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Feigning Cognitive Symptoms after TBI: Validation of the TOMM and DCT and the Influence of Coaching

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Abstract

The awareness about the issue of patients feigning their cognitive deficits after traumatic brain injury (TBI) is increasing in neuropsychological assessment. Therefore, tests developed to detect simulated cognitive impairments need to be validated for their integration in standardized assessment procedures. In our simulation study, 114 students from the University of Groningen were randomly assigned to a naïve or coached TBI simulation group and archival data of 43 healthy controls and 22 genuine patients with TBI were integrated. All participants were assessed with a neuropsychological battery and group outcomes were compared in order to analyze the Test of Memory Malingering (TOMM) (Tombaugh, 1996) and Dot Counting Test (DCT) (Boone, Lu, & Herzberg, 2002) regarding 1) their validity in detecting individuals feigning their symptoms and 2) the influence of coaching on the discriminatory value of the tests. Large effect sizes and satisfying Areas Under the Curve of Receiver Operating Characteristic analyses were found and the sensitivity and specificity of the tests were analyzed with regard to different cut-off scores. As a result, both the TOMM and DCT proved to be efficient in their classification abilities and were unaffected by coaching in the TBI context. Following these promising results, future research should examine the utility of the tests for other neurological conditions with varying degrees of severity in order to be able to integrate them in a standardized test battery to assess feigning. Additionally, the DCT needs to be further studied regarding its cut-off score for patients with head injuries.

Keywords: TBI, feigning, coaching, TOMM, DCT

Feigning Cognitive Symptoms after TBI: Validation of the TOMM and DCT and the Impact of Coaching

"Why don't you just feign a headache?" – Probably every one of us has heard this presumably well-intentioned advice once or even came up with the idea him - or herself, when we found ourselves in situations where being sick or otherwise impaired led to better outcomes than honestly facing critical situations.

The problem of feigning symptoms, either physical, cognitive, or psychiatric, is not a new phenomenon (Stone & Boone, 2007). It is observable in different areas, but appears to be especially prominent in two contexts (Rogers & Bender, 2003). One of them comprises the juridical context, where the prevalence of intentional feigning is almost 30% (Mittenberg, Patton, Canyock, & Condit, 2002). The other domain encompasses the clinical population, where the frequency of feigning especially cognitive impairments might be even higher than feigned symptoms observed in forensic settings (Kosheleva, Spadoni, Strigo, Buchsbaum, & Simmons, 2016). This makes focusing on the detection of simulated cognitive symptoms in the clinical context especially important.

Several motivators lie behind the decision to feign neurological impairments. They range from more simple ones, including not wanting to go to work for a day or two, to monetary compensations, an earlier retirement, or other supplements which are intended to correlate with the pain and suffering, degree of impairment and future repercussions triggered by the injuries (Greenberg, 2003). Additionally, other external incentives like the avoidance of responsibility or threat of punishment can play a role (Teichner & Wagner, 2004). The detection of dishonest patients is highly relevant since major costs are involved with feigning. As described by Tucha, Fuermaier, Koerts, Groen, and Thome (2015), negative consequences of undetected feigning

include costs for the society with regard to assessment, drug abuse and an unjustified allocation of medical treatments, since resources needed by actual sufferers are distributed to simulators. Even though this study focused on feigning ADHD, those negative outcomes can be expected in the context of brain damages as well.

One of the most common forms of brain damage (Hoover, Zottoli, & Grose-Fifer, 2014) and the leading cause of disability in children and adults is traumatic brain injury (TBI) (Wang & Liu, 2016). Even after mild TBI, patients report neurocognitive impairments, whereby memory problems, attentional and concentration difficulties, learning impairments and slowed responses belong to the most common symptoms (Odgen, 2005), amongst others (Chiaravalloti, Sandry, Moore, & DeLuca, 2016). As one might suspect, the combination of TBI and feigning cognitive disabilities is quite prominent, resulting in the awareness of the need to include the assessment of fabricated cognitive impairments as an integral part in neuropsychological evaluations. For example, Slick, Hopp, Strauss, Hunter, and Pinch (1994) found out that TBI feigners performed worse on a forced choice five-digit memory test about numbers compared to controls and patients suffering from TBI, regardless of item difficulty or short retention intervals.

Especially feigning neurological symptoms after TBI seems advantageous for some individuals, because of its high prevalence and the common symptoms. Indeed, one probably has a concept about TBI in mind regarding the presence and extent of certain symptoms and may therefore feel more confident to simulate accordingly compared to other neurological conditions. For example, most people have experienced concentration problems once before, so forgetting information might appear easy to exaggerate in so far that the fabricated condition may present as an authentic memory impairment.

Despite the awareness about feigning in the neuropsychological context being on the increase, neuropsychologists are still faced with issues regarding its detection. Besides the consideration of medical records and observed behavior (Mittenberg, Patton, Canyock, & Condit, 2002), several measures have been developed to assess non-credible effort in individuals. For example, self-report measures, like the MMPI-2 (Butcher, Dahlstrom, Graham, Tellegen, & Kaemmer, 1989), usually include several validity indices. Also, cognitive performance can be assessed using the WASI-II (Wechsler, 2011), where intellectual abilities are tested without response bias. Additionally, performance validity, which is the degree to which test outcomes represent a patient's true ability (Grossi, Green, Einzig, & Belfi, 2017), can be assessed in this context, where the Test of Memory Malingering (TOMM) by Tombaugh (1996) and the Dot Counting Test (DCT) by Boone, Lu, and Herzberg (2002) constitute two of those measures.

Even though various tests have been developed for the detection of feigned cognitive impairments, fabricated symptoms of mild TBI can be especially hard to detect, since even genuine symptoms often remain unrecognized in neuropsychological testing (Odgen, 2005). At least two problems can be observed in the assessment of feigned TBI symptoms after having an accident. Firstly, even though there has been an increase in the application of assessment tools to identify individuals feigning cognitive impairments, there is no consensus yet about which measures to use in order to validly and reliably discriminate simulators from patients with TBI in a standardized manner (Spadoni, Kosheleva, Buchsbaum, & Simmons, 2015). Some measures are also susceptible to both low effort and the intentional exaggeration of impairments (Vagnini, Berry, Clark, & Jiang, 2008), which makes it difficult to investigate the cause of the conspicuous results. Secondly, it is not yet clear how and to what extent symptom validity tests are affected in their ability to discriminate simulators from genuine patients with TBI when individuals who

decided to feign their symptoms obtained information about cognitive impairments due to TBI prior to the neuropsychological assessment (Jelicic, Ceunen, Peters, & Merckelbach, 2011).

Regarding the first problem, a promising assessment tool in the context of feigned TBI involves the TOMM (Tombaugh, 1996). As one of the most widely applied and researched tests of feigned performance (Jelicic, Ceunen, Peters, & Merckelbach, 2011), the TOMM is a symptom validity instrument in the format of a forced choice recognition test (Rivera et al., 2015) and can be performed in pencil and paper or computerized form (Vanderslice-Barr, Miele, & Jardin, 2011). Especially in the fabrication of neurological symptoms after mild TBI, the TOMM is frequently implemented, since memory abilities measured by the TOMM are usually preserved in patients of mild TBI (Jelicic, Ceunen, Peters, & Merckelbach, 2011; Powell, Gfeller, Hendricks, & Sharland, 2004; Green, 2008). Therefore, the test serves as a promising instrument to be included in a standardized neuropsychological assessment setting of feigned cognitive impairments.

Also appealing is that the test seems to be unaffected by distractions; Batt, Shores, and Chekaluk (2008) compared TBI patients and healthy individuals feigning cognitive impairments after TBI. In their simulation study, an auditory distraction task was applied where participants had to “add three” to an orally presented number and state the answer aloud during the learning phases of the TOMM. The task did not influence the participants’ performance, thus highlighting the TOMM being less a measure of cognitive “ability” than of “effort” and further underlining its promising task as an exclusive measure of cognitive effort. However, it has been claimed that the TOMM might not be suitable for malingering assessments when patients suffer from moderate to severe TBI. Additionally, there is no consensus about the application of the TOMM with regard to other neurological conditions of several degrees (Green, 2011; Rivera et al., 2015).

Another measure applied in detecting individuals who feign their cognitive impairments is the Dot Counting Test (Boone, Lu, & Herzberg, 2002). Not only appealing because of its short duration and non-verbal nature, but also because of its ability to measure functions that are preserved in patients, the DCT might be a valuable candidate for the inclusion in a standardized malingering assessment procedure. For example, several studies have discovered that the performance on the DCT is preserved in patients with memory deficits (Arnett & Franzen, 1997; Pachana, Boone, & Ganzell, 1998). With regard to feigning cognitive impairments, where participants were told to imagine a scenario and afterwards were instructed to feign head injury symptoms with and without further information, the simulators scored higher compared to severely head-injured patients following TBI and healthy individuals (Rose, Hall, & Szalda-Petree, 1998). This is underlined by a simulation study conducted by Binks, Gouvier, and Walters (1997), where patients suffering from different neurological conditions (including TBI) were compared to healthy controls, naïvely feigning and instructed feigning individuals. The results showed atypical differences in response times; especially the sum of incorrect responses was an important discriminator between study groups. This is a promising outcome, since errors are quickly determined and compared in the DCT.

