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Cognitive underperformance and symptom over-reporting in patients with acquired brain injury and neuropsychiatric problems.

Indicators and influence on neuropsychological test-results

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Neuropsychological assessment in patients with Acquired Brain Injury (ABI) can be influenced by cognitive underperformance (lower performance due to lower effort) or by symptom over-reporting (patients reporting more symptoms than they actually have). This study aimed to examine factors related to cognitive underperformance and symptom over-reporting and to investigate their influence on cognitive measures in patients with ABI and neuropsychiatric problems. Patients (N=170) were recruited from two mental health centres in the Netherlands. The Amsterdam Short Term Memory Test (ASTM), the Test of Memory Malingering and the Structured Inventory Malingered Symptomatology (SIMS) were used to measure symptom validity. Patients who failed these tests were compared to patients who passed the test on age, gender, educational level, depression, awareness, executive function, and memory. The cognitive underperformers were significantly older than the control group (p = .021). The symptom over-reporting group reported significantly more depressive symptoms (p = .009) and their Awareness Questionnaire (AQ)-discrepancy scores were significantly lower (p = .05) than the control group. No association was found of cognitive underperformance with the cognitive measures. Symptom over-reporting was associated with lower memory scores (β = .30, p = .010). In conclusion, age appeared to be the strongest predictor of cognitive underperformance. Depression and an underestimation of functioning seem to predict symptom over-reporting. The use of the ASTM in this patient group should be further investigated, however the SIMS may be a good indicator of lower effort in memory tests.

Keywords: acquired brain injury; cognitive underperformance; symptom over-reporting; demographic variables; awareness; depression; cognition

INTRODUCTION

Patients with Acquired Brain Injury (ABI) are often referred for neuropsychological assessment to assess cognitive and psychological functioning. Neuropsychological assessment in this group is not easy because ABI is often comorbid with (neuro)psychiatric and/or psychological problems, which influence test results (Hendriks, Kessels, Gorissen, & Schmand, 2006). For example stress (Stulemeijer, Andriessen, Brauer, Vos, & Van der Werf, 2007), certain personality traits (Stulemeijer, et al., 2007), a mood disorder (Webb, Batchelor, Meares, Taylor, & Marsh, 2012), and psychosis (Hendriks, et al., 2006; Webb, et al., 2012) can lead to lower effort during testing. When patients perform lower than they would have done when their effort was adequate, this is called cognitive underperformance. In addition to cognitive underperformance, patients may also report more symptoms than they actually have, which is called symptom over-reporting. These two phenomena are often related (Dandachi-Fitzgerald, Ponds, Peters, & Merckelbach, 2011; Haggerty, Frazier, Busch, & Naugle, 2007; Nelson, Sweet, Berry, Bryant, & Granacher, 2007) and both can influence test results (Hendriks, et al., 2006; Locke, Smigielski, Powell, & Stevens, 2008).

Several methods have been developed to assess cognitive underperformance and symptom over-reporting. To measure cognitive underperformance, different symptom validity tests (SVTs) have been developed, for example the Test of Memory Malingering (TOMM) and the Amsterdam Short Term Memory Test (ASTM) (Schmand, de Sterke, & Lindeboom, 1999; Tombaugh, 1996). To measure the tendency to over-report symptoms, the Structured Inventory of Malingered Symptomatology (SIMS) can be used (Smith & Burger, 1997).

The estimated prevalence of cognitive underperformance and symptom over-reporting is variable throughout studies, depending on, for example, the type of patients, and the type of SVT that is used (Dandachi-Fizgerald, et al., 2011). In patients with ABI, the prevalence of cognitive underperformance was estimated between 15% and 30% (Donders & Boonstra, 2007; Moore & Donders, 2004; Ruocco, Swirsky-Sacchetti, Chute, Mandel, Platek, & Zillmer, 2008; Stulemeijer, et al., 2007; Webb, et al., 2012). In samples of psychiatric patients, the prevalence of cognitive underperformance was found to be between 20% and 25% (Dandachi-FitzGerald, et al., 2011; Gorissen, Sanz, & Schmand, 2005). The percentage of symptom over-reporting was found to be 11-18% in patients with TBI and was higher in patients with a litigation status (Bianchini, Curtis, & Greve, 2006). The prevalence of symptom over-reporting in psychiatric patients was estimated at 21-23% (Beilen, Griffioen,

Gross, & Leenders, 2009; Dandachi-FitzGerald, et al., 2011). Several studies compared patients who failed SVTs with patients who passed SVTs on litigation status. In these studies it was found that the prevalence of cognitive underperformance and symptom over-reporting was higher in patients with a litigation status (Bianchini et al., 2006). However, cognitive underperformance and symptom over-reporting also seem to occur in non-litigant settings, which suggests additional factors are of influence. It is important to examine which factors are associated with cognitive underperformance and symptom over-reporting in order to develop effort-increasing interventions (Stulemeijer, et al., 2007).

Several studies have already investigated potential predictors of cognitive underperformance and symptom over-reporting. In several studies relationships between cognitive underperformance and certain demographic variables were found, for example lower educational levels, being foreign-born, higher age, and being female were related to cognitive underperformance after ABI (e.g. Donders & Boonstra, 2007; Stulemeijer, et al., 2007; Webb, et al., 2012). Additionally, in psychiatric patients lower educational levels and higher age have been associated with cognitive underperformance (Dandachi-FitzGerald, et al., 2011), although in some studies no relationship between cognitive underperformance after ABI and level of education, age, and gender was found (e.g. Donders & Boonstra 2007; Locke, et al., 2008; Stulemeijer, et al., 2007).

In addition to demographic variables, injury-related variables might be related to cognitive underperformance. Some studies have shown an 'inverse dose-response assertion' which means that mild brain injury is more related to cognitive underperformance than severe brain injury (Donders & Boonstra, 2007; Greiffenstein & Baker, 2006; Webb, et al., 2012). However, in the study of Moore and Donders (2004) this relationship was not found.

