD = 23.4$).

In order to determine whether awareness was related to outcome measures, a series of one-way ANOVAs were conducted, with the three awareness levels in each of the three cognitive domains as the independent variables and the four outcome measures – psychiatric symptomatology, behavioral disturbances, independence in daily functioning and vocational status – as the dependent variables.

Psychiatric symptomatology: In each cognitive domain there was a significant group effect in terms of levels of awareness, such that under-estimators had lower GSI scores than good-estimators, and good-estimators had lower GSI scores than over-estimators (Attention: $F_{(2,\ 49)} = 11.6$, $p < .001$; Memory: $F_{(2,\ 45)} = 5.130$, $p < .01$; Comprehension: $F_{(2,49)} = 3.24$, $p < .05$; Total Awareness Score: $F_{(2,42)} = 8.95$, $p < .001$) (see Fig. 1). A post hoc Scheffe' analysis revealed significant differences ($p < .05$) between the under-estimators and the over-estimators in all four comparisons and an additional significant difference between the good-estimators and the over-estimators in the attention domain. A more detailed ANOVA of each of the nine psychopathological scales of the SCL-90–R revealed similar results.

Behavioral outcome: Evaluations of behavioral disturbances provided by family members revealed a weaker trend in the same direction – under-estimators and good-estimators were endorsed less behavioral disturbances than over-estimators. In the comprehension domain, there was a significant group effect of awareness level ($M = 1.88$, $SD = 1.04$ for under-estimators; $M = 1.68$, $SD = 1.08$ for the good-awareness group and $M = 3.21$, $SD = 0.46$ for the over estimators; $F_{(2,\ 28)} = 7.22$, $p < .002$). A post hoc Scheffe' analysis revealed that family members of over-estimators attributed significantly more behavioral disturbances to their relative than did family members of participants in the other two levels of awareness ($p < .01$). A similar pattern of results, though not a significant one, was evident in the Mean Awareness Score ($M = 1.56$,