Also, there is good indication that the DCT is a valid measure for performance validity. In a control study on healthy Spanish participants conducted by Robles, Lopez, Salazar, Boone and Glaser (2015) the DCT proved as a successful performance validity measure, independent of education years (zero to ten), language and cultural factors. The DCT might therefore be a promising malingering measure because of its robustness against different factors. Other investigators, however, are less convinced about the usefulness of the DCT; a few studies report lower levels of utility. For example, Greifenstein, Baker and Gola (1994) found no differences in

outcomes between instructed simulators and patients with TBI. Nevertheless, it seems that TBI simulators usually overestimate the time needed by actual sufferers to respond (Willison & Tombaugh, 2006). Overall, the DCT appears to be able to differentiate between genuine patients and those who feign their impairments, therefore its usefulness needs to be further established in order to include the DCT in a standardized neuropsychological malingering assessment.

With regard to the second problem, the degree to which individuals attempt to feign in assessment situations might vary regarding the content and intensity of training to fabricate their symptoms. Where some individuals appear to be not prepared at all, others might research assessment tools and teach themselves how to perform convincingly. This probably depends on potential compensations for acquired brain injuries (DiCarlo, Gfeller, & Oliveri, 2000). There even exists converging evidence that clients are advised by attorneys on how to adjust their response behavior on neuropsychological tests (Less-Haley, 1997) in order to either decrease negative court decisions or increase settlements like monetary compensations. Evidence suggests that training indeed helps self-declared patients to feign cognitive impairments more convincingly compared to their untrained counterparts in a category test (DiCarlo, Gfeller, & Oliveri, 2000), for example the Booklet Category Test (Defilippis & McCampbell, 1979) consisting of seven subtests of different item difficulty and depicting numerical and geometric shapes. However, it seems that instructions on how to feign need to have a certain degree of detail to be effective on simulation performance testing (Gunstad & Suhr, 2001).

It is important to identify measures that are vulnerable to pre-assessment training as well as to find those assessment tools that are robust and transpire as valid measures in symptom validity testing in the TBI context. In several studies, the TOMM was reported to be a useful tool in detecting individuals feigning (Davis, Wall, & Whitney, 2012; Powell, 2004), even when

different forms of training were performed beforehand (Jelicic, Keunen, Peters, & Merckelbach, 2011). Also, when TBI impairments were simulated, the TOMM indicated significant performance differences between individuals informed about either useful test strategies or cognitive symptoms of mild TBI and healthy controls (Powell, Gfeller, Hendricks, & Sharland, 2004). Concerning the DCT, Martin, Hayes, and Gouvier (1996) reported that feigners of a post-concussive syndrome, trained or un-trained, performed worse than patients or controls. However, research concerning the DCT in the context of trained simulation of TBI is scarce which indicates that further research with the DCT needs to be conducted. Pointing to the TOMM, despite its promising results, assessment outcomes regarding feigned TBI are to be replicated and validated in order to draw conclusions and to officially integrate this measure in neuropsychological simulation testing.

The purpose of our clinically relevant study is therefore two-fold. On the one hand, we aim to validate the ability of selected neuropsychological tests to detect feigned cognitive impairments after TBI. In order to achieve this goal, we compared test outcomes of people who were instructed to feign their symptoms of TBI and a control group with data from patients actually suffering from brain damage. The assessment battery used in this study consists of the Test of Memory Malingering (TOMM) Trial 1, Trial 2 and the Retention and the Dot-Counting Test (DCT).

On the other hand, we want to find out whether training (coaching) has an influence on the afore-mentioned ability of those tests to detect feigning. Participants were therefore randomly assigned to either receive information on how to feign or to be withheld of that information, compiling the *TBI coached* and *TBI naïve* group, respectively. Each group was then compared to people who are suffering from cognitive dysfunction following TBI (called *patients* as a group in

our study) and the difference between the group comparisons was finally compared. To assure that the performance of all groups (*TBI naïve*, *TBI coached* and *patients*) was deviating from the cognitive abilities of healthy individuals, each group was compared separately to a control group, named *controls*.

Based on the aims of our study, two hypotheses emerge. Firstly, we expect a large difference in test outcomes between people who feign their symptoms and those who are truly suffering from brain damage after TBI, indicating the valid use of the TOMM and DCT. Secondly, we assume that coaching influences the ability to detect individuals who are simulating cognitive impairments after TBI using the TOMM and DCT; the difference between *TBI naïve* and *patients* is expected to be larger than the difference between *TBI coached* and *patients* on each of the tests.

Methods

Ethics statement

The Ethics Committee of the University of Groningen ("Ethische Commissie van het Heymans Instituut voor Psychologisch Onderzoek") approved the study before its implementation. All participants signed a written informed consent prior to the start of the study.

Participants and Design

In our between-subjects design, a total of 130 people were recruited for our experiment. Of those, 16 participants (*TBI naïve* = 5, *TBI coached* = 11) failed to achieve a score of 7 or higher on the Digit Span and therefore needed to be excluded, since a score below the cut-off on this test served as an indicator for poor cognitive effort and results obtained in the further assessment procedure from those participants could have been biased for that reason. The resulting number of recruited participants and archival data, as well as the information about age,

gender, and IQ can be found in Table 1. All recruited participants were international first year psychology students from the University of Groningen and most of them obtained the highest school degree from Germany (*N* = 78). The predominant first language was German (*N* = 65), followed by Dutch (*N* = 20), and other languages (*N* = 29). The majority of the participants had not completed a vocational training before studying (*N* = 101). Of the recruited participants, 10.5% were suffering either today or in the past from neurological conditions, predominantly ADHD and depression, but dyslexia, restless legs syndrome, anxiety, OCD and other conditions were also individually reported. Furthermore, 5.3 % were on medication due to their neurological conditions.

All participants were randomly assigned to one of two conditions, namely *TBI naïve* (*N* = 61) and *TBI coached* (*N* = 53). The students were compensated for their participation with SONA credits, which are part of the internal research system of the University of Groningen and need to be collected by first year students in order to complete their propaedeutic degree.

The *controls* group was compiled of archival data from the Clinical and Developmental Neuropsychology Department of the University of Groningen, also mainly consisting of international first year psychology students. They were predominantly German by their first language (*N* = 40), followed by Dutch (*N* = 26) and other languages (*N* = 7). Of the *controls*, 17.8% were suffering from neurological conditions, either at the time of assessment or in the past, where ADHD was mostly reported. Other conditions included dyslexia, PDD NOS, ADD, bipolar disorder, depression, autism, and panic attacks. Any use of medication has not been assessed. The data were collected between 2016 and 2017.

Finally, archival data of 22 *patients* from Germany suffering from TBI were included in our study. The highest German school degree was predominantly achieved (*N* = 20) and the

native language was German for all participants. Of the *patients*, 86% received stationary treatment, whereas 14% received part time stationary treatment. The number of weeks hospitalized ranged from 0 to 100 weeks. With regard to medical treatment, 59% were on medication, primarily on pain reducer (e.g. Ibuprofen). As for the *controls*, the data were collected between 2016 and 2017.

Table 1

Descriptives of recruited participants and archival data

Group	*N*	Male	Age range	*M* age	*SD* age	IQ range	*M* IQ	*SD* IQ
Recruited participants	114	45	18 to 34	20.76	2.68	83 to 112	96.56	7.17
Controls	73	23	17 to 25	19.95	1.54	97 to 124	110.50	12.09
Patients	22	16	17 to 69	35.00	14.29	81 to 118	96.90	9.21

Note. Recruited participants constitute the *TBI naïve* and *TBI coached* group.

Materials

The materials utilized in the experiment included an anamnesis document, a comprehensive battery of neuropsychological tests, simulation and coaching instructions, one question about the personal impression of the purpose of the tests, a self-rating scale, and further equipment for the appropriate implementation of the tests, namely a stopwatch and a laptop.

Anamnesis document. In the beginning of the assessment, participants were asked about their demographic information.

Digit Span Test. The Digit Span Test forward and backward is the most heavily researched assessment tool (Glassmire, Toofanian Ross, Kinney, & Nitch, 2016) of the WAIS-IV (Wechsler, 2008). Initially developed to assess working memory, we included the test in our study as a measure of cognitive effort, since several studies investigated its utility as a malingering detection method, where participants were instructed to perform below their cognitive potential. For example, Iverson and Franzen (1994) conducted a mixed-simulator / clinical-specificity design study where the DST successfully differentiated between TBI patients and college students who were instructed to fake memory impairments. Additionally, the test is a measure of attention and memory (Heinly, Greve, Bianchini, Love, & Brennan, 2005), which is usually preserved even in persons with brain dysfunction (Iverson & Franzen, 1996). Hence, utilizing the DST as a measure for cognitive effort seemed reasonable since test outcomes should be equal between all groups.

The test itself consists of number sequences, which are orally introduced forwards and backwards to the participant with a pause of one second between each digit. The participant's task is to repeat the number sequence correctly in the presented order. Number sequences from two to eight digits are firstly introduced forwards. As soon as the participant incorrectly repeats two number sequences of one item (each item consists of two number sequences of the same length), the forward assessment stops and the introduction of the backward number sequences starts. Here, the participant is instructed to repeat the number sequences from two to nine digits backwards. As soon as an item of two number sequences is repeated incorrectly, the assessment is over. From this, a scaled digit span score using a norm table can be calculated as well as a reliable digit span score (RDS). A RDS of 6 or below is associated with a false-positive error rate

of 10% or less in clinical, forensic and healthy samples (Greve et al., 2007). Scores in this range therefore point to poor effort (or negative response bias).

MWT-B. The Mehrfach Wortschatz Intelligenztest B (Lehrl, 1999) is a German measure to assess general intelligence verbally and can be applied between 20-65 years of age. The test is quickly conducted, as it takes only four to six minutes. Participants are presented with 37 rows of five words, where each row contains a maximum of one actually existing word that should be marked, whereas the other remaining words are neologisms. In case of doubt, patients are instructed to avoid guessing, but are allowed to follow their gut feeling. If they do not know the answer at all, the row needs to be left out. Each correctly marked word, as long as only one word was marked per row, counting as one point, is added up to a sum score, which leads to an IQ score using a standard table.

Simulation. A scenario about the participant involved in a car accident has been invented (see Appendix A), where he or she was instructed to assume the role described. In the presented case, the participant suffered a mild concussion without any consequential neurological damages. In the court room, however, the participant sees a chance to receive more money and other supplements if neurological impairments were found. Therefore, he or she decides to fake cognitive symptoms in a psychological assessment setting. Participants were now instructed to feign cognitive dysfunction after TBI. As soon as the situation was orally presented by the experimenter, participants were asked to read through the scenario and tell in their own words what they just read. The *TBI naive* were given no further instructions, whereas the *TBI coached* received more information as described in the following.

Coaching. The *TBI coached* were provided with additional information in order to feign their cognitive symptoms after TBI more believably (see Appendix B). Information about 1)

common problems following brain injury (slowed down thinking and responses, attentional and concentration difficulties, memory problems, learning impairments), and 2) details to be aware of during the assessment, including not feigning too obviously and keeping in mind that measures assessing feigning might be at least once implemented, were handed in paper form.

Incentive to simulate TBI. After the participants were told about the simulation scenario, the chance of winning a tablet PC was introduced as a motivator to feign cognitive symptoms appropriately. It was explained that the tablet PC will be randomly allocated to one of the participants who feigned their cognitive impairments most convincingly (see Appendix A and B).

To assess the difference between those who feign their cognitive symptoms with genuine patients, the TOMM and the DCT were performed.

Test of Memory Malingering. The TOMM is a forced choice visual recognition test developed to detect feigned memory impairments, consisting of three parts: Trial 1, Trial 2 and Retention. Both Trial 1 and Trial 2 consist of two parts; a learning trial and a retention trial. In the learning trial, the same 50 line drawings depicting common objects, one per page of the booklet, are presented to the participant for three seconds, one after the other. The participant is told to remember the images presented, but names of objects do not need to be memorized. Subsequently, in the second part, two objects per page are presented to the participant, where one depicts an object contained in the previous pages, whereas the other image illustrates a new object. Again, 50 pages are presented. The participant is now instructed to point at the picture that was seen before. Feedback is immediately given after each time the participant points at one of the images (“right” or “wrong”). In case the participant does not remember or does not

respond after ten seconds, he or she is reminded that an answer needs to be given and in case of doubt the participant is free to guess.

The Retention is implemented 20 minutes after Trial 2 ends. It only includes the retention part, namely the 50 pages depicting both the previously presented images from Trial 1 and Trial 2 and another new image. The instructions are the same as for part two of Trial 1 and Trial 2; the participant has to point at the object seen before and feedback is immediately provided. Record forms are part of each trial and are used for recording and scoring outcomes. Results of a cut-off score < 45 in Trial 2 or the Retention point to suspect effort.

Dot Counting Test. The DCT is a measure of effort put into cognitive tasks, whether intentional or unintentional, usually taking less than 10 minutes. The first six cards show randomly arranged dots, while the last six cards depict dots arranged in a clustered fashion, leading to a total of 12 cards. Participants are instructed to count the dots and give their answer as quickly as possible. Time taken for each card is measured with a stop watch. Also, the examiner counts and records the total amount of errors. The mean time needed to count the dots of the first six and last six cards are calculated, yielding the Mean UG and Mean G, respectively. These two variables are added to the total of errors resulting in an E-Score, which has a cut-off of 20 as a valid score for head injury assessments.

Question about tests. Patients were orally asked about their opinion about the purpose of the tests with regard to detect feigning (“Do you think one or several of the tests applied were specifically designed to detect feigned cognitive dysfunction? If so, which ones?”).

Self-assessment of simulation. A written self-assessment was handed to the patients, where they had to indicate, on a 5-point Likert scale ranging from strongly disagree (1) to strongly agree (5), whether they 1) tried their very best to simulate cognitive dysfunction, 2)

managed to realize their strategies, and 3) managed to simulate cognitive dysfunction convincingly. Additionally, they had to name their strategies used to simulate cognitive dysfunction and which symptoms they actually feigned. Participants could choose one or more answer possibilities (slowed down responses, inattention, memory problems, and disorganization) and could also describe other strategies they had used.

Archival data. Archival data of the Clinical and Developmental Neuropsychology department have been used and made up the *controls* and the *patients* in our experiment. Thus, the collection of data of both groups was not part of the presented study.

Procedure

As the participants entered the laboratory, information about the structure and duration of the study was provided. Afterwards, the informed consent was signed. For the preliminary assessment, an anamnesis was conducted. In the following, The Digit Span task was applied. In case the participants were German by their first language, the MWT-B was implemented. Afterwards, the actual neuropsychological assessment of feigned TBI symptoms started.

Depending on the prior assignment, people were either introduced to a simulation situation with (*TBI coached*) or without (*TBI naïve*) further instructions on how to feign cognitive dysfunction after TBI. As soon as the *TBI naive* understood the simulation situation and their task sufficiently, the assessment of feigned symptoms began. The *TBI coached* were additionally asked to read instructions on how to feign cognitive impairments following TBI and a few details to be aware of. After the *TBI coached* orally repeated the coaching information and internalized them sufficiently, the subsequent assessment followed the same structure as for the *TBI naïve*.

The assessment of feigning started with Trial 1and Trial 2 of the TOMM. Following Trial 2, the DCT was implemented. Other tests were utilized subsequently to fill the 20 minutes needed before continuing with the TOMM Retention. Between each of the tests the participants were reminded to remain in their simulation condition. In case of questions during the assessment, participants were told to ask them when the experiment ended so that the simulation procedure was not disturbed.

After the simulation testing, participants had to tell if they had the impression that one or several of the tests were specifically designed to detect feigned cognitive symptoms, and if so, they were asked to indicate orally for which test(s) this might be the case. Ensuing this, they filled out a self-assessment questionnaire about their performance and strategies. Finally, participants were debriefed about the purpose of the study and were welcomed to ask any (previous) questions. Results of the two simulation conditions were compared to archival data of the *control*s and *patients*.

Statistical Analysis

Groups. In our group-comparison study, four groups were compared to each other in previously determined combinations. Those were comprised of two simulation groups, namely *TBI naïve* and *TBI coached*, the *patients* suffering from TBI and healthy *controls* doing their best on the tests.

Check for statistical assumptions

The Statistical Package for the Social Sciences Version 23 was utilized to carry out the statistical analysis. The assumptions of 1) normality, 2) homoscedasticity, and 3) independence were checked. Non-parametric tests were applied since the assumption of normality was violated as explained in the following.

Normality. Regarding the TOMM, both simulation groups followed a non-normal distribution in at least one of the three subtests indicated statistically by the Shapiro-Wilk normality test and visually by different plots. Skewness and kurtosis were deviating from the normal distribution in the *controls* and simulation groups observable in histograms and normal Q-Q plots. The statistical test indicated normality for the *patients*, but again the histogram distributions for all subtests were highly skewed to the left, therefore normality was violated. Concerning the DCT, the Shapiro-Wilk test revealed that normality was given among *controls* and simulators. However, this was not confirmed by histograms which illustrated that all distributions were strongly skewed to the right. The *patients* results visually and statistically violated the normality assumptions. Box-plots displayed several outliers for the *TBI naïve* and *TBI coached*, but their exclusion did not result in normal distributions, therefore all outliers were left in the sample.

Homoscedasticity. Equal variance across all outcome values needs to be given to perform a parametric test. Since normality is already violated and, for that reason, non-parametric tests will be applied in the statistical analysis, further checking for homoscedasticity remained unnecessary.

Independence. Participants were randomly sampled for each group, therefore the independence of samples was granted.

Statistical tests. The analyses of group means were performed using the non-parametric Kruskal-Wallis H test and the Mann-Whitney U test. According to previously determined group combinations, effect sizes (Cohen's d) of the groups were compared and described among TOMM and DCT results. Also, the Receiver Operating Characteristic (ROC) analysis with their Area Under the Curve (AUC) was applied.

Validity testing (hypothesis 1). Before the main group comparison started, it was analyzed whether at least one group differed significantly from the other groups using the Kruskal-Wallis H test. Afterwards, the Mann-Whitney U test was implemented to determine which groups specifically differed significantly from each other. At first, *TBI naïve*, *TBI coached* and the *patients* were compared against the *controls*. Then, effect sizes were used to detect the magnitude of group differences between *patients* vs *TBI coached* and *patients* vs *TBI naïve*.

Effect of coaching (hypothesis 2). Statistical results of the first hypothesis were compared to each other and descriptively analyzed. The Cohen's d values of *patients* vs *TBI naïve* and *patients* vs *TBI coached* were compared to each other. Also, the sensitivity and specificity of the discriminatory variables of each test were compared with regard to different cut-off scores. To analyze the sensitivity and specificity of each test, the ROC analysis with the AUC was run and cut-off scores were compared regarding their sensitivity and specificity, also relating to the first hypothesis.

Results

Two hypotheses were tested in the present study. Firstly, the assumption was investigated that the TOMM and DCT are valid measurements in the discrimination of simulators from genuine patients suffering from brain damage after TBI, indicated by large differences in test outcomes between simulators and patients. Secondly, this discriminatory ability of the DCT and TOMM in the assessment of cognitive impairments after TBI was assumed to be affected by coaching, where unprepared simulators were expected to be easier identified by the tests than coached simulators.

Hypothesis 1. From all groups, the mean and standard deviation for each subtest of the TOMM and measured values of the DCT were calculated and are depicted in Table 2 and Table 3, respectively. For the analysis, an alpha level of $\alpha = .05$ was adopted.

Table 2

Means and standard deviations of the TOMM across all four groups and subtests

	Trial 1		Trial 2		Retention	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*
TBI naïve	27.54	8.20	27.84	8.32	26.95	8.58
TBI coached	29.98	6.20	31.89	7.99	30.13	8.45
Patients	46.24	4.05	49.52	1.44	49.45	1.76
Controls	48.37	1.95	50	0	49.97	0.16

Note. TBI = Traumatic brain injury. TOMM = Test of Memory Malingering (Tombaugh, 1996). *TBI naïve* = recruited participants instructed to feign cognitive symptoms after TBI without further instructions. *TBI coached* = recruited participants instructed to feign cognitive symptoms after TBI with further instructions provided. *Patients* = genuine patients suffering from cognitive impairments after TBI. *Controls* = healthy individuals instructed to do their best on the tests.

Table 3

Means and standard deviations of the DCT across all groups and measured values

	Sum of errors		Mean UG (1-6)		Mean G (7-12)		E-score	
Group	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
TBI naïve	3.87	2.64	9.15	4.59	7.42	4.62	20.51	9.48
TBI coached	2.62	1.95	9.66	2.85	6.47	2.85	18.74	6.37
Patients	1.57	1.43	7.11	2.43	2.91	1.64	11.04	4.24
Controls	1.15	1.28	5.92	1.40	2.54	1.02	9.63	2.88

Note. TBI = Traumatic brain injury. DCT = Dot Counting Test (Boone, Lu, & Herzberg, 2002). *TBI naïve* = recruited participants instructed to feign cognitive symptoms after TBI without further instructions. *TBI coached* = recruited participants instructed to feign cognitive symptoms after TBI with further instructions provided. *Patients* = genuine patients suffering from cognitive impairments after TBI. *Controls* = healthy individuals instructed to do their best on the tests.

At first, the Kruskal-Wallis H test was applied. Concerning the TOMM, the test indicated that at least one group differed significantly from the other groups in Trial 1 (χ^2 = 145. 86, *df* = 3, $p < .001$), Trial 2 (χ^2 = 164.74, *df* = 3, $p < .001$), and the Retention trial (χ^2 = 163.90, *df* = 3, $p < .001$). Also, for the DCT at least one group differed from the others on all measured values, namely the Sum of Errors (χ^2 = 58.10, *df* = 3, $p < .001$), the mean reaction time on card 1-6 called Mean UG (χ^2 = 60.58, *df* = 3, $p < .001$), the mean reaction time on card 7-12 called Mean G (χ^2 = 100.98, *df* = 3, $p < .001$), and the E-score (χ^2 = 104.84, *df* = 3, $p < .001$).

To find out which groups specifically differed from each other, the Mann-Whitney U test was performed. As a first step, the *TBI naïve*, *TBI coached* and *patients* were each compared to

the *control*s. The difference between *TBI naïve* vs *controls* was significant for Trial 1, Trial 2 and Retention of the TOMM (z = -9.64, p <.001; z = -10.73, p < .001; z = -10.64, p < .001) and Sum of Errors, Mean UG, Mean G, and E-score of the DCT (z = -7.17, p < .001; z = -5.85, p < .001; z = -7.91, p < .001; z = -8.63, p < .001). Results were similar for the *TBI coached* vs *controls* comparison for the TOMM (z = -9.43, p < .001; z = -10.51, p < .001; z = -10.54, p < .001) and DCT (z = -4.61, p < .001; z = -7.11, p < .001; z = -8.23, p < .001; z = -7.92, p < .001), pointing to significant differences in test outcomes of both tests between the groups.

In the comparison of *controls* vs *patients*, the TOMM still indicated significant differences on Trial 1 (z = -2.27, p = .022) and Trial 2 (z = -3.26, p = .01), but not on the Retention (z = -1.46, p = .059). Concerning the DCT, all differences were non-significant, more precisely concerning the Sum of Errors (z = -1.31, p = .19), the Mean UG (z = -1.95, p = .051), Mean G (z = -.46, p = .65) and the E-score (z = -1.63, p = .10).

The main analysis for hypothesis 1 was manifested in the comparison of the difference between *patients* and simulator comparisons. The Mann-Whitney U test highlighted significant differences comparing outcomes of *patients* and the two simulator groups on the TOMM and DCT. Outcomes of the Mann-Whitney U analysis and effect sizes are depicted in Table 4 for the TOMM and in Table 5 for the DCT.

Table 4

Mann-Whitney U test z-values and significance outcomes and effect sizes (Cohen's d) of the TOMM

	Patients vs TBI naïve			Patients vs TBI coached		
	z	*p*	*d*	*z*	*p*	*d*
Trial 1	-6.35	<.001	2.89	-6.32	<.001	3.12
Trial 2	-6.71	<.001	3.63	-6.54	<.001	3.07
Retention	-6.59	<.001	3.63	-6.52	<.001	3.17

Note. TBI = Traumatic brain injury. TOMM = Test of Memory Malingering (Tombaugh, 1996). *TBI naïve* = recruited participants instructed to feign cognitive symptoms after TBI without further instructions. *TBI coached* = recruited participants instructed to feign cognitive symptoms after TBI with further instructions provided. *Patients* = genuine patients suffering from cognitive impairments after TBI.

Table 5

Mann-Whitney U test z-values and significance outcomes and effect sizes (Cohen's d) of the DCT

	Patients vs TBI naïve			Patients vs TBI coached		
	z	*p*	*d*	*z*	*p*	*d*
Sum of Errors	-3.96	<.001	1.08	-2.13	.033	.61
Mean UG (1-6)	-2.04	<.001	0.56	-3.06	.002	.96
Mean G (7-12)	-5.02	<.001	1.30	-4.95	<.001	1.53
E-score	-5.01	<.001	1.29	-4.61	<.001	1.42

Note. TBI = Traumatic brain injury. DCT = Dot Counting Test (Boone, Lu, & Herzberg, 2002). *TBI naïve* = recruited participants instructed to feign cognitive symptoms after TBI without further instructions. *TBI coached* = recruited participants instructed to feign cognitive symptoms after TBI with further instructions provided. *Patients* = genuine patients suffering from cognitive impairments after TBI.

With regard to the TOMM, both the *patients* vs *TBI naïve* as the *patients* vs *TBI coached* comparison indicated similar negatively valued z-scores and very low p-values as well as very high Cohen's d-values using Rogers's (2008) categorization for Cohen's d. For the DCT, z-scores were smaller and slightly more diverse for the *patients* vs *TBI coached* comparison than for the more equal values obtained for *patients* vs *TBI naive*, but differences were still significant. Even though the Cohen's d values differed clearly from those measured for the TOMM, they still indicated a moderate to very large effect.

Hypothesis 2. As depicted in Table 4, the effect size was larger for Trial 1 and Retention in the *patients* vs *TBI naïve* comparison compared to *patients* vs *TBI coached*, whilst a larger effect size was seen in Trial 1 in the comparison between *patients* vs *TBI coached* compared to *patients* vs *TBI naïve*. With regard to the DCT, only the Sum of Errors indicated a larger effect size in the *patients* vs *TBI naïve* comparison compared to *patients* vs *TBI coached*, whilst the effect sizes were larger in the comparison of *patients* vs *TBI coached* on the Mean UG, Mean G and E-score than those values of *patients* vs *TBI naïve*. The average mean effect size of *patients* vs *TBI naïve* was larger (*Md* = 3.38) than for *patients* vs *TBI coached* (*Md* = 3.11) for all subtests of the TOMM. For all four assessment values of the DCT, on average, the mean effect size was smaller between *patients* and *TBI naïve* (*Md* = 1.06) than between *patients* and *TBI coached* (*Md* = 1.13).

The sensitivity of the TOMM and DCT was assessed by analyzing the ROC (Receiver Operating Characteristics) and their AUC (Area Under the Curve) as well as by applying different cut-off scores. Here, the sensitivity is the ability of the tests to detect individuals of feigned cognitive symptoms and to classify them as such. The specificity, respectively, is the detection of genuine patients and the classification of them as patients. The ROC curves for the TOMM Trial 2, the Retention Trial and the E-scores of the DCT are depicted in Figure 1 to Figure 6. Calculated sensitivity and specificity outcomes with regard to certain cut-off scores are depicted in Table 6 concerning outcomes of the TOMM Trial 2, in Table 7 regarding outcomes of TOMM Retention, and Table 8 depicts outcomes of the E-score of the DCT. Each Table also contains the AUC for the group comparisons of their measured value. Official cut-off scores are bold.

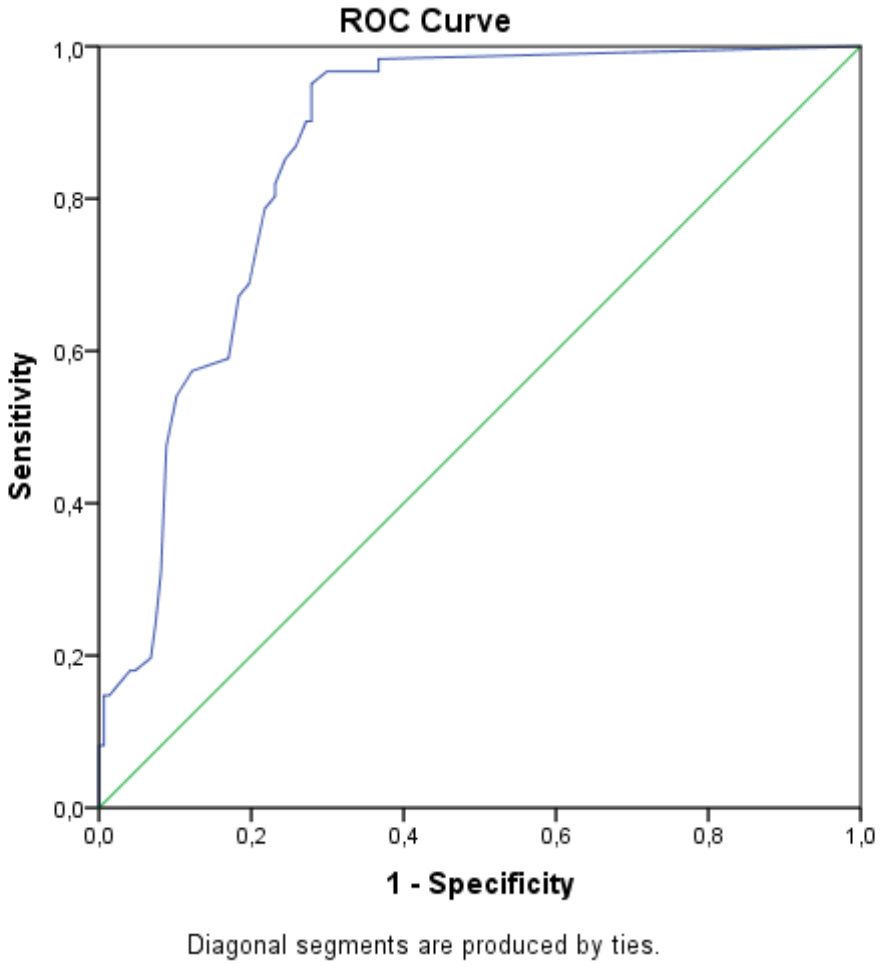

Figure 1. Sensitivity of the TOMM Trial 2 for *patients* versus *TBI naïve*.

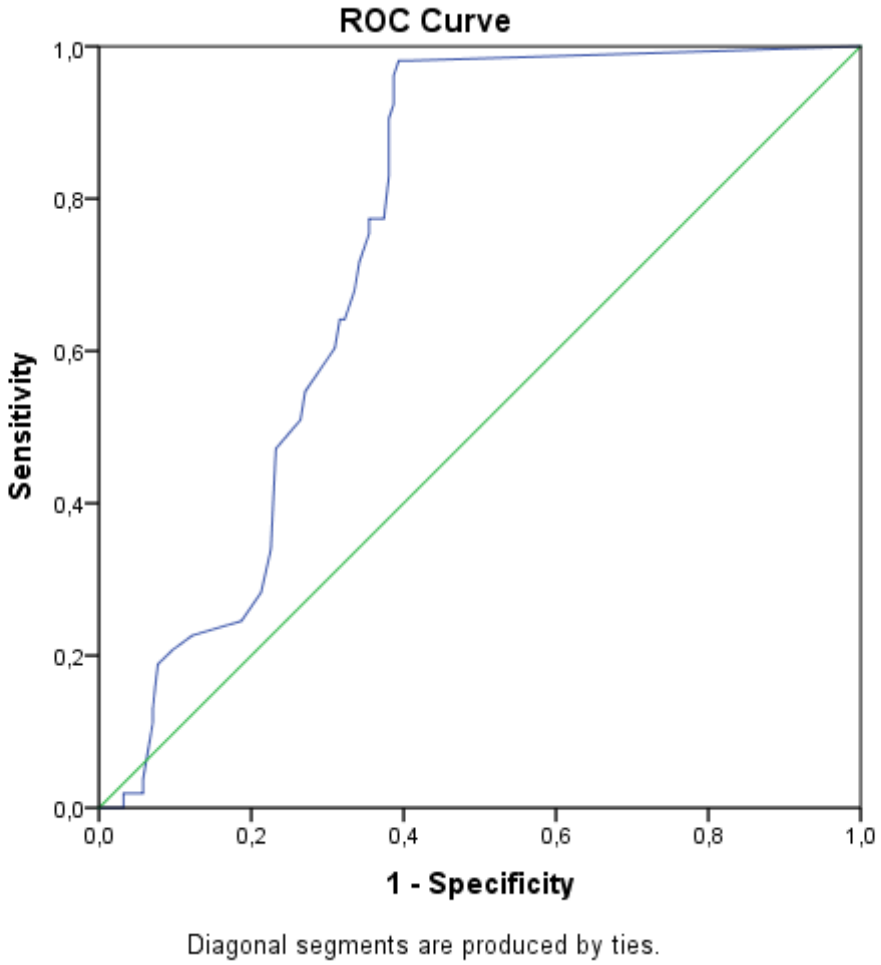

Figure 2. Sensitivity of the TOMM Trial 2 for *patients* versus *TBI coached*.

Table 6

Sensitivity of the TOMM Trial 2 with different cut-off scores and Are Under the Curve (AUC)

Patients vs TBI naïve			Patients vs TBI coached		
Positive if Less Than or Equal To	*Sensitivity*	*Specificity*	*Positive if Less Than or Equal To*	*Sensitivity*	*Specificity*
35	.950	1	35	.641	1
40	.951	.952	40	.773	1
45	.951	.952	**45**	.962	.952
46	.951	.951	36	.962	.952
48	.983	.904	48	.981	.904
AUC = .861			*AUC* = .746		

Note. TBI = Traumatic brain injury. TOMM = Test of Memory Malingering (Tombaugh, 1996). *TBI naïve* = recruited participants instructed to feign cognitive symptoms after TBI without further instructions. *TBI coached* = recruited participants instructed to feign cognitive symptoms after TBI with further instructions provided. *Patients* = genuine patients suffering from cognitive impairments after TBI.

The ROC curves illustrated that the TOMM Trial 2 was more sensitive for *patients* vs *TBI naïve* than for *patients* vs *TBI coached*. This was underlined by the higher AUC of the *patients* vs *TBI naive* than for the *patients* vs *TBI coached* comparison having a difference of .115 and the higher sensitivity values for different cut-off scores. The specificity of the TOMM Trial 2 was very high in both comparisons with almost equal values for each cut-off score.

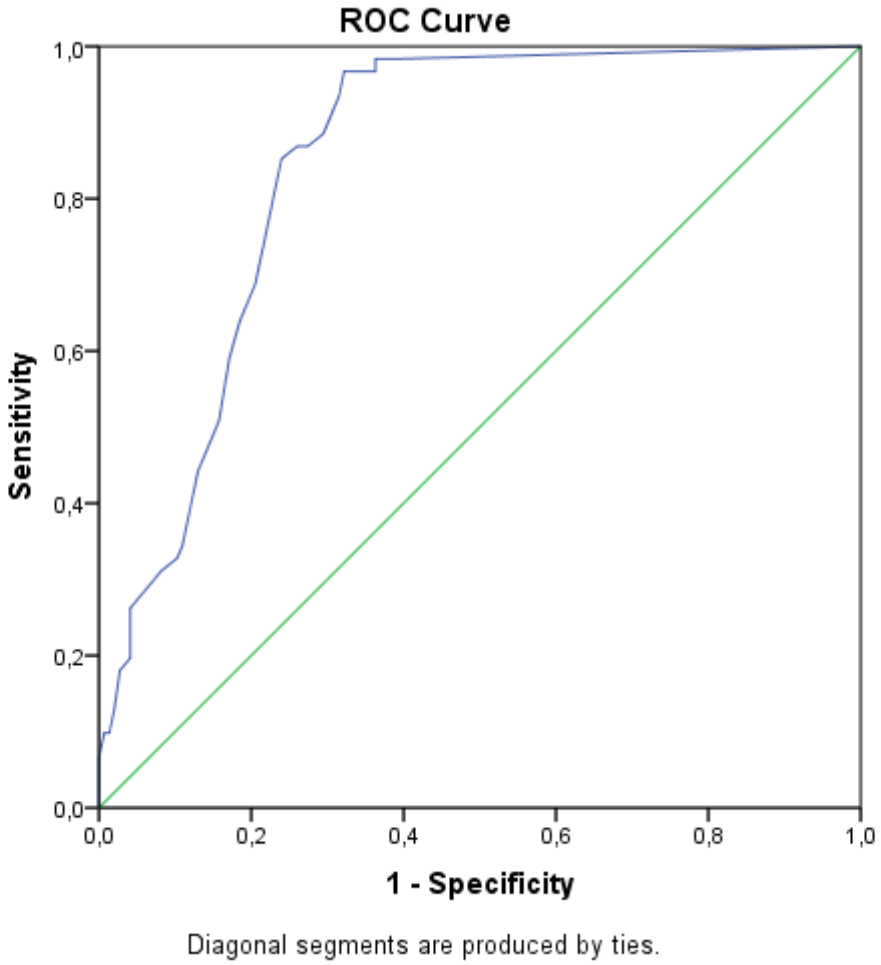

Figure 3. Sensitivity of the TOMM Retention for *patients* versus *TBI naive*.

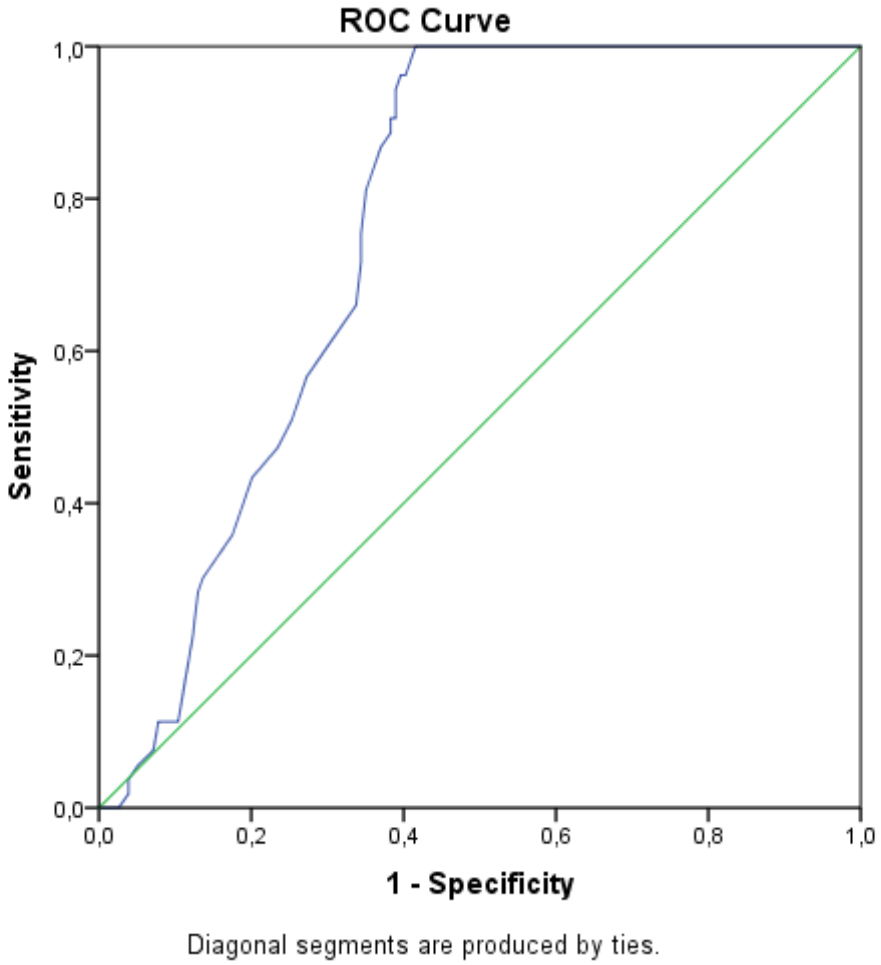

Figure 4. Sensitivity of TOMM Retention for *patients* versus *TBI coached*.

Table 7

Sensitivity of the TOMM Retention with different cut-off scores and Area Under the Curve (AUC)

Patients vs TBI naïve			Patients vs TBI coached		
Positive if Less Than or Equal To	*Sensitivity*	*Specificity*	*Positive if Less Than or Equal To*	*Sensitivity*	*Specificity*
35	.868	1	35	.716	1
40	.951	1	40	.867	1
45	.951	.95	**45**	.924	.95
46	.951	.9	46	.962	.9
48	.983	.9	48	.962	.9
AUC = .848			*AUC* = .763		

Note. TBI = Traumatic brain injury. TOMM = Test of Memory Malingering (Tombaugh, 1996). *TBI naïve* = recruited participants instructed to feign cognitive symptoms after TBI without further instructions. *TBI coached* = recruited participants instructed to feign cognitive symptoms after TBI with further instructions provided. *Patients* = genuine patients suffering from cognitive impairments after TBI.

For the TOMM Retention, the ROC curves indicated a higher sensitivity for the *patients* vs *TBI naïve* than for the *patients* vs *TBI coached* comparison. Again, this was underlined by a higher AUC with a difference of .085 between the group comparisons and higher sensitivity scores for certain cut-off scores in the *patients* vs *TBI naïve* comparison. Additionally, the

specificity of the TOMM Retention was observed to be very high as well in both comparisons, indicated by equal specificity values.

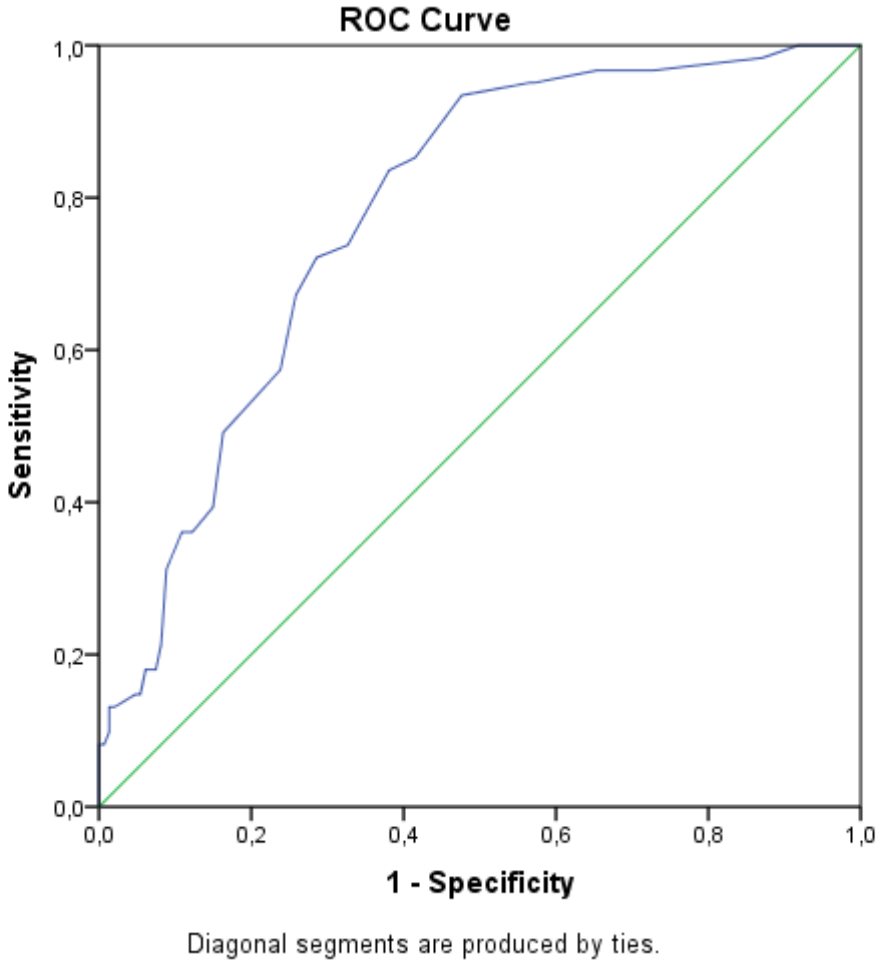

Figure 5. Sensitivity of the DCT E-score for *patients* versus *TBI naïve*.

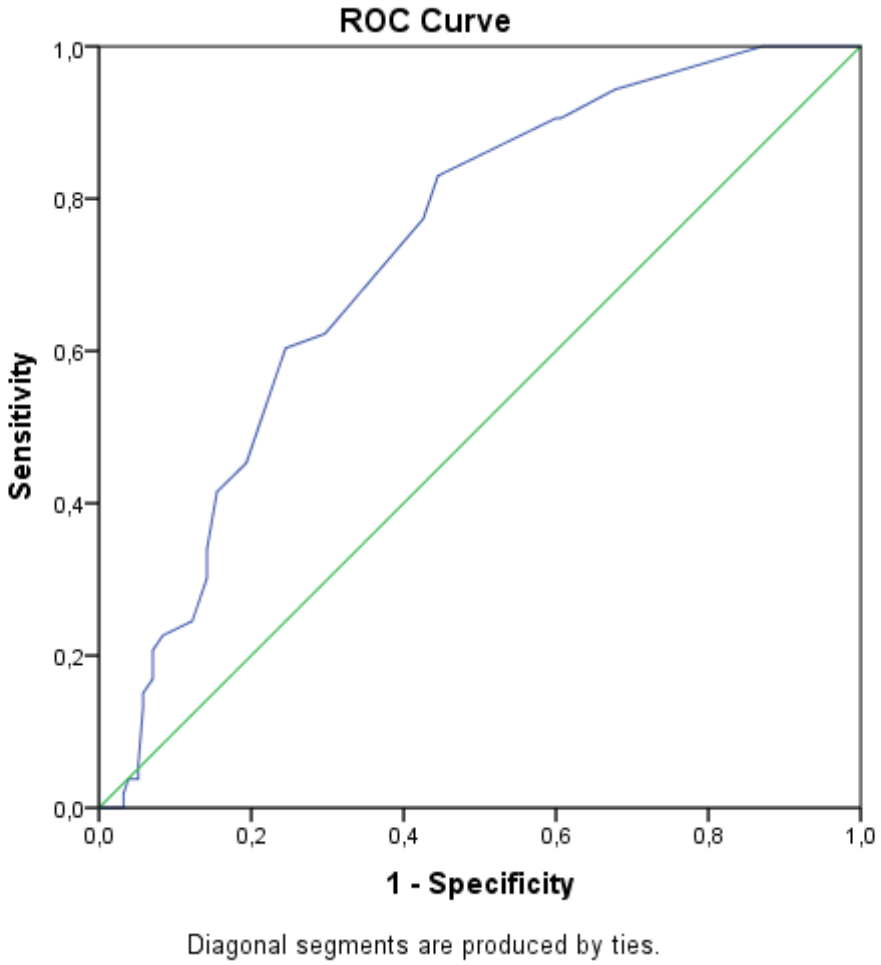

Figure 6. Sensitivity of the DCT E-score for *patients* versus *TBI coached*.

Table 8

Sensitivity of the DCT E-score with different cut-off scores and Area Under the Curve (AUC)

Patients vs TBI naïve			Patients vs TBI coached		
Positive if Less Than or Equal To	*Sensitivity*	*Specificity*	*Positive if Less Than or Equal To*	*Sensitivity*	*Specificity*
20	.360	1	**20**	.339	1
18	.491	1	19	.452	1
17	.573	.904	17/18	.603	.904
15	.721	.857	15	.698	.714
13	.751	.782	13	.773	.714
AUC = .778			*AUC* = .730		

Note. TBI = Traumatic brain injury. DCT = Dot Counting Test (Boone, Lu, & Herzberg, 2002). *TBI naïve* = recruited participants instructed to feign cognitive symptoms after TBI without further instructions. *TBI coached* = recruited participants instructed to feign cognitive symptoms after TBI with further instructions provided. *Patients* = genuine patients suffering from cognitive impairments after TBI.

With regard to the DCT, ROC curves about the E-score outcomes were less diverse than for the TOMM. This was demonstrated by a lower difference between AUCs of .048, where individuals of the *patients* vs *TBI naïve* comparison were again more often correctly classified. Equally, sensitivity levels for certain cut-off scores were higher for the *patients* vs *TBI naïve*. By

applying the cut-off scores depicted in Table 8, the specificity of the DCT indicated similar sensitivity levels from medium to very high in both comparisons.

Discussion

In our simulation study, two hypotheses were analyzed. Firstly, it was assessed whether the TOMM and DCT are valid measurements in the detection of individuals showing non-credible effort in neuropsychological assessments compared to patients suffering from cognitive impairments after TBI. Secondly, it was tested whether providing both information about symptoms of brain damage after TBI and what to be aware of during neuropsychological assessments have an influence on the discriminatory ability of those tests to identify individuals feigning their symptoms from genuine patients.

Discussion hypothesis 1. When *patients* and simulator groups were each compared to the *controls*, significant differences were observed between simulators and *controls*, but not between *patients* and *controls* on all values of the DCT and the TOMM Retention Trial. This outcome underlines the tests' restricted ability in that they were designed to identify simulators from patients (Bett, Shores, & Chekaluk, 2008) and that they are not suitable for clinical diagnosis. This observation highlights the importance to apply tests in the contexts for which they were purposely designed as long as further research has not made aware of other possible areas of application.

Results of the analysis confirmed our expectations for both the TOMM and DCT concerning the first hypothesis. With regard to the TOMM, both the Trial 2 and the Retention were able to significantly distinguish between genuine patients suffering from TBI and healthy individuals feigning their cognitive impairments after TBI, regardless of the simulator condition participants were allocated to (*TBI naïve* or *TBI coached*). Applying the categorization of Cohen's d by

Rogers (2008) for the identification of individuals feigning their cognitive symptoms relative to genuine patients, the very high Cohen's d values underlined that very large differences were observed in test performances, indicating that this test is well suited to detect non-credible effort; simulators recognized significantly less objects correctly compared to head injured patients.

It needs to be acknowledged, however, that the head injury studied in this experiment was of mild nature. With regard to more severe head injuries or neurological conditions, it has been claimed that the TOMM does not serve as an appropriate measure for the distinction between genuine patients and individuals showing non-credible effort. For example, in assessing patients suffering from severe dementia, out of 37 tested patients the TOMM yielded only 73% specificity and failed in 27% of the assessments (Green, 2011). It is assumed that patients with severe neurological impairments may perform better on other nonverbal tests like the Nonverbal Medical Symptom Validity Test (NV-MSVT), indicated by higher specificity rates for patients (Green, 2008).

When Green (2008) compared the TOMM and NV-MSVT in a known-groups design, he indeed found higher sensitivity and specificity rates for the latter test for different neurological conditions (dementia, stroke, multiple sclerosis, psychiatric conditions). However, patients suffering from mild TBI made more errors than patients suffering from moderate to severe TBI, which stands in contrast to expected outcomes for the TOMM, but can also be explained with poor effort.

A reason why the TOMM might not be applicable for patients with moderate to severe TBI lies in its nonverbal nature; patients with more pronounced consequential neurological damages might suffer from perceptual impairments, whereby the TOMM might not serve as an appropriate instrument and a verbal test may be of better value (Rivera et al., 2015). Concerning

mild TBI, however, the TOMM again proved to be a useful assessment tool in the detection of low-performing individuals due to non-credible effort (Powell, 2004; Jelicic, 2007).

In the present study, the DCT also demonstrated its ability to discriminate between *patients* and both groups of instructed simulators, independently of their group allocation. More specifically, simulators were clearly making more errors and took more time to respond compared to *patients*, resulting in significantly different outcomes compared to genuine patients' performance. The difference in these responses was not as large as for the TOMM, as they were moderate to very large following Rogers's (2008) classification, with the largest effect observable on the Mean G and E-score for both group comparisons. However, since we focused on the E-score as our discriminatory variable, it can be concluded that the DCT is able to discriminate validly between patients and simulators. Therefore, our data support hypothesis 1, with the TOMM having a larger discriminant value than the DCT. Also, the ROC analysis of hypothesis 2 supports the valid discriminatory ability of both tests with their satisfying AUCs, indicating that both tests are able to generally classify patients and simulators in a substantial number of cases, described in detail below.

Several reasons might explain the large differences in outcomes between genuine TBI patients and those who simulated cognitive impairments after TBI. Previous simulation experiments in the case of head injuries indicated that firstly, individuals who feign their cognitive impairments generally overestimate the deficits associated with head injury (Coleman, Rapport, Millis, Ricker, & Farchione, 1998; Iverson & Franzen, 1998). Secondly, simulators often display error patterns that are unusual in neuropsychological tests (Benton & Spreen, 1961; Osimani, Alon, Berger, & Abarbanel, 1997). And lastly, they perform worse on the more obvious tests than on subtle ones (Bernard, McGrath, & Houston, 1996).

Discussion hypothesis 2. It was assumed that coaching affects the discriminatory ability of the TOMM and DCT; participants were believed to create a clearer concept of the cognitive symptoms presented after TBI due to given information and performance should therefore be more sophisticated (Youngjohn, Lees-Haley, & Binder, 1999). Additionally, making them aware of malingering assessments let us expect that participants may become more cautious in their simulated symptom presentation.

Regarding the TOMM, the differences were observed to be larger in the comparison of *patients* vs *TBI naïve*, meaning that the test was slightly better at discriminating participants when no coaching was involved, however, the difference to *patients* vs *TBI coached* is very small. So, even though the TOMM was better able at discriminating simulators from *patients* when they were untrained, coaching itself did not have a meaningful influence on the ability of the TOMM to discriminate between *patients* and simulators.

Equally, coaching did not seem to have an effect on the DCT's discriminatory value as it can be seen in the very small differences in effect sizes and AUC outcomes between group comparisons of *patients* vs *TBI naïve* and *patients* vs *TBI coached*. Interestingly, the results of the analyses applied even point at different directions of the effect of coaching on the discriminatory ability of the DCT; whereas Cohen's d values indicated that *TBI coached* vs *patients* were slightly better identified, the AUCs show that *TBI naive* vs *patients* were easier classified. Previous studies indicated mixed results, where Rose, Hall and Szalda-Petree (1998) concluded that coaching had no impact on the discriminatory ability of the DCT, confirming our results, whereas others found that naively feigning simulators were detected more easily (Lezak, 1983; Binks, Gouvier, & Waters, 1997). The latter was marginally observed

in our study, since coached individuals were either slightly more or less easily detected depending on the statistical analysis applied.

These mixed results of previous studies point at the need to conduct further research on the DCT in order to rule out any impact of coaching on its discriminatory value. A possible reason for the slightly larger effect size of the *patients* vs *TBI coached* comparison on the DCT may lie in the observation that participants, when taught about cognitive impairments and tests, become more confident in how to feign compared to naïve simulators, who might experience insecurities towards the fabricated symptoms and therefore feign to a lower degree than coached individuals (Erdal, 2002). Still, the difference in effect sizes between *patients* vs *TBI naïve* and *patients* vs *TBI coached* is very small.

All in all, these are positive observations, as they illustrate that the TOMM and DCT are not significantly affected in their discriminatory ability to identify those who feign their cognitive deficits and others who truly suffer from TBI correctly by previous information about cognitive symptoms after TBI. Also, making simulators aware that malingering assessment will take place did not impair both tests. It might be argued that simulating individuals simply forgot about the symptoms and lost their awareness of malingering tests during the assessment. However, to avoid this issue, after each test participants were both always reminded about their simulation condition and the sheet describing the symptoms and information about the assessment was lying next to the coached participants during the whole simulation assessment. Therefore, our outcomes confirm the results of Tombaugh (1996;1997) and others (Rees et al., 1998; Powell et al., 2004) that the TOMM and the DCT (Rose, Hall, & Szalda-Petree, 1998) are unaffected by coaching in its classification abilities between individuals who feign their impairments after TBI and genuine patients with TBI. As a result, hypothesis 2 is not confirmed.

In order to obtain a clearer picture of the discriminatory ability of the tests (hypothesis 1) and the influence of coaching (hypothesis 2), the sensitivity and specificity of the TOMM and DCT were assessed. With regard to the TOMM, the ability to correctly categorize both simulators (sensitivity) and genuine patients (specificity) is good with 86% when participants naively simulated their impairments, whereas this ability is fair for the coached simulators with 75%. By analyzing different cut-off scores, the official cut-off score of 45 turned out to be an accurate score for the TOMM Trial 2 and Retention, since for naïve and coached individuals, 92-96% of simulators were correctly classified, with still approximately 95% correctly identified genuine patients, supporting previous research (Tombaugh, 1997; Powell et al., 2004).

Similar correct classification values of 90% to 95% for individuals simulating mild dementia symptoms have been found in a simulation design by using a cut-off score of 45 on Trial 2 (Rees et al., 1998; Tombaugh, 1996; Tombaugh, 1997), which highlights the TOMM's probable ability to assess the simulation of different mild neurological impairments to a similar degree. With regard to dementia patients, specificity was perfect (100%) compared to the present TBI context. Our outcomes also support results of previous studies, where simulating participants were also correctly identified by 90% (Jelicic et al., 2007) to 93-96% (Powell et al., 2004) when coaching was involved. Therefore, the TOMM seems to be a robust measure of effort regardless of coached or naïve simulation of symptoms after TBI, which is in line with previous conclusions (Jelicic, Ceunen, Peters, & Merckelbach, 2011; Powell et al., 2004) and also supports hypothesis 1 in that the TOMM is a valid measure in discriminating between simulators of cognitive deficits after TBI and patients with TBI.

Even though the specificity was higher with a lower cut-off score for the TOMM, reducing the cut-off score is not recommended, because 20-30% of simulating participants might be

overlooked if trained beforehand. Since it is impossible to control for coaching in assessment settings, we recommend to not utilize a lower score. A higher cut-off score does reduce specificity by almost 5%, whereas sensitivity only increases by 1-3% in both simulation situations, so increasing the cut-off score for both the Trial 2 and Retention does not lead to significantly preferable results.

With regard to the DCT, the ability to correctly classify patients and simulators is generally fair with 78% for naïve and 73% for coached simulators. It is noticeable that the established cut-off score of 20 for head injuries does not appear to be advantageous in our simulation study; all simulators were only correctly classified in 34-36% of the cases, compared to a correct classification of all genuine patients, also for a lower score of 19 to 18.This confirmed the conclusion of the simulation study done by Rose, Hall, and Szalda-Petree (1998), where it was advised to interpret the DCT with caution if applied alone regarding its ability to detect individuals fabricating cognitive symptoms after TBI. The sensitivity of the DCT was below satisfactory in their study with only 10% of simulators being categorized as such, whereas patients suffering from TBI were correctly identified in over 90% of the cases.

Therefore, a lower cut-off of 17 may be more effective in identifying simulators correctly; in our study, 57-60% would have been correctly classified, which is almost double of what was identified with a score of 20, whereby over 90% of genuine patients would still be spotted, which is an adequate level of classification accuracy. However, almost half of the simulators would not be detected, independent of previous coaching. As a result, the test should be applied in combination with other symptom validity or malingering tests in order to increase the ability to detect simulators of cognitive impairments after TBI and correctly classify genuine patients of that condition. Consequently, relating to hypothesis 1, a lower cut-off might increase the

discriminatory value of the DCT. Even though the test is still able to discriminate amongst simulators and patients, an adjusted cut-off score might result in more satisfying classifications.

To conclude, coaching has only a slight and rather meaningless effect on both the TOMM and the DCT. With regard to the sensitivity of the tests, the TOMM proved to be successful in classifying simulators as such and the application of the official cut-off score of 45 is justified for both the Trial 2 and Retention. For the DCT, however, the established cut-off score of 20 for head injuries resulted in rather unsatisfying sensitivity levels in our study. We recommend reducing the cut-off to a score of 17 based on our results in order to classify at least every second simulator correctly without missing a substantial number of patients. In general, tests developed to discriminate simulators from genuine patients should be applied together in a battery in order to assure correct classification of both simulators and patients with TBI (or other conditions).

Strengths of the study. Several strengths of the study are noticeable. Firstly, genuine patients suffering from TBI were included, which increased the ecological validity of the test outcomes. Secondly, different cut-off scores were evaluated with regard to their sensitivity and specificity which, on the one hand, were helpful to further question the predetermined cut-off scores and, on the other hand, can serve future researchers to contrast their statistical outcomes with our presented results. Thirdly, the study dealt with official neuropsychological tests applied in clinical settings, so outcomes are not only of theoretical but also of practical importance for the clinical context. Fourthly, the Digit Span Task served as an additional determinant to assess whether participants were indeed motivated and took care to perform appropriately. By doing this, students who appeared unambitious were removed prior to the analysis and therefore did not bias any simulation outcomes.

Fifthly, the study focused on a single specific cognitive impairment, so that conclusions of the TOMM and DCT can be drawn with regard to TBI specifically. This is important, because of the high prevalence of genuine TBI as well as feigning of cognitive impairments after TBI. Sixthly, an external incentive was introduced to participants instructed to simulate, which increased the chance of participants to do their best and it increased the ecological validity of malingering. Lastly, the simulation scenario chosen in our study reflected a common situation so that imagining oneself suffering from TBI and deciding to feign impairments appeared not to be an abstract task.

Limitations of the study. Besides the informative results of our study, there are a few limitations which should not be overlooked. Firstly, the recruited participants were mainly psychology students from a Dutch University, so the simulation groups and the *controls* where rather homogenous with regard to their age, educational level, and cultural background. Therefore, the assessment outcomes might be biased and consequentially do not reflect the performance of individuals feigning cognitive symptoms of TBI of the general population.

Secondly, the sample size of the patient group was relatively small and outcomes are therefore difficult to generalize on the population of TBI patients. Additionally, they were recruited in Germany, so comparing German patients suffering from TBI to students from the Netherlands might be problematic with regard to language; German patients were assessed in their first language whereas the mostly German students from the Netherlands were assessed in English. However, the students showed good language skills, so this was not expected to be a major issue. It still can be argued, though, that students did not fully understand the simulation scenario and their task, so that they did not internalize the simulation scenario well. But again,

this did not seem to be the case in our design, nevertheless results may be better comparable if collected in the same language because of standardization and comprehension issues.

Thirdly, the coaching condition might not have been representative enough, since there are several ways to instruct oneself how to feign. On the one hand, it might have been favorable to provide additional information about the degree of cognitive impairments in mild TBI. On the other hand, we only focused on the deficits after TBI; Even though TBI can have major effects on quality of life (Failla, Juengst, Arenth, & Wagner, 2015), including the preserved abilities might increase participants' awareness concerning the actual behavior of mild TBI patients. Also, an example of the behavior of a patient with TBI in daily situations might have increased the ability of the participants to fully understand the consequences of TBI and to internalize the scenario.

Lastly, