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Psychomotor Retardation: Authentic or Malingered? A Comparative Study of Subjects with and Without Traumatic Brain Injury and Experimental Simulators

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Abstract

Background: *Injury to some brain areas may produce deficits of attention, with prolonged reaction time (RT) as well as increased error rates. However, both slowed RT and reduced accuracy are easy to malinger. The present study examines whether assessment of attentional subsystems allows recognizing feigned impairment.*
Method: *The sample comprised four groups, three of them being compensation-seeking patients of independent medical examinations: patients without brain injury, patients with mild traumatic brain injury (TBI), patients with moderate or severe TBI, and healthy experimental simulators (entire sample N = 232). RT was assessed with the Attentional Network Test. A symptom validity test (Word Memory Test, WMT) was used for the assessment of effort. The test is seemingly a measure of memory, but performance below an empirically established cutoff is, in fact, indicative of insufficient test motivation.*
Results: *Effort as measured by the WMT had a far stronger effect on RT than brain injury. Both RT and intraindividual variability of RT were significantly higher in persons who scored below the WMT cutoff, but there was a substantial overlap with patients with TBI. RT variation across complex attentional tasks was preserved in most patients with and without TBI as well as in patients failing the effort test and in experimental simulators.*
Conclusion: *While very slow RT and abnormal RT variance may raise suspicion of suboptimal performance, neither of these variables nor preserved variation of RT across complex attentional tasks reliably identify malingering. Thus, specific tests for effort are required to identify non-authentic attentional impairment (German J Psychiatry 2010; 13: 1-8).*

Keywords: reaction time, attention, malingering, brain injury, forensic assessment

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Introduction

Among the consequences of traumatic brain injury (TBI) may be a persistent decrease of psychomotor speed, even after the initial disturbance of consciousness has resolved (Collins & Long, 1996; van Zomeren & Brouwer, 1994). Consequently, reaction time (RT) tasks have been proposed as essential components in neuropsychological assessment of brain injured persons. Available RT paradigms differ in their sensitivity to brain injury. For instance, simple RT tasks (conceived to measure the speed with which a stimulus is detected) are less strikingly affected by brain injury than choice paradigms (conceived to be contingent on the information_contained in several stimuli and contexts) (Stuss et al., 1989). It has been proposed that RT for any paradigm contains two components. One component, the "pure" reaction time, is considered to be an indicator of general information processing speed and correlates with speed in other cognitive tasks (Felmingham et al., 2004). The other one is a task-specific component which has been called "complexity effect". It is thought to indicate processing capability involving various cognitive domains. Tombaugh et al. (2007) have reported that, while pure reaction time is somewhat increased in subjects with mild or severe TBI as compared to controls, differences are more pronounced for the complexity effect.

In clinical as well as in forensic assessments, two problems frequently arise: 1) is the slowing of RT genuine; and 2) is it caused by the TBI in question? The first problem is of relevance because psychomotor retardation is easy to feign. The second question reflects the observation that on one hand not all kinds of TBI may produce a slowing of RT, while on the other hand, non-traumatic brain conditions, such as cerebrovascular or demyelinating disease, as well as affective disorders may produce attentional deficits. Alexander et al. (2005) found that in a serial choice RT paradigm only patients with lesions to the right superomedial frontal regions had prolonged reaction times, with a mean increase of 160 ms. Subjects with lesions to other frontal brain areas performed normally. The groups did not differ with respect to response accuracy. Mild TBI is thought not to lead to persistently slow RTs. The WHO collaborative centre task force published a review on the prognosis of mild TBI, based on 428 studies (Carroll et al., 2004). The authors concluded that there is sound evidence that mild TBI is followed by cognitive deficits in the first few days after the injury, including recall of material, speed of information processing, and attention. There are consistent findings that these deficits resolve within three months. The authors note that (self-reported) cognitive deficits after brain injury suffered during sports-related activities resolved particularly fast, that is within 15 minutes to two weeks. The only predictor for chronic complaints about cognitive deficits was litigation. Similarly, a meta-analysis by Binder and Rohling (1996) identified compensation seeking as the foremost predictor for ongoing cognitive complaints. Another recent meta-analysis of the prognosis of mild traumatic brain injury (Iverson, 2005) arrived at similar conclusions. Iverson stated that a great number of factors may contribute to the functional outcome, such as pre-injury psychiatric disease, substance abuse, chronic medical illness, unemployment, and litigation.