As mentioned earlier, psychological problems in patients with ABI may also be related to cognitive underperformance. In some studies it was found that more psychiatric problems, more distress, more depressive symptoms, a self-reported mood disorder, higher fatigue, less motivation, and psychotic illness were related to cognitive underperformance after ABI (Donders & Boonstra, 2007; Moore & Donders, 2004; Stulemeijer, et al., 2007; Webb, et al., 2012). However in other studies, psychiatric history and depression were not related to cognitive underperformance after ABI (Locke et al., 2008; Rohling, Green, Allen, & Iverson, 2002).

Research on factors related to symptom over-reporting is more limited. In most studies, psychological disorders appeared to be associated with symptom over-reporting. For example, Carone, Iverson and Bush (2010) describe that symptom exaggeration is associated

with major depression, chronic pain and with somatoform disorders. The concepts 'somatoform disorder' or 'somatization' refer to patients 'who report multiple somatic complaints that are medically unexplained and cause significant impairment or disruption in everyday life' (Carone, et al., 2010, p.1). In the study of Ownsworth, Fleming, & Hardwick (2006) associations of high level of symptom reporting with greater self-awareness, mild (compared to severe) TBI, higher age, higher level of depressive symptoms and a tendency to blame other people were found in patients with ABI. In this study, self-awareness was described as the patient being aware of his/her post-injury changes in physical, cognitive, and behavioural functioning (Ownsworth, et al., 2006). In psychiatric patients, lower IQ scores, lower educational level, more psychological problems (Dandachi-FitzGerald, et al., 2011) and depression (Rohling, et al., 2002) have been related to symptom over-reporting.

As it appears from the studies mentioned above, evidence in the recent literature about factors related to cognitive underperformance and symptom over-reporting remains equivocal. Possible explanations for these variable results are for example different operalisations of variables (e.g. self-reported depressive symptoms versus a diagnose of depression) or the use of different SVTs. In addition, these studies included patients who had ABI or were psychiatric patients. To our knowledge, no studies have investigated factors associated with cognitive underperformance and/or symptom over-reporting in patients with both ABI and severe neuropsychiatric problems. In the current study, factors associated with cognitive underperformance and symptom over-reporting were investigated in patients with both ABI and severe psychiatric problems.

In addition to factors associated with cognitive underperformance and symptom over-reporting, the influence of failing a SVT on neuropsychological test-results was investigated. Intuitively, it seems obvious that lower effort will lead to lower test-results, however in previous studies this hypothesis was not always confirmed and was never tested in patients with a combination of ABI and severe neuropsychiatric problems.

In several studies it appeared that patients with ABI who fail a cognitive validity test perform lower on measures of cognitive flexibility, cognitive speed, memory, intelligence, and attention (Constantinou, Bauer, Ashendorf, Fisher, & McCaffrey, 2005; Lange, Iverson, Brooks, & Ashton Rennison, 2010; Locke, et al., 2008; Ord, Greve, Bianchini, & Aguerrevere, 2010; Stevens, Friedel, Mehren, & Merten, 2008; Stulemeijer, et al., 2007). Also in patients with Post Traumatic Stress Disorder (PTSD), a general effect of cognitive underperformance on all tested domains including intellectual/academic functioning, executive functioning, verbal learning and memory, attention/working memory, and cued

recall/recognition was found (Demakis, Gervais, & Rohling, 2008). In contrast, symptom over-reporting appeared to be unrelated to neuropsychological test results in this patient group (Demakis, et al., 2008) and in other psychiatric patients (Dandachi-Fitzgerald, et al., 2011). In psychiatric patients, cognitive underperformance was related to lower scores of memory, however not to other measures of cognitive underperformance (Dandachi-Fitzgerald, et al., 2011). This is in line with the finding that memory complaints are the most prevalent complaints in patients with a lower effort level or in patients who simulate (Hendriks, et al., 2006). How cognitive underperformance and symptom over-reporting are related to cognitive functioning in patients with ABI and neuropsychiatric problems was not addressed in the studies mentioned above.

With these considerations in mind, the aim of this study was twofold. The first aim was to examine which factors are associated with cognitive underperformance and symptom over-reporting in patients with ABI and neuropsychiatric problems. Factors included in the study were age, gender, level of education, awareness and depression. Second, the influence of cognitive underperformance and symptom over-reporting on test-results was investigated, and if specific tasks are more sensitive than others. Following these aims, the first research question was: 'Are demographic variables, including age, gender and educational level related to cognitive underperformance and/or symptom over-reporting?'. The second research question was: 'Are psychological factors, including self-awareness and depression related to symptom over-reporting?'. The last research question was: 'Are cognitive underperformance and symptom over-reporting related to neuropsychological test-results and if yes, is this a general effect or are specific tasks more sensitive than others?'

Based on the literature it was hypothesized that a low level of education, higher age and being female are related to cognitive underperformance and symptom over-reporting. For the second research question it was expected that greater self-awareness (more awareness of changes in functioning) and having more depressive symptoms are related to symptom over-reporting. To answer the third research question we hypothesized that cognitive underperformance is related to lower neuropsychological test-scores. Furthermore, based on earlier literature (Dandachi-fitzgerald et al., 2011; Hendriks, et al., 2006) it was expected that memory tasks are more sensitive to cognitive underperformance than other tasks. Lastly, we hypothesized that symptom over-reporting is not related to neuropsychological test-scores.

METHODS

Participants

The participants included in this study are patients with ABI in combination with neuropsychiatric problems who were referred for neuropsychological assessment between 2010 and 2014 at two mental health centres in the Netherlands; Huize Padua (HP), which is part of GGZ Oost Brabant, and Vesalius, which is part of GGZ Altrecht. In total, 170 patients were included in the study, of which 119 were from Huize Padua and 51 were from Vesalius. Inclusion criteria for patients to be admitted to Huize Padua or Vesalius were acquired brain injury confirmed by neurological and/or neuroimaging data, a minimum age of 17 years, at least one neuropsychiatric symptom, and a sufficient command of the Dutch language. Exclusion criteria were: having primary behavioural or psychiatric problems, degenerative brain disease other than vascular dementia, whiplash injury, Korsakov or other substance related brain injury. These criteria were checked during the intake procedure.

An additional inclusion criterion for participation in this study was the completion of at least one validity test, the TOMM, the ASTM, or the SIMS. In total, 170 patients met the inclusion criteria of which 112 were male (65.9%) and 58 were female (34.1%). The participants had a mean age of 43.7 (*SD* = 13.35) with the youngest participant being 17 years old and the oldest 73. Of these patients, 8 patients were tested more than once, for example because there were indications for underperformance in the first assessment or because they developed additional brain injury which required new neuropsychological assessment. For these 8 patients, only the first assessment was included in this study.

Procedure

The current study was retrospective. Data were collected from neuropsychological assessment files from the two mental health institutions mentioned above. In the Netherlands the use of anonymized routine data does not require ethical approval or written informed consent. For additional data, written informed consent was obtained from all participants and their informant (AQ, PHQ, & SIMS). Neuropsychological assessment was carried out by a neuropsychologist or test-assistant during the regular intake processes of the two institutions. The following data were used from the files and entered in SPSS: demographic information (gender, age, level of education), scores on underperformance tasks (TOMM, ASTM), scores on symptom over-reporting questionnaire (SIMS), scores on psychological measures (PersonHealthQuestionnaire-9 (PHQ) and the Awareness Questionnaire (AQ)), scores on two tasks measuring executive function (Trail Making Test and Stroop Color-Word Test) and

scores on a memory task (Verbal Learning Test). After entering all data, all patients were checked on missing values and outliers due to data entry errors.

Measurements

Amsterdam Short Term Memory Test (ASTM)

The ASTM was used to measure underperformance (Schmand, et al., 1999). It is presented as a test of memory and concentration and consists of 30 trials. Each trial consists of five words from a particular semantic category, the participant is instructed to remember these five words. Next, the participant has to complete a math exercise. Lastly, the participant has to select three words that he/she can recognize from the first list. In total, 90 correct answers can be given. The cut-off score is 85, thus more than 5 mistakes is an indication of cognitive underperformance (Schmand et al., 1999). Using this cut-off score, the ATSTM distinguished between participants who were instructed to simulate a disorder (N=57) and groups of patients with real neurological disorders (N = 139) with a sensitivity of 84% and a specificity of 90% (Schmand et al., 1999).

Test Of Memory Malingering (TOMM)

The TOMM was used to measure underperformance (Tombaugh, 1996). In this test, 50 images are shown to the participant. Next, the participant is presented with 50 items, each consisting of 2 images. The participant has to recognize which of the two images he/she has seen before. The maximum-score is 50, the cut-off score is 45. This means that more than five mistakes is an indication of cognitive underperformance. Compared to the ASTM, the TOMM has higher specificity. In addition the TOMM can be used for patients with observable cognitive dysfunction while this is not recommended for the ASTM (van den Heuvel, & Psychonomie, 2009).

Structured Inventory of Malingered Symptomatology (SIMS)

The SIMS is used for the screening of symptom over-reporting (Smith, & Burger, 1997). The SIMS is a self-assessment scale containing 75 statements which have to be answered with ‘yes’ or ‘no’. The statements cover five domains that are known to be sensitive for malingering. The areas are: cognitive dysfunction, depression, neurological disorders, psychosis and memory disorders (Merkelbach, Koeyvoets, Cima, & Nijman, 2001). The cut-off score is 16, this means that a score above 16 is indicative of symptom over-reporting (Rogers, Hinds, Sewell, 1996). In the study of Merkelbach and Smith (2003) with 298

participants, it was shown that the SIMS has a good sensitivity of 93% and a specificity of 98% using this cut-off score.

Patient Health Questionnaire-9 (PHQ-9)

The PHQ-9 assesses DSM-IV criteria of depression (Kroenke, Spitzer, & Williams, 2001). It is a self-report rating scale and contains nine items that are rated on a 4-point Likert scale ranging from 0 = not at all to 3 = nearly every day. The polarity of some items was reversed according to the test-manual and then the scores of the individual scores were added up to obtain a total score. Total scores range from 0 to 27, with higher scores indicating higher depression severity (Kroenke, et al., 2001). The original validation study revealed that a cut-off score of 10 as an indication for major depression had a sensitivity of 88% and a specificity of 88%. Furthermore, it revealed that PHQ-9 scores of 5, 10, 15, and 20 represented mild, moderate, moderately severe, and severe depression, respectively (Kroenke, Spitzer, & Williams, 2001). In this study the total PHQ-9 scores will be used as a measure of depression.

Awareness Questionnaire (AQ)

The AQ measures 'awareness of functioning in physical, cognitive, and behavioural domains as well as functioning in community activities in patients with TBI' (Sherer, Bergloff, Broake, High, & Levin, 1998, p. 64). Current functional abilities are rated in comparison to the patient's pre-injury abilities (Kroenke, et al., 2001). It is a rating scale using patient-, clinician- and/or significant other (SO)-ratings. It contains 17 items that are rated on a 5-point scale from 1 (much worse than before injury) to 5 (much better than before injury) and has three subscales: cognitive, behavioural/affective and motor-sensory (Sherer, Hart, & Nick, 2003). The polarity of some items was reversed according to the test-manual and then the scores on the individual items were added up to obtain a total score. A measure of awareness is obtained through calculating the discrepancy between the patient's self-reported score and the score of the SO ($AQ_{\text{Patient VS. SignificantOther}}$)/or clinician ($AQ_{\text{Patient VS. Clinician}}$), the significant others' or clinician's score is subtracted from the patient's score. These discrepancy scores can range from -68 to 68, with higher discrepancy scores indicating greater impairment of self-awareness. Negative discrepancy scores indicate an underestimation of functioning, positive discrepancy scores an over-estimation of functioning and scores around zero indicate good awareness of deficits (Smeets, et al., 2014). Both the discrepancy scores calculated from a family member and the discrepancy scores calculated from the clinician will be used in the analyses as measures of awareness of deficits.

Stroop Colour-Word test (SCWT)

The Stroop measures interference in cognitive functioning and response inhibition and consist of three cards (Stroop, 1935). The first card contains names of colours printed in black and the second card contains coloured rectangles. The patient has to read out loud the first card and name the colours of the second card as fast as possible. On the third card, the colour words are printed in incongruously coloured ink and the patient has to name the colour of the ink. An interference score is calculated by subtracting the mean time on card one and two from the time on card three (Valentijn, et al., 2005). For this study, the interference score was used to measure inhibition of a habitual response. Higher interference scores indicate more difficulty with inhibition of the habitual response (Valentijn, et al., 2005).

Trail Making Test (TMT)

The TMT task is a measure of executive functioning (Armitage, 1946) and consists of two cards; A and B. The patient has to connect numbers on card A. Card B is more difficult, the patient has to connect numbers and letters by alternating between the two sequences. The patients are instructed to work as fast as possible. A TMT ratio score is calculated through dividing the time on card B by the time on card A. For this study the TMT ratio score was used as a measure of mental flexibility (Arbuthnott & Frank, 2000). Higher TMT ratio scores indicate more difficulties in mental flexibility (Arbuthnott & Frank, 2000).

Delayed Recall of the Verbal Learning Test (VLT)

The Dutch adaptation of the VLT, *the Groningen Vijftienwoorden test* (Groningen Fifteen Words Test) which had been developed by Brand and Jolles (1985), measures memory and the ability to learn new information (Rey, 1958; Van der Elst, Van Boxtel, Van Breukelen, & Jolles, 2005). The test exists of 15 low-associative words, which are read out to the patient and which he/she has to repeat. After five repetitions of this list, a delay of 15 minutes follows. After this delay, the patient is asked how many words he/she can remember (delayed recall). The delayed recall trial measures long-term memory processes (Van der Elst, et al., 2005). The delayed recall trial will be included in this study because the immediate recall trials only measure encoding while the delayed recall trial also measures retention (Lezak, Howieson, Bigler, Tranel, 2012). Higher scores are indicative of better performance.

Level of education

Level of education was coded according to the standardized Dutch schooling system (De Bie, 1987). The categories were low (1–2), medium (3-4) and high (5–8) education.

Statistical analyses

Raw test-scores were screened for outliers. Outliers were deleted if they were entry errors, or if they were influential cases.

There was some variation in the tests that were administered to each patient. Data was available from almost all patients of the Stroop, the TMT, and the VLT. In addition, demographic information was present in all neuropsychological test files. However, in one group of patients data was available of the SIMS, the AQ, and the PHQ-9 but no information was present about cognitive underperformance. In contrast, there was also a group of patients to which the ASTM and TOMM were administered, however in these files no data was present of the SIMS, the AQ, and the PHQ-9. Therefore patients with data of the SIMS, the AQ and the PHQ were analysed separately from patients with data of the ASTM and TOMM.

Investigating the association of demographic variables, depression and awareness with cognitive underperformance and symptom over-reporting

First, some exploratory analyses were conducted to investigate which factors were associated with cognitive underperformance and symptom over-reporting. TOMM and ASTM variables were analysed as binary variables based on clinical cut-off scores, resulting into a cognitive underperformance group versus a no cognitive underperformance (control) group for both measures. The SIMS variable was similarly analysed as a binary variable, and the result was a symptom over-reporting and a no symptom over-reporting (control) group.

Six pearson's Chi-square tests of contingencies were performed to compare the cognitive underperformance (measured by the ASTM and the TOMM) and symptom over-reporting groups with their control groups on level of education and gender.

Independent samples *t* tests were performed to test age differences between the cognitive underperformance groups (ASTM and TOMM) and symptom over-reporting group on the one hand and the control groups on the other hand. In addition, independent samples *t* tests were conducted to compare symptom over-reporting with the no symptom over-reporting group on the PHQ-9, $AQ_{\text{Patient VS. SignificantOther}}$, and $AQ_{\text{Patient VS. Clinician}}$. When the assumption for normality was not met, Mann-Whitney U test was used, which is the non-parametric alternative for independent samples *t* test.

To investigate the effect of the combination of factors and to investigate the relative importance of the significant factors, two logistic regression analyses were performed. Factors that were significant or borderline significant in the exploratory analyses were entered as

predictors. In the first logistic regression analysis, cognitive underperformance measured by the ASTM was the dependent variable. In the second logistic regression analysis, symptom over-reporting was the dependent variable. Level of education was transformed into a dummy-variable using 'low' as the reference category.

Investigating the effect of cognitive underperformance and symptom over-reporting on cognitive measures

To explore the effect of cognitive underperformance and symptom over-reporting on test-results, TMT- and Stroop-scores were log transformed because the assumption of normality was not met. Secondly, three independent samples *t* tests were conducted to compare cognitive underperformance measured by the ASTM and the control group on TMT-, Stroop- and VLT-scores. In addition, three independent samples *t* tests were performed to compare symptom over-reporting with no symptom over-reporting on TMT-, Stroop- and VLT-scores. If log transformation did not result in a normal distribution, a Mann-Whitney U test was used, the non-parametric alternative for independent samples *t* test. When the t-test or Mann-Whitney U test was (borderline) significant, the effect was further explored by a hierarchical multiple regression analysis (MRA) to control for age, level of education, and gender.

In all analyses mentioned above, *p* values smaller than 0.05 were considered to be statistically significant, *p* values smaller than 0.10 were considered to be borderline significant. For each analysis, the relevant assumptions were checked. All statistical analyses were conducted using the IBM SPSS 20 for Windows software package.

RESULTS

In total, 170 patients were included in the study. As mentioned in the method section, there was variation in the symptom validity tests that were administered to each patient. The number of patients to which each symptom validity test was administered, is presented in Table 1. The mean age of all participants was 43.7 years (*SD* = 13.35). Other demographic information is provided in Table 2. A score below the cut-off for the ASTM or for the TOMM is indicative of cognitive underperformance and a score below the cut-off for the SIMS is indicative of symptom over-reporting. For conducting the analyses, patients were divided into two groups for each symptom validity test; a group of patients who failed the test (cognitive underperformance or symptom over-reporting) and a group of patients who passed the test (control group). The frequencies of these groups are also presented in table 2.

Table 1
The number of patients to which each symptom validity test (ASTM, TOMM, SIMS) was administered

Symptom validity tests	Frequency
Only ASTM	16
Only TOMM	33
Only SIMS	58
ASTM & TOMM	48
ASTM & SIMS	4
TOMM & SIMS	2
ASTM, TOMM & SIMS	9

Table 2.
Demographic information

	Frequency	%
Demographic information		
Gender		
Men	112	65.9
Women	58	34.1
Total	170	100
Type of lesion		
Traumatic	73	42.9
Vascular	42	24.7
Inflammation	10	5.9
Hypoxia	5	2.9
Tumor	6	3.5
Intoxication	2	1.2
Multiple	18	10.6
Other	14	8.2
Total	170	100
Level of education[a]		
Low	57	33.5
Medium	78	46.4
High	33	19.4
Missing	2	1.2
Total	168	100
Dependent variables		
Tomm[b]		
Cognitive underperformance	7	7.6
Control	85	92.4
ASTM[c]		
Cognitive underperformance	47	61.0
Control	30	39.0
SIMS[d]		
Symptom over-reporting	23	31.5
Control	50	68.5

[a] Level of education is coded according to Maas.
[b] TOMM cut-off score is 45
[c] ASTM cut-off score is 85
[d] SIMS cut-off score is 16

Effect of age, gender, level of education, depression and awareness on cognitive underperformance and symptom over-reporting

Cognitive underperformance

Pearson's chi-square tests of contingencies showed no significant association of gender and level of education with cognitive underperformance. However, a trend towards significance was found for the association between gender and cognitive underperformance measured by the ASTM, χ^2 (1, n = 77) = 3.124, p = .077. In both groups the number of men was larger than the number of women, but in the cognitive underperformance group the number of women was relatively larger than the number of women in the control group. An independent samples *t* test revealed that patients in the cognitive underperformance group were significantly older (M = 43.62, SD = 12.93) than the control group (M = 36.43, SD = 13.14), t (75) = -2.36, p = .021, two-tailed. When cognitive underperformance was measured with the TOMM, no significant difference in age was found between the cognitive underperformance group and the control group.

To further explore the effect of gender and age on cognitive underperformance measured with the ASTM, a logistic regression analysis was conducted. A test of the model containing both predictors was significant, indicating that the model was able to distinguish between cognitive underperformance and the control group, χ^2 (2, N = 77) = 7.824, p = .02. The model as a whole explained 13.1% (Nagelkerke R squared) of the variance in cognitive underperformance, and correctly classified 63,6% of cases. As can be seen in table 3, only age was a significant predictor (Wald = 4.338, p = .037), recording an odds ratio of 1,04. This odds ratio indicates that when age is raised by one unit (one year), the odds ratio is 1.04 times as large (cognitive underperformance is 1.04 time more likely). These results are shown in Table 3.

Table 3
Results of the logistic regression analyses with cognitive underperformance (measured with the ASTM) as the dependent variable, gender and age as predictors (n = 77)

Predictor	*B*	*S .E.*	*Wald*	*P*	*Odds ratio(OR)*	*95% Confidence limits for OR*	
						Lower	Upper
Constant	-.66	.88	.56	.453	.52		
Gender	-.79	.52	2.26	.132	.46	0.16	1.27
Age	.04	.02	4.34*	.037	1.04	1.00	1.08

*p < .05

Symptom over-reporting

Pearson's chi-square tests of contingencies showed no significant association of gender and

level of education with symptom over-reporting. In addition, no significant differences were found in age between the symptom over-reporting group and the control group. However, Mann-Whitney U test revealed depression scores were significantly higher in the symptom over-reporting group (*Md* = 11, *IQR* = 6, *n* = 19) than in the control group (*Md* = 8, *IQR* = 7.5, *n* = 48), *U* = 268, *z* = -2.62, *p* = .009.

In addition, an effect of awareness ($AQ_{Patient\ VS.\ significant\ other}$) was found. On average, the symptom over-reporting group had a negative discrepancy score (*M* = -2.33, *SD* = 11.84) and the control group a positive discrepancy score (*M* = 3.71, *SD* =7.01). This difference was statistically significant, *t* (38) = -2.017, *p* = .05. The independent samples *t* test comparing symptom over-reporting with the control group on $AQ_{patient\ VS.\ clinician}$ showed no significant differences.

To further investigate the effect of depression and awareness ($AQ_{Patient\ VS.\ significant\ other}$) on symptom over-reporting, a logistic regression was performed. A test of the model containing both predictors was statistically significant, indicating that the predictors as a set were able to distinguish between symptom over-reporting and the control group, χ^2 (2, *n* = 39) = 7.114, *p* = .029. The model as a whole explained 23.5% (Nagelkerke's R squared) of the variance in symptom over-reporting and correctly classified 69.2% of the cases. Although a significant association was found for both awareness and depression with symptom over-reporting in the exploratory analyses, neither of them made a unique statistically significant contribution to the model. These results are shown in Table 4.

Table 4
Results of the logistic regression analyses with symptom over-reporting as the dependent variable, depression and awareness as predictors (n = 39)

Predictor	*B*	*S .E.*	*Wald*	*P*	*Odds ratio(OR)*	*95% Confidence limits for OR*	
						Lower	Upper
Constant	-2.12	.90	5.52	.019	.12		
$AQ_{Patient\ VS.\ SignificantOther}$	-.06	.05	1.70	.192	.94	0.85	1.03
PHQ-9	.14	.08	3.02	.082	1.15	0.98	1.36

$^{*}p < .05$

Influence of cognitive underperformance and symptom over-reporting on cognitive measures

Cognitive underperformance measured with the ASTM

To answer the third research question, three independent samples *t* tests were performed. The assumptions of normality and equality of variances were met after logtransforming Stroop- and TMT-scores. One extreme low Stroop score in the no-cognitive underperformance group

(*Stroop interference score* = 1) was deleted because it was an influential case. Stroop interference scores appeared to be higher in the cognitive underperformance group (*Md* = 51, *IQR* = 38,13) than in the control group (*Md* = 37.5, *IQR* = 21). An independent samples *t* test with the logtransformed Stroop-scores revealed this difference was significant, *t* (57) = -.143, *p* = .036 as can be seen in Table 5. However, as can be seen in Table 6, when corrected for age, gender and level of education, cognitive underperformance was not a significant predictor of Stroop interference scores any more (standardized *beta* = .19, *p* = .16). This analysis was performed again including the outlier mentioned above, then the result turned out to be borderline significant (standardized *beta* = .226, *p* = .085). Therefore, this outlier was considered an influential case and consequently excluded from the analyses.

No significant differences were found between the cognitive underperformance group and the control group on TMT-, and VLT-scores. The results of these t-tests are shown in Table 5. Post-hoc analysis demonstrated that using a cut-off score of 83 for the ASTM did not reveal any other results than using a cut-off score of 85. The effect of cognitive underperformance measured by the TOMM was not investigated because there were only 3 patients who scored below the clinical cut-off score.

Symptom over-reporting

After logtransforming TMT-scores the assumptions of normality and equality of variances were met for the TMT-scores. As can be seen in Table 5, an independent samples *t* test revealed no significant differences between the symptom over-reporting and the control group on TMT-scores. Stroop interference scores were not normally distributed, therefore a Mann-Whitney U test was performed which also revealed no significant differences between the symptom over-reporting and the control group, *U* = 404.500, *z* = -.834, *p* = .404. However, a significant difference was found between the symptom over-reporting group and the control group on $VLT_{delayed\ recall}$ scores, *t* (68)= -2.32, *p* = .023, two tailed. The symptom over-reporting group had significantly lower scores on the VLT (*M* = 5.71, *SD* = 3.94) than the control group (*M* = 7.98, *SD* = 3.66). The magnitude of the differences in the means (mean difference = 2.27, 95% *CI*: -4.21 to .32) was moderate to large (eta squared = .08). The medians and results of the t-tests are shown in Table 5.

To further explore the effect of symptom over-reporting on $VLT_{delayed\ recall}$ scores while controlling for age, level of education and gender, a hierarchical multiple regression analysis (MRA) was performed. All assumptions (normality, linearity, multicollinearity and homoscedasticity) were met. The three control measures (age, gender, and level of education)

explained an additional 11% of the variance in VLT-scores, R^2 change = .11, F change (4,64) = 2,24, p = .08. In combination, symptom over-reporting, age, level of education and gender accounted for 18.7% of the variance in VLT-scores, R^2 = .187, F (5,64) = 2.94, p = .02. Controlled for age, gender and level of education, symptom over-reporting was still a significant predictor of $VLT_{delayed\ recall}$ scores (standardized *beta* = -.30, p = .010). In addition, age was a significant predictor (standardized *beta* = -.33, p = .01). These results are summarised in Table 7. Post-hoc analyses revealed that when the relationship between symptom over-reporting and $VLT_{delayed\ recall}$ scores was controlled for depression, symptom over-reporting remained a significant predictor of $VLT_{delayed\ recall}$ scores.

Table 5
Results of the independent samples t tests comparing the cognitive underperformance measured by the ASTM and symptom over-reporting group with their control group on VLT-, TMT-, and Stroop scores.

	Cognitive underperformance/ symptom over-reporting			*Control*				
	Median	*IQR*	*N*	*Median*	*IQR*	*N*	*t*	*Sig.*
Cognitive underperformance								
$VLT_{delayed\ recall}$	5	4	24	6	4	23	1.528	.133
TMT_{ratio}	2.33	1.29	35	2.13	.71	26	-.063	.950[a]
$Stroop_{interference}$	51	38.13	36	37.5	21	23	-2.14*	.036[a]
Symptom over-reporting								
$VLT_{delayed\ recall}$	5	6	21	8	6	49	-2.32*	.023
TMT_{ratio}	2.26	1.06	21	2.17	1.08	47	.302	.764[a]
$Stroop_{interference}$	48.5	75	19	44	27.75	49	404.5[b]	.404

*$p < .05$
[a] Based on analysis with logtransformed scores
[b] Mann-Whitney *U* test

Table 6
Results of the first hierarchical multiple regression analysis with logtransformed Stroop scores as the dependent variable and cognitive underperformance measured with the ASTM as the independent variable, corrected for age, gender and level of education (n = 58)

	Unstandardized coefficients		*Standardized coefficient*		*95,0% Confidence Interval for B*	
	B	*Standard Error B*	*β*	*p*	*Lower*	*Upper*
Constant	1.22	.20		.00	.81	1.62
Cognitive $underperformance_{ASTM}$	.12	.09	.19	.16	-.05	.29
Age	.01	.003	.26	.06	.00	.01
Gender	.02	.09	.03	.82	-.15	.19
Level of education (middle versus low)	.04	.09	.06	.67	-.15	.22
Level of education (High versus low)	-.15	.11	-.20	.18	-.38	.07

Note: R^2 = .075 for Model 1, change R^2 = .090 for Model 2 (p = .240).
*p <.05, **p<.01

Table 7
Results of the second hierarchical multiple regression analysis with VLT_{recall}-scores as the dependent variable, symptom over-reporting as the independent variable, corrected for age, gender and level of education (n = 69)

	Unstandardized coefficients		*Standardized coefficient*		*95,0% Confidence Interval for B*	
	B	*Standard Error B*	*β*	*p*	*Lower*	*Upper*
Constant	11.42	2.06		.00	7.31	15.54
Symptom over-reporting	-2.36**	.93	-.30	.01	-4.22	-.51
Age	-.09**	.03	-.33	.01	-.16	-.03
Gender	-.10	.91	-.01	.91	-1.91	1.70
Level of education (middle versus low)	-.11	1.00	-.02	.91	-2.10	1.88
Level of education (High versus low)	1.53	1.12	.16	.21	-.89	3.95

Note: R^2 = .07 for Model 1, change R^2=.11 for Model 2 (p = .075).
*p < .05, **p < .01

DISCUSSION

The first aim of this study was to examine whether demographic variables, depression, and awareness of deficits were related to cognitive underperformance and symptom over-reporting in a group of patients with ABI and neuropsychiatric problems. After dividing the patients into groups of failing and passing the symptom validity tests, it was found that the cognitive underperformance group was significantly older than the control (non-cognitive underperformance) group. Gender also appeared to be related to cognitive underperformance, the number of women in the cognitive underperformance group was relatively larger than in the control group. However, this result was only borderline significant. Level of education was not related to cognitive underperformance. Compared to gender and level of education, age appeared to be the most important predictor of cognitive underperformance in this study. No associations were found of symptom over-reporting with gender, level of education or age. Depression and awareness of deficits both appeared to be related to symptom over-reporting in the exploratory analyses. The symptom over-reporting group reported more depressive symptoms than the control group. Considering awareness, the symptom over-reporting group had an average negative discrepancy score while the control group had a positive score. This means the symptom over-reporting generally underestimated their functioning while the control group more often over-estimated their functioning. When depression and awareness were entered into a regression model at the same time, neither of them was a significant predictor anymore which suggest there is a small relationship between them. The second aim of this study was to examine the influence of cognitive underperformance and symptom over-reporting on performance on cognitive tests. Contrary to expectations, cognitive

underperformance appeared to be unrelated to neuropsychological test-results, while symptom over-reporting was related to lower memory scores, even after controlling for age, gender, and level of education.

The finding that the cognitive underperformance group was significantly older than the control group is in line with the study of Webb and colleagues (2012). They suggest that because age is associated with a prolonged disability from work following illness (Flach, Krol, & Groothoff, 2008) age was also related to a lower effort level (Webb, et al., 2012). However, they do not explain why a prolonged disability from work would be related to a lower effort level. Dandachi-Fitzgerald and colleagues (2011) put forward a more plausible explanation, they suggest that higher age might also be related to the false positives (patients incorrectly classified as underperformers) of the ASTM. According to the test manual, the ASTM is not suitable for patients with clinically evident cognitive impairment as in dementia and Korsakoff syndrome (Schmand & Lindeboom, 2005). As older people are more likely to have severe cognitive impairment than younger people (Salthouse, 2010), lower scores on the ASTM in older people might be caused by their lower cognitive functioning and not by their effort level.

Previous studies found that a low educational level and low intelligence were associated with cognitive underperformance and/or symptom over-reporting (Dandachi-Fitzgerald, et al., 2011; Solomon, Boone, Skidmore, Cottingham, Victor, 2010; Stulemijer et al., 2007) because low cognitive functioning (reflected by IQ and educational level) can lead to higher scores on the SIMS because patients do not fully understand the questions (Dandachi-Fitzgerald, et al., 2006) and can lead to lower scores on effort tests due to a lower working memory of the patients (Merten, et al., 2007; Bigler, 2014). Therefore it was expected that patients with a lower educational level would more often fail symptom validity tests than patients with a higher educational level. This relationship was not found probably because premorbid educational level is not a good measure of current cognitive functioning in this study. Patients with higher premorbid education and high intelligence are expected to have more cognitive reserve and therefore to experience less impairment from brain injury (Stern, 2002). However, due to the severity and variety of brain lesions they do necessarily have better current cognitive functioning than patients with a lower educational level. According to the cognitive reserve theory more cognitive reserve (reflected by higher premorbid educational level) in combination with greater brain damage can result in the same deficits as lower cognitive reserve in combination with milder brain damage (Stern, 2002).

For the second research question it was hypothesized that having more depressive symptoms and being more aware of changes in functioning would be associated with symptom over-reporting. In concordance with previous studies (Ownsworth, et al., 2006; Rohling, et al., 2002; Trahan, Ross, Trahan, 2001), depression indeed appeared to be related to symptom over-reporting. According to Trahan and colleagues (2001) this relationship can be explained by the general pessimism and dissatisfaction of these patients, which is common with depression. Ownsworth and colleagues (2006) add that individuals in emotional distress, for example depression, are preoccupied with their symptoms and overgeneralise the effects of their injury which makes them over-report their symptoms.

In addition to an association with depression, Ownsworth and colleagues (2006) found a relationship between greater self-reported changes in functioning and symptom over-reporting. To investigate awareness, the current study examined the difference between these self-reported changes and the reported changes of a significant other or clinician using AQ-discrepancy scores. Negative discrepancy scores indicate an underestimation of functioning, positive discrepancy scores an over-estimation of functioning, and scores around zero indicate good awareness of deficits (Smeets, et al., 2014). A significant relationship was found between AQ-discrepancy$_{\text{significant other}}$ scores and symptom over-reporting. The symptom over-reporting group had a negative mean discrepancy score, while the control group had a positive one. This means the symptom over-reporting generally underestimated their functioning while the control group more often over-estimated their functioning. However, when depression and awareness were entered into a regression model at the same time, neither of them was a significant predictor any more. Although the assumption of multicollinearity was checked before doing the regression analysis and no significant correlation was found between depression and awareness, this suggests a small relationship exists between depression and the estimation of functioning and therefore they partly explain the same amount of variance in symptom over-reporting. This is in concordance with Smeets and colleagues (2014), who found that depression was related to awareness, the underestimation group reported more depressive symptoms than the overestimation group. An underestimation of functioning may be reflective by the negative view of self that is a characteristic of depression (McBrinn, et al., 2008).

For the second aim of the current study it was hypothesized that cognitive underperformance would be associated with lower test-results, especially with lower memory-scores because memory complaints are the most malingered or exaggerated complaints (Dandachi-Fitzgerald, et al., 2011; Hendriks, et al., 2006). Based on previous literature

(Carone, et al., 2010; Dandachi-Fitzgerald, et al., 2011; Demakis, et al., 2008; Ownsworth, et al., 2006; Rohling, et al., 2002), symptom over-reporting was not expected to be related to neuropsychological test-results. Contrary to our expectations, cognitive underperformance measured with the ASTM was not related to neuropsychological test-results, while symptom over-reporting was related to lower memory scores.

The first explanation for the fact that no effect of cognitive underperformance was found, could be that patients score lower on the ASTM than on the neuropsychological tests that were administered later during the assessment. Patients completed the ASTM in the beginning of the assessment to estimate the validity of the subsequent cognitive tests. They may have been nervous for the neuropsychological assessment which influences scores on the ASTM, whereas they may have felt more comfortable during the subsequent neuropsychological tests. Second, when ASTM scores were lower than 80 or when both the ASTM and TOMM were below the cut-off score, patients got an effort increasing conversation with the psychologist before continuing testing. Consequently, low scores on the first test (ASTM) do not mean the patient's effort level is low during the rest of testing. This may clarify why no relationship was found between the ASTM and neuropsychological test-scores.

A second explanation may be that the standard cut-off score of the ASTM is not suitable in the patient group used in this study. This may have resulted in too many false positives (patients incorrectly classified as underperformers) and consequently no relationship with cognitive measures was found. It was suggested by Dandachi-Fitzgerald and colleagues (2011) that in some patient groups the standard cut-off score is not applicable because their cognitive impairment is too severe (Merten, et al., 2007; Schmand & Lindeboom, 2005). In the current study the percentage of patients who failed the ASTM was considerably higher (61%) than in other studies with non-litigant patients, which may suggest that in this study a high number of false positives was present. For example, in studies with patients with only ABI, the prevalence of cognitive underperformance was estimated between 15% and 46% (Donders & Boonstra, 2007; Merten, Bossink & Schmand, 2007; Moore & Donders, 2004; Ruocco, 2008; Stulemeijer, et al., 2007; Webb, et al., 2012), and in a study with psychiatric patients only 21% failed the ASTM (Dandachi-Fitzgerald, 2011). This suggests that the standard cut-off score of the ASTM is too high for the patients in this study who are more likely to have severe cognitive impairment. Therefore a post-hoc analysis was performed with a cut-off of 83 instead of 85. However, this did not solve the problem, still no significant differences were found between patients who failed the ASTM and patients who passed it on

the cognitive measures. Bigler (2014) addresses this problem, he suggests that below chance performance indeed implies knowingly falsifying the answers and that passing an SVT is the best indicator of valid neuropsychological test findings. However, according to Bigler (2014) it is unclear whether scores below SVT cut off but above chance indicate invalid performance or reflect cognitive or behavioural dimensions of test performance. He does not have a solution for this except to further investigate how other factors than effort influence SVT performance above chance level but below cut-off.

Contrary to expectations, a relationship between symptom over-reporting and memory scores was found. Because earlier studies found no relationship between symptom over-reporting and cognitive measures in psychiatric patients (Dandachi-Fitzgerald, et al., 2011; Demakis, et al., 2008), it was expected that symptom over-reporting would not be related to lower scores on cognitive tests. As the symptom over-reporting group also had higher depression scores, depression could have explained the relationship between symptom over-reporting and memory, as depression often underlies memory-problems (den Hartog, 2003; Kessels, Eling, Ponds, Spikman & van Zandvoort, 2012). However, post hoc analyses revealed that the relationship between symptom over-reporting and memory was not explained by depression. This suggests that although the SIMS is mostly used to detect exaggeration of symptoms on questionnaires it may also be used to detect lower effort in memory tests. As the SIMS also contains items about incredible memory problems (Merkelbach, et al., 2013) an association with lower effort in memory tests seems plausible.

The current study has some limitations that should be taken into account. The first limitation is that the use of the TOMM in this patient group could not be investigated because only 7 patients scored below the cut off score. A second limitation is that injury-related variables, like the severity or type of the lesion, were not included in this study because no data were available. However, it can be assumed that the patients in this study have severe brain injury since they were recruited from two mental health care institutions, specialized in treating people with severe brain injury in combination with neuropsychiatric problems. A problem associated with the variety and severity of problems is that due to this heterogeneity it may have been hard to find an association of for example level of education with cognitive underperformance or symptom over-reporting. However, at the same time the strength of this study is that, to our knowledge, it is the first time that cognitive underperformance and symptom over-reporting are addressed in patients with ABI and neuropsychiatric problems. Another limitation of the current study is that it is unknown if patients had external incentives for putting lower effort or over-reporting their symptoms. This may have provided more

insight into the motivations for patients to fail the symptom validity tests. However, because of the non-litigant setting of this study, the number of cases with external incentives are assumed to be low and therefore of minimal influence on this study.

For future research it is recommended to further investigate the use of the ASTM in this patient group to clarify factors related to scores above chance level but below the cut-off score. Also the use of the TOMM should be further investigated in this patient group as this test is considered to be more robust against cognitive impairment than the ASTM (van den Heuvel, & Psychonomie, 2009). In addition it is recommended to include injury-related variables like the severity and type of the lesion. Lastly, it can be recommended to extend the tests that are administered to each patient. This way, more insight can be provided into the factors related to cognitive underperformance and symptom over-reporting. For example it would be interesting to investigate the association of depression and awareness with cognitive underperformance and to compare the ASTM, TOMM and SIMS with each other.

In conclusion, compared to gender and educational level, age appeared to be the most important predictor of cognitive underperformance in this study. However, it seems that this relationship is not caused by older people having a lower effort level yet by older people having more cognitive impairment. No association was found of educational level with cognitive underperformance or symptom over-reporting, probably because premorbid educational level was not a good reflection of current cognitive functioning in this patient group. Considering the psychological factors, it seemed that a general pessimism and negative view of the self, reflected by both depression and an underestimation of functioning, are predictive of symptom over-reporting. No general effect of cognitive underperformance or symptom over-reporting on cognitive measures was found, however, a specific effect of symptom over-reporting on memory scores was found. This suggests that besides detecting symptom over-reporting, the SIMS may also be a good indicator for lower effort in memory tests.

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