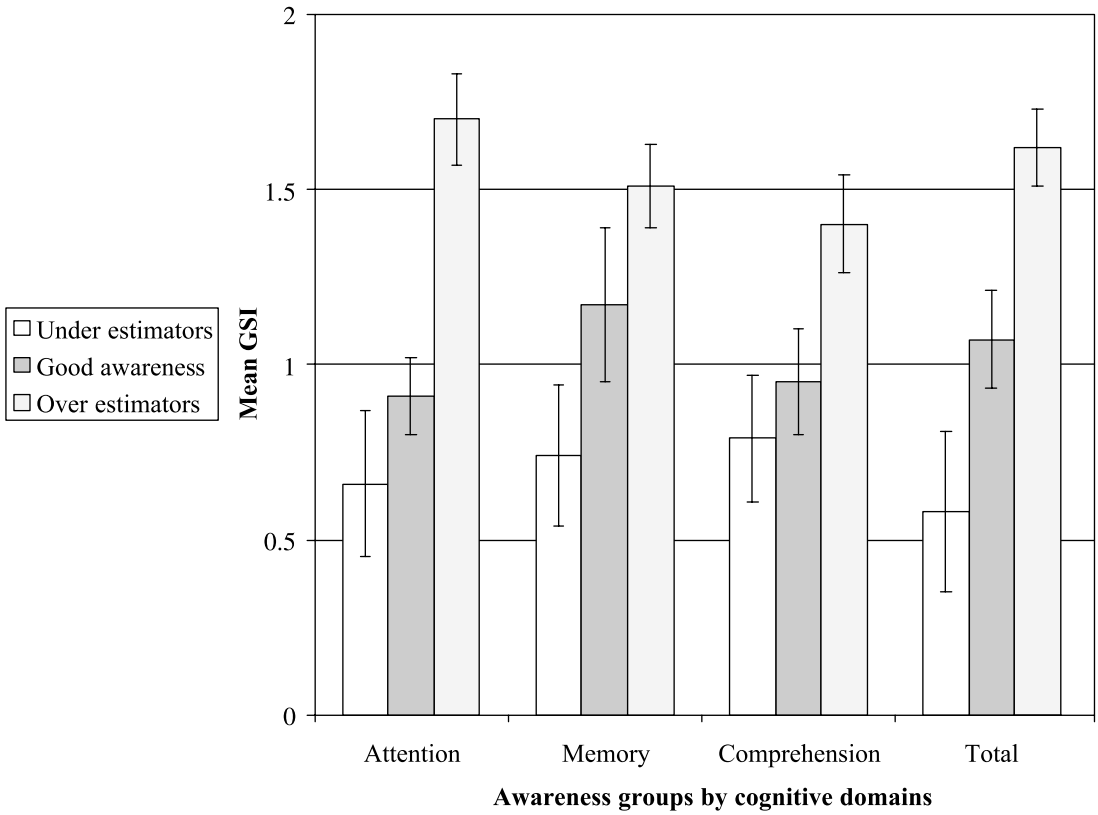

Fig. 1. Means and SEs of GSI scores by awareness groups and cognitive domains.

$SD = 1.03$ for under-estimators; $M = 2.2$, $SD = 1.17$ for the good-awareness group and $M = 2.56$, $SD = 1.1$ for the over-estimators). On the other hand, in the attention and memory domains, no significant differences were found, nor a similar trend of differences between the three awareness levels.

Extended ADL: In the Comprehension domain, relatives of over-estimators attributed less independence in extended ADL to their family members than did relatives in the two other groups ($M = 3.01$, $SD = 0.80$ for the under-estimators; $M = 3.4$, $SD = 0.79$ for the good-estimators and $M = 2.4$, $SD = 0.59$ for the over-estimators; $F_{(2,\ 27)} = 3.8$, $p < .05$). A post hoc Scheffe' analysis revealed that family members of over-estimators attributed significantly less independence in extended ADL to their relatives than did family members of participants in the other two levels of awareness ($p < .05$). A similar trend of results, though not a significant one, was also evident in the other two comparisons.

Vocational functioning: was measured by the Employed/Unemployed Index and by the Index of Stability at Work. Overall, no association between vocational functioning and awareness was found. A nonparametric Chi square analysis showed no significant correlations between the Employment Index and the three awareness levels in all cognitive domains. Nevertheless, although not significant, in the memory domain the over-estimators had a lower employed/unemployed ratio (7/32, i.e., 23% employed vs. 11/22, i.e., 50% unemployed) than the under-estimators (16/32, i.e., 50% employed vs. 5/22, i.e., 22% unemployed, Chi square = 5.6, $df = 2$, $p < .06$). On the Index of Stability at Work, no significant differences between the three awareness levels were found in any of the cognitive domains. However, the under-estimators tended to show higher rates of stability

at work than either the good-estimators or the over-estimators in both the attention and the comprehension domains (Attention: $M = 0.40$, $SD = 0.31$ for under-estimators vs. $M = 0.21$, $SD = 0.19$ for good-estimators and $M = 0.26$, $SD = 0.28$ for over-estimators. Comprehension: $M = 0.38$, $SD = 0.28$ for under-estimators vs. $M = 0.29$, $SD = 0.31$ for good-estimators and $M = 0.20$, $SD = 0.27$ for over-estimators). These differences reached only marginal significance and were not replicated in the memory domain.

DISCUSSION

The study of unawareness of deficits among persons with TBI focuses on the differential distribution of unawareness across mental and functional domains, on the relations between unawareness of deficits and outcome and on the validation of measurement methods. The first goal of the present study was to examine the differential distribution of unawareness of deficits across cognitive domains. Previous studies have suggested that persons with TBI tend to be more aware of concrete and evidently measurable deficits and reveal difficulties in their awareness of more abstract and less measurable traits (Flemming & Strong, 1999; Sherer, Boake, et al., 1998). This hypothesis was examined mainly by comparing awareness of physical and motor disabilities, affective characteristics, behavior, intellectual abilities, and daily functioning. However the concrete-abstract continuum of awareness has not been tested within the cognitive domain. We have hypothesized that since memory and attention are more concrete and measurable than comprehension, their evaluation by persons with TBI should be better associated with actual performance on neuropsychological tests that measure these domains. However this hypothesis was only partially supported by the data.