Resnick (1988) suggested that malingerers might inadvertently show much longer RTs than authentic patients. He assumed that malingerers overestimate the amount of time that TBI patients require to respond. Alternatively, the mental processes involved in elaborating the artificial slowing may itself delay reactions by adding some hundreds of milliseconds. Strauss et al. (1994) reported that in reaction time paradigms simulators had the longest RTs, followed by TBI patients and controls. RT scores would yield a prediction rate for group membership of 76 percent.

The cooperativeness of an individual and his or her willingness to perform with full effort may be assessed by symptom validity tests (for a review, see Bender and Rogers, 2004; for current guidelines see Bush et al., 2005). However, response latencies in symptom validity tests were not found to be different for cooperative and uncooperative subjects (Rose et al., 1995). Conversely, Rees et al. (1998) reported that RTs for correct responses in the Test of Memory Malingering-Computerized (TOMM-C: Tombaugh, 1998) were consistently longer for simulators. Similar findings were reported by Bolan et al. (2002) and by Strauss et al. (2000), using two different forced-choice number-recognition tests. However, symptom validity tests may not be appropriate for assessing attentional deficits because neither are they presented as RT tests nor is the patient asked to react as fast as possible.

The Attentional Networks Test (ANT: Fan et al., 2001, 2002) appeared particularly suitable to serve the demands of a study on malingered reaction times. As explained above, RT is expected to vary in a systematic and predictable way across paradigms involving the complexity effect. The ANT yields measures of pure reaction time as well as measures of task specific complexity effects. In contrast to other reaction time tests involving complexity effects, it is not confounded by mental processes unrelated to attention, like verbal memory or mental rotation. The ANT is supposed to test three attentional subsystems which serve functionally different tasks and are located in different brain areas (Posner et al., 1994; Fan et al., 2002). The "alerting network" consists of frontal and parietal cortical areas on the right hemisphere. The "orienting network" comprises parts of the superior and inferior parietal cortex, the frontal eye fields as well as subcortical areas such as the superior colliculi, the pulvinar and the nucleus reticularis thalami. The "executive control network" comprises parts of the medial frontal cortex and anterior cingular cortex, lateral prefrontal cortex, and the basal ganglia. A forced-choice reaction time paradigm has been shown to allow dissociation of the contribution of these attentional subsystems (Fan et al., 2001, 2002).

In any study investigating the cooperativeness of the subjects, the choice of the gold standard appears to be of utmost importance. There are several reasons to assume that the Word Memory Test (WMT: Green, 2002) is a reliable gold standard. It has repeatedly demonstrated its validity for diagnosing suboptimal performance (e.g., Gervais et al., 2004; Green et al., 1999; Green et al., 2001; for a review of the test: Green et al., 2002, and Wynkoop & Denney, 2006) and was rated favorably in a comparison of different instruments (Hartman, 2002). Several investigations have shown that malingerers do not tend to feign specific deficits. In contrast, effort scores have repeatedly been found to correlate with performance in a broad range of psychological tests, including reaction time tasks (Green, 2006; Green et al., 2001; Constantinou et al., 2005; Stevens et al., 2007).

The following parameters could be hypothetically used to identify malingered attentional impairment: First, according to the literature, RT will be expected to be much longer in malingerers than in patients with TBI. Also, high intraindividual variability of RTs might indicate unreliable performance in malingerers. Second, response accuracy is expected to be lower in malingerers than in TBI. Third, the use of a graded attention test probing different attentional subsystems could assess whether or not the normal pattern of reaction times across the attentional subtasks is preserved. Presumably, a normal pattern despite prolonged RTs would betray malingerers because they are supposedly unable to fake systematic RT distortions. However, this latter assumption implies that in brain-injured patients one or several of the attentional subsystems are damaged and the overall pattern is distorted. Fourth, uncooperativeness might be indicated by a non-random deviation from the normal ratio of key presses (malingerers might try and hit the wrong keys and the ratio of key presses they produce may consequently deviate from the pattern normally obtained with TBI patients).

Specifically, the following hypotheses were tested:

Malingering may be identified by 1) extremely long reaction times and large intraindividual variability, 2) very low response accuracy, 3) a normal variation of response times with attentional subtests or 4) a deviation from the 1 : 1 ratio of left/right key presses normally produced by authentic responding.

The sample included four groups of subjects: 1) forensic patients with radiologically proven substantial brain injury (STBI), 2) forensic patients with mild traumatic brain Injury (MTBI), 3) forensic patients with no history of traumatic injury (NTBI), and 4) experimental simulators with no history of traumatic brain injury (ES).

Method

Participants

Between March 2004 and June 2005, N = 199 adult patients were referred for an independent medical evaluation (IME) of personal injury claims. The sample was limited to patients who reported cognitive deficits which they attributed to the injury. Most of them were referrals from the German Workers' Compensation Board (49%) or plaintiffs in personal injury claim cases (20%). The category "other" (31%) included claimants with a personal accident insurance and civil servants eligible for accident compensation. For each patient, a detailed description of the accident including technical reports and the initial clinical assessments with cranial CAT scans or NMR findings were available. The examination was performed at least one year after the injury. The experimental simulators (N = 33) were recruited from nurses and interns working at the Psychiatric hospital. However they had not been involved in psychological assessment as part of their education or work. A more detailed sample description can be found in Table 1.

Table 1. Sample Description

	Simulators	No TBI	Mild TBI	Moderate/ Severe TBI
N	33	88	32	79
Age (means ± SD)	31 ± 8	45 ±12	45 ±13	40 ±14
WMT pass/fail	n/a	63 / 25	16 / 16	54 / 25
Gender (male/ female)	20 / 13	50 / 38	23 / 9	57 /22
Education				
Less than 11 years	15	60	23	59
More than 11 years	11	28	9	20
Time passed since accident, median (months)	n/a	22	19	29
Site of brain lesion[1]				
Frontal				44
Parietal				30
Temporal				29
Occipital				8

[1] Multiple entries for subjects with multiple brain lesions were possible. *Abbreviations:* TBI traumatic brain injury, WMT Word Memory Test.

For all participants, a detailed medical history was taken. All except the ES participants underwent a general medical, a neurological, and a psychiatric examination. Based on history and the radiological findings, the cases were divided into three groups: the group NTBI (no brain injury) comprised all those with neither clinical nor radiological signs of brain injury. Clinical signs of brain injury were impairment ("fogginess") or loss of consciousness as well as unsteadiness of gait, vomiting or abnormal neurological findings at the initial clinical assessment. Radiological signs of brain injury were intracranial hemorrhage or brain edema. The category MTBI (mild traumatic brain injury) consisted of cases fulfilling the ACRM (1993) criteria for mild traumatic brain injury. The group STBI (substantial brain injury; comprising moderate and severe TBI) comprised all patients with radiological evidence of traumatic brain injury (hemorrhage, brain swelling, axonal damage). Glasgow Coma Scale ratings are not routinely used in Germany. For all patients with structural brain damage, the site of the lesion was coded according to the radiological expertise included in the patients file. The following lesion types were distinguished: generalized edema, frontal, temporal, parietal, temporal, and occipital lesion. Multiple entries were possible.

Each patient was given a psychological test battery. The battery comprised an assessment of intelligence, verbal and visual memory, and executive functions. In the present study, only the results for the RT test (ANT) and the symptom validity test (WMT) are described. The entire assessment, including the medical examination, was organized as a one-day session. The psychological test battery was administered to each patient individually by a psychologist. All patients had given written informed consent to the anonymous use of his/her data.

The experimental simulators were given the following verbal instruction: "Please imagine that, a couple of months ago, you had suffered a vehicle accident. You are now complaining about persistent cognitive deficits, especially a slowing of your reaction speed. Now you will be examined by a psychologist. You have decided to demonstrate that you are severely impaired and you will deliberately perform not at the best of your abilities. Instead, you try and feign that your reactions are very slow. However, be careful and avoid exaggerating." This scenario was followed by the standard instruction of the ANT. ES participants were only given the ANT and no other instrument.

Instruments

Attention was assessed by the German adaptation of the Attentional Networks Test (Fan et al., 2001, 2002) by Gauggel and Böker (2003). The test runs on a personal computer. On the screen, there is a cross on which the subjects are told to focus their attention. At varying intervals of time, either at the same location as the star, or immediately above or below appears an arrow, pointing to the left or the right. The subject is instructed to press the corresponding response key as soon as the arrow appears. In a randomized order, the arrow is preceded by a cue indicating either that a target will appear soon or where the target will appear. In other trials the central arrow will be flanked by different arrows pointing either into the same direction as the target (congruent flankers) or to the opposite direction (incongruent flankers) or to the central arrow (neutral). Thus, by combining these conditions, the test comprises nine different subtasks.