Analysis of the relation between self-evaluation and actual performance revealed a significant correlation only in the memory domain. In addition, the correlation between subjective evaluations of memory and objective measures of that domain was significant and higher than the correlation of self-evaluation of memory and objective measures of either attention or comprehension. Inter-correlations within both the subjective and the objective measures revealed a stronger association between attention and comprehension and a weaker, yet significant, correlation between these two domains and memory. Thus, a possible dissociation between the subjective and objective measures of memory on the one hand, and the subjective and objective measures of attention and comprehension on the other hand is suggested by the correlational analysis. This dissociation may provide partial support for the hypothesis that memory abilities are more concrete than both attention and comprehension abilities and hence more accessible for self-awareness. At the same time, self-assessment of memory was no more precise than that of either attention or comprehension, as can be seen through the comparison of the means of absolute differences between self-evaluations and actual performance on neuropsychological tests.

Were all three cognitive abilities too abstract for the participants to self-evaluate correctly? This may be the case but our study does not warrant such an interpretation. In accordance with previous studies (Prigatano, 1991, 1998; Sherer, Boake, Levin, et al., 1998), it may imply that in this group of persons with TBI the measurement and comparisons of awareness of specific cognitive abilities are relatively problematic, at least from the two aspects tested here – the estimation-performance association and the accuracy of estimation.

Two methodological issues seem to be of importance. First, in the present study we assumed a concrete-abstract continuum that could be seen with the use of common neuropsychological measures of attention, memory, and comprehension. These measures were not a priori constructed to represent distinct points on the concrete-abstract dimension. Moreover, two of the measures (attention and comprehension) were taken from one battery (WAIS–R) and the third measure (memory) from a different battery (WMS–R), and this by itself could have led to the dissociation between the objective measures. Further examination of this hypothesis should apply measures specifically constructed to represent the distinct attributes of the concrete-abstract cognitive continuum.

Second, a post hoc analysis of the division of the participants into the three awareness groups in each of the cognitive domains indicates that the lack of differentiation in self-awareness across cognitive domains is not repeated in an intra-personal analysis. Among the 61 participants, only 17 were assigned to the same awareness group in all three cognitive domains. Eleven participants turned out to be over-estimators in one cognitive domain and under-estimators in another domain, while the remaining participants fell under two adjacent groups, demonstrating good awareness in one domain and either over- or under-estimation in the other domains. Hence, although awareness is not systematically differentiated across a concrete-abstract continuum in a between-subjects analysis it tends to show differentiation when a within-subjects analysis is conducted. These differences may be accounted for by currently unidentified cognitive, emotional or motivational within-subjects factors, or by low reliability of the method of measurement of awareness. Further studies are needed in order to determine the exact source of the discrepancy between the results of within-subject and between-subject designs in terms of the lack of clear differentiation in awareness of distinct cognitive domains.

The second goal of the current study was to examine whether awareness of cognitive abilities was related to outcome in terms of psychiatric symptomatology, behavioral disturbances, independence in daily living, and occupation. In accordance with previous methodological recommendations we assigned the participants to three awareness levels according to the direction as well as the magnitude of the difference between self-evaluation and actual performance.

Our results revealed significant correlations between self-awareness and several indices of mental and functional outcome. It appears that participants who over-estimate their cognitive abilities tend to fare worse in mental and functional terms, as compared to those who possess good awareness or those who under-estimate their abilities. The latter two groups do not differ significantly. More specifically, over-estimators of cognitive functioning endorse higher rates of psychiatric symptomatology than do participants in the other two awareness groups, a finding that has been previously reported by Malec and Moessner (2000). The over-estimators were also assessed by their family members as suffering from more behavioral disturbances and as being less independent in their extended ADL than participants in other two groups. These two outcome measures followed the same general trend but reached significance only in the comprehension domain.

Note that these outcome measures are all based on evaluations, either by the participant (i.e., psychiatric symptomatology) or by his/her family member (i.e., behavior disturbances and ADL). Thus, when outcome is measured by subjective or semi-objective measures, a common trend of association between self-awareness and outcome is revealed. This association supports the common assumption that the lack of awareness to manifestations of disability is related to deficient adaptation, at least as it is evaluated by the person himself or his family. Nevertheless, this correlation was not found when objective measures of outcome were examined. There was no significant correlation between measures of vocational outcome and self-awareness in any of the cognitive domains. Over-estimation of memory was only slightly related to a lower frequency of employment, while over-estimation of comprehension was slightly related to less stability at work, as compared to under-estimation of those abilities. This finding was not repeated in the other two cognitive domains although under-estimators tended to be more vocationally stable. Hence, when outcome is measured objectively, its association with awareness is weakened relative to the association found when outcome is measured more subjectively (Malec & Moessner, 2000). Sherer, Berglof, Levin, et al. (1998) suggested, that outcome is not directly affected by awareness but that it is mediated by cognitive factors and readiness for change. Our study did not examine these relations but supports their finding of a relatively weak association between awareness and vocational outcome. In a previous study we also reported that there was no association between intellectual abilities and employment among persons with TBI (Hoofien, et al., 2001). This could partially explain the weak

correlations between cognitive awareness and rate of employment in the present study. The generalization of these findings must be cautiously considered due to the possible selection bias that was described in the methods section. As detailed above, about 50% of the initial potential sample for the present study was lost at follow-up, mainly due to the length of time between the first referral (for clinical purposes) and the present study (2–16 years) and circumstances related to that time period. Clinical long-term outcome studies that span more than 10 years post injury are relatively rare, possibly due to such sampling difficulties. They are, nevertheless, quite important in determining the lasting effects of traumatic brain injury, as long as the length-of-time/drop-out cost is taken into account.

The current study applied two previously recommended methods for the measurement of unawareness of deficits. Firstly, participants' self evaluations of their cognitive abilities were compared to neuropsychological test scores rather than scores based on evaluations provided by family members or clinicians, thus yielding a more objectively based measure of awareness (Deaton, 1986). A second methodological advantage of the present study lies in the method of division into the three awareness groups. Following Prigatano and Altman (1990), we took into account the magnitude of the difference rather than its direction only (minus, plus, or zero). The participants were divided by $\pm(1/2)$ *SD* around the average to the 'Good awareness' group and at the two ends of the distribution, above and below (1/2) *SD* from the average, to 'Under estimators' and 'Over estimators,' respectively. This method of division proved to be efficient, at least in the numerical distribution of the participants between the three groups in each of the cognitive domains. Difference scores are frequently considered problematic due to the irregular distributions they form. In our case, where both the direction as well as the magnitude of the difference were taken into account, the distributions were relatively normal, a fact that is also revealed by the standard deviations of the awareness scores. The results of the correlations between this method of division to three awareness groups and measures of outcome, further emphasize its importance, at least from the point of view of the interesting and quite frequent (about 33% of the participants) phenomenon of under-estimation of the ability. In certain outcome measures the under-estimating participants showed better functioning even when compared to the good awareness group and mostly performed as well as the well-aware participants. We found no evidence that the under-estimators were inferior to the participants whose awareness was good in any of the comparisons conducted in the current study. Thus, among the participants in this study, under estimation of the ability was found to be as good as good awareness, at least when it comes to outcome. This last finding supports previous studies that regarded under-estimators as overly aware persons, and as a consequence did not separate them from those who possessed good awareness of their abilities.

This finding has also important clinical implications. About two thirds of our sample did not suffer from the negative aspects of unawareness of cognitive deficits, that is, over-estimation of cognitive abilities or denial of cognitive disabilities. Previous studies and clinical reports have repeatedly argued that unawareness is a common phenomenon and a major obstacle on the route to rehabilitation among persons with TBI. Nevertheless, this argument has received little empirical support and is not supported by our study either. Interestingly, Hinkin et al. (1996) report of a very close proportion of awareness/denial of episodic memory abilities in a group of patients with HIV-1 infection. Whether the proportion of one-third denial to two-thirds good-awareness that was found is unique to the cognitive domains that were studied requires further examination.

Note also that our sample is composed of persons with TBI whose injuries occurred on average 13.8 years ($\pm$5.8) prior to the study. The denial/awareness proportions that we found, as well as any other aspect of this study, may be strongly related to this characteristic of the sample. These persons have evidently shaped and elaborated their mode of adaptation to their disabilities during the years that passed since the injury. While Flemming and Strong (1999) report a much smaller proportion of under-estimators within 1 year postinjury, Prigatano and Altman (1990) report, at an average of 16 months

postinjury, a proportion of 25% of over-estimators, 53% good-estimators, and 17% under-estimators, closer to our findings. Whether these differences of proportions indicate to a gradual increase of under-estimation and good awareness from the more immediate, acute phases to the later stages of rehabilitation, or are determined by differences in the methods of measurement – needs further examination.

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