The computerized Word Memory Test (WMT: Green, 2003) served as the gold standard to detect malingering. The WMT is one of the most prominent SVTs available. On a computer screen, a list of 20 word pairs is presented twice to the patient. After that, the computer displays word pairs containing one of these targets words and another one, which was not shown. The subject is required to recognize the word that was shown previously, in the original learning list. Thus, a total of 40 test items are produced on the Immediate Recognition trial (IR). After a delay of 30 minutes, the same recognition procedure is performed again, using different foil words in the Delayed Recognition trial (DR). The third effort variable is consistency between IR and DR. A number of additional WMT subtests were not included in the present analyses so they need no further description here. A number of simulation studies have shown high sensitivity and specificity with correct classification rates of 99 to 100 percent in studies by Tan et al. (2002), Brockhaus and Merten (2004) and Brockhaus and Peker (2003). The WMT is presented to the patient as a verbal memory test while, in fact, it is designed primarily to measure test motivation. The task is much easier than it appears and makes use of the Floor Effect; it can hardly be failed in a plausible way unless there is a condition of bona-fide dementia, moderate to severe aphasia or other severe authentic neurocognitive impairment. According to the number of correct responses, the test yields measures of effort as continuous variables, which are used to classify the patients on the basis of empirically derived cutoff scores as “fail” (showing insufficient effort) or “pass” (showing sufficient effort).

Statistical design

Hypotheses 1 and 3 (RTs) were combined and tested in one repeated measures ANOVA with reaction time as dependent variable, test condition as within subject factor, group as between-subjects factor and age as a covariate (because response time is known to increase with age). Hypotheses 2 and 4 (response accuracy and key press ratio) were tested by separate one-way ANOVAs with group (NTBI, MTBI, STBI, ES) and effort (fail, pass) as between-subjects factor and age as a covariate. Significance was assumed for $p < .05$. Statistical analyses were performed using SPSS 12 software.

Table 2. Results of the ANOVA with Reaction Time as Dependent Variable

Factor	df	F	eta²
Cue	2, 448	8.45**	0.036
Cue x Group	6, 448	0.78	0.010
Flanker	2, 448	7.11**	0.031
Flanker x Group	6, 448	1.52	0.020
Age	1, 224	12.8**	0.540
Group	3, 224	18.1**	0.194
Effort	1, 224	25.3**	0.102
Effort x Group	2, 224	1.75	0.015

Note: ** $p < .01$

Table 3. Estimated Group Means for Reaction Time

	Mean (ms)	*SD*
No TBI	560.6	133.8
Mild TBI	597.8	135.3
Moderate or severe TBI	598.6	146.5
Simulators	909.9	275.2

Notes: Mean reaction times were calculated for the entire sample (patients failing or passing the effort test). Abbreviation: TBI traumatic brain injury.

Results

Effects of brain lesion and effort on RT

There were significant main effects for the variables group, cue, flanker, age, and a very large effect for effort (Table 2). Post-hoc analyses revealed that the effect for cue was due to a significant decrease in RTs (as compared to the no-cue condition) when a cue indicating the target location was given (orienting effect; $F[1, 224] = 5.03$; $p < .05$). In contrast it was observed that the alerting cue without spatial information failed to reach significance ($F[1, 224] = 1.79$; n.s.). The effect for flanker was due to a significant increase in RTs (as compared to the no-flanker condition) when incongruent flankers appeared ($F[1, 224] = 7.72$; $p < .01$), while congruent flankers did not decrease RT ($F[1, 224] = 0.02$; n.s.). None of the first-order interactions involving group were significant. This means that the groups differed with respect to RT, but not with respect to the increases or decreases of RT across the combinations of cues and flankers. Pairwise comparison of the groups showed that ES had the longest RTs ($p < .001$ for all comparisons) while the groups NTBI, MTBI and STBI did not differ significantly among each other. There was a significant effect for age. Failing the effort test led to an average increase in RT of 200 ms and an average increase of SD of 100 ms (Table 3). However, when a receiver operating characteristics (ROC) curve was calculated, it was found that reaction time did not sufficiently well predict inadequate effort (area under the curve: .77). For example, a cutoff of 700 ms would yield a specificity of .89, but a sensitivity of only .39. In order to exclude that the effect for effort was caused mainly by the ES group, the analysis was repeated with ES participants excluded. Again, a large and significant effect for effort was obtained (F[1,192] = 40.42; p < 0.001).

In order to explore the second part of hypothesis 1, suggesting an abnormal intraindividual variation of RT in malingerers, we used the standard deviation (SD) of RTs calculated for individual subjects as dependent variable. Because standard deviation is expected to covariate with the mean task specific reaction time, for each individual the ratios SD / mean RT for each of the nine reaction time tasks were computed and averaged. Thus, the mean individual ratio of SD / RT was entered as dependent variable in a repeated measures ANOVA with factors and covariates identical to the ones described above. There was a significant effect for effort (F[1, 224] = 44.06; p < .0001), for age (F[1, 224] = 12.08; p < .0001), and diagnosis (F[1, 224] = 12.87; p < .0001). Cue and flanker did not yield significant effects (F[2, 896] = 0.10 and F[2, 896] = 0.20). None of the first order interactions attained significance. Thus, participants who failed the effort test showed an abnormally large variation of their RT, in contrast to patients who had suffered traumatic brain injury and did not fail in the effort test. However, when a ROC curve was calculated for the ratio individual SD / RT and effort (pass vs. fail the WMT) (Figure 2), it was found that the ratio did not provide a reliable classification (area under the curve = .77). For example, a cutoff at 0.26 yielded an estimate for specificity of 0.88 and sensitivity of only 0.48. That means that 88 percent of cases with an SD / RT ratio beyond 0.26 are probably malingering (they fail the effort test), but the test is not sensitive enough because only 48 percent of supposed malingerers (who fail the effort test) were correctly identified.

Effects of brain lesion and effort on response accuracy and response patterns

An ANOVA with the number of correct responses as dependent variable and group and effort as between-subjects factors yielded significant effects for neither group (F[3, 158] = 0.99; n.s.) nor effort (F[1, 158] = 0.20; n.s.).

An ANOVA with the ratio of left to right key presses (response pattern; the ratio within the ANT is normally 1.0) as dependent variable and group and effort as between-subjects factors yielded significant effects for neither group (F[3, 158] = 1.0; n.s.) nor effort (F[1, 158] = 2.0; n.s.)

Effects of brain lesion site on RT

In order to evaluate whether lesions at specific brain areas or brain edema were associated with task-dependent attention deficits, a series of repeated measures ANOVAs was calculated (one for each major brain region), with RT for each attentional task (condition) as dependent variable, condition as within-subjects factor and age as a covariate. Only subjects passing the effort test were included in this analysis. Patients with a brain lesion at the specific area were compared to all those without lesion at this area (i.e. to patients

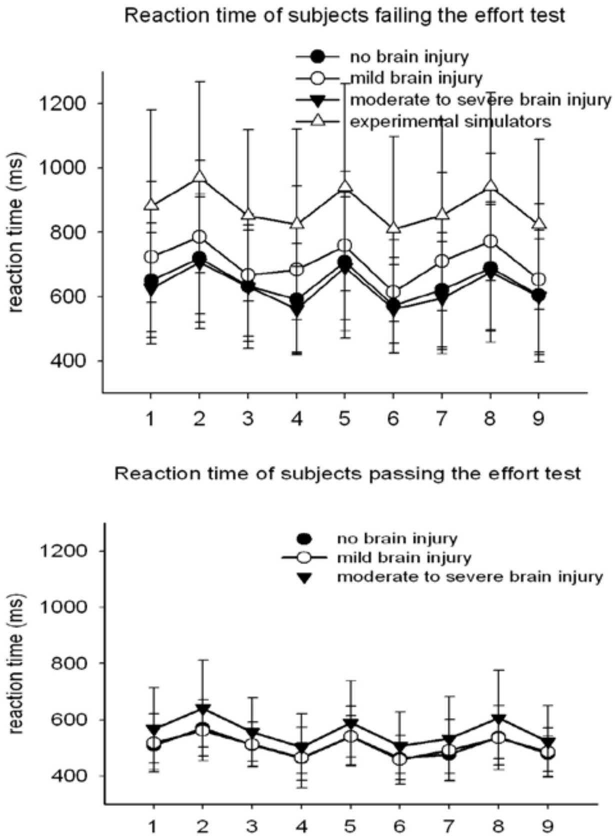

Figure 1. Figure 1a shows mean reaction times (y axis) and standard deviations for patients who passed the effort test. There are separate lines for patients with no brain injury, with mild brain injury and with moderate and severe brain injury. In Figure 1b, mean reaction times and standard deviations are presented for patients failing the effort test and for the experimental simulators. The labels on the x axes correspond to the 9 ANT sub-tasks (1 no cue/congruent flankers, 2 no cue/incongruent flankers, 3 no cue/neutral flankers, 4 alerting cue/congruent flankers, 5 alerting cue/incongruent flankers, 6 alerting cue/neutral flankers, 7 orienting cue/congruent flankers, 8 orienting cue/incongruent flankers, 9 orienting cue/neutral flankers).

with lesions to other brain areas, to patients with mild TBI and to patients without brain injury). According to the small number of cases, this has to be considered a preliminary analysis. No correction for multiple statistical comparisons was applied. Also, left and right side lesions were not differentiated. All ANOVAs reproduced the effects for age, cue and flanker described above. RT was elevated in patients with frontal and parietal lesions as well as patients with brain edema, but not for those with occipital and temporal lesions. The interactions with cue and flanker were significant for patients with frontal lesions, but not for patients with lesions to other brain areas or with brain edema.

Table 4. Response Accuracy

Group	Percentage of correct responses: mean (*SD*)	
	WMT Pass	WMT Fail
Simulators	n/a.	85 (12)
No TBI	93 (10)	93 (34)
Mild TBI	74 (33)	90 (8)
Moderate or severe TBI	83 (26)	75 (33)

Abbreviation: WMT Word Memory Test.

Discussion

The main result of the study is that measuring reaction time with a paradigm addressing attentional subsystems does not appear to be useful to detect malingered deficits of attention. The characteristic pattern of reaction time increases and decreases across the sub-tasks was preserved in most patients with moderate and severe traumatic brain injury as well as in patients who failed the effort test and in experimental simulators. Both patients who failed the effort test and experimental simulators showed an extreme increase of RT across all tasks and, likewise, a large increase of intraindividual RT variability. Although the group means for both RT and variance differed significantly between subjects failing the effort test and those passing it, there was substantial overlap with brain injured patients who passed the WMT. ROC analyses indicated that neither reaction time nor variance did sufficiently well identify malingering.

A detailed analysis of the results showed that not all subjects with substantial brain injury suffer from attention deficits. Only subjects with frontal and parietal lesions as well as brain edema showed increased "pure" reaction times. The task-specific interactions with cues and flankers ("complexity effects") were significant only for patients with frontal lesions (when only subjects passing the effort test were included in the analysis). Deficits in the executive and the orienting networks have been reported by Wang et al. (2005) in a sample of patients with schizophrenia. This is of interest, because, in schizophrenia, a dysfunction of frontal brain areas is assumed. However, to the best of our knowledge, there are presently no studies of attentional subsystems in subjects with brain injury.

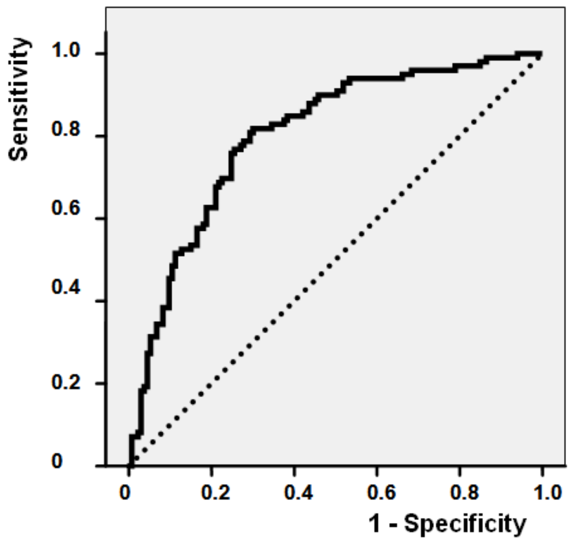

Figure 2. Receiver Operating Characteristics curve for the ratio SD / RT

Table 5. Interaction of Lesion Site and Reaction Time

Lesion	*df*	*F*	eta²
Frontal	1, 130	18.0**	.12
Parietal	1, 130	6.30*	.05
Temporal	1, 130	3.26	.02
Occipital	1, 130	0.06	.00
Edema	1, 130	4.16*	.16

Notes: * *p* < .05; ** *p* < .01

Table 6. Interaction of Lesion Site with Cue and Flanker Tasks

Lesion		Cue		Flanker	
	df	*F*	eta²	*F*	eta²
Frontal	2, 129	6.83*	.09	3.81	.06
Parietal	2, 129	0.63	.01	0.29	.01
Temporal	2, 129	0.88	.01	0.31	.00
Occipital	2, 129	0.14	.00	0.17	.00
Edema	2, 129	1.10	.02	0.20	.00

Notes: * *p* < .05

Thus, while the present results partly confirm the assumptions of Fan et al. (2001, 2002) that the ANT allows to dissociate the function of attentional subsystems, there appears to be limited practical use. Consistent with the theory, all patients without substantial brain injury (but also patients with substantial injury to occipital and temporal areas) as well as experimental simulators and patients who failed the effort test responded to cues and flankers with an adequate increase and decrease of RT (cf. Figure 1). This means that the task-specific "complexity effect" is reliably reproduced in all four groups and that there are no between-groups differences allowing to identify malingerers.

The only potentially useful indicator for malingering may be seen in the fact that both patients failing the effort test and the experimental simulators overshot their goal and demonstrated a retardation of RTs far beyond that of patients with moderate and severe TBI (Figure 1). This confirms earlier findings of Resnick (1988) and of Strauss et al. (1994). In contrast to the findings presented here, Tombaugh et al. (2007) reported that controls, patients with mild TBI and patients with severe TBI differed significantly in their susceptibility to the "complexity effect". However, these authors used forced-choice RT paradigms based on concrete/literal processing and on conceptual (semantic) processing. Thus, the tasks included in their experiment included cognitive processes which go well beyond attentional systems and are thought to be mediated by temporal and parietal brain areas. Also, their research report does not control for the location of the patients' brain lesions.

The data presented here are thus consistent with hypotheses (1) and (3), which predicted that malingerers show prolonged

RTs and preserved patterns of reaction times across attentional sub-tasks. Malingerers produce exaggerated prolongations of RT and are imprecise in doing so with large intraindividual RT variability, while being unable to fake impairment of attentional subsystems. However, RTs of malingerers overlap with RTs found in true brain injury, and, more damaging, impairment of specific attentional subsystems in moderate to severe brain injury is the exception rather than the rule. As for hypotheses (2) and (4), neither response accuracy nor response patterns (like random responding) were significantly different for experimental simulators and patients suspected for malingering as compared to those patients who passed the effort test. The observation that response accuracy is not reduced in subjects with TBI confirms earlier findings by Tombaugh et al. (2007). One might speculate why malingerers do not attempt to hit the wrong key. One possible explanation is that the amount of time is not sufficient to deliberately press the wrong key. Rather, persons who perform suboptimally appear to opt for delaying their reactions.

There are some important limitations of the study. The time which had elapsed since brain injury varied considerably among subjects. Thus, a sample more homogeneous with respect to time from injury may show different effects of substantial brain injury on attentional processes. For most subjects, we had no access to the brain imaging films, but instead had to rely on the description of the lesion site in the radiological reports. Due to the fact that this is a naturalistic study, the subsamples were not matched with respect to age and gender. Also, effects of possibly confounding internal disorders (like thyroid dysfunction or effects of medication) were not systematically controlled for. The gold standard employed to detect malingering in the clinical sample is disguised as a test of verbal memory. Individuals who feign attention deficits may not necessarily fake verbal memory impairment and, consequently, may not be detected by this type of effort test. However, this potential limitation may be of minor importance as is indicated by results of Constantinou et al. (2005) who found that malingerers tend to demonstrate rather non-specific impairment going across a number of different cognitive domains.

In summary, the assessment of attentional subsystems as proposed by the ANT appears not to facilitate the detection of malingered cognitive deficits. Abnormally retarded RTs and an increased variance may raise the suspicion of malingering but RT cannot be considered a measure sufficiently sensitive and specific for malingering identification. It is recommended that, in the context of litigation, measures of reaction times are never taken at face value. In contrast, the validity of individual test scores and test profiles has to be assessed by the employment of well developed symptom validity tests.

Disclosure of interests

The study did not receive third party funding. The second author has participated in the development of the German version of the Word Memory Test, with no financial benefit. He has also arranged German adaptations of other symptom validity tests.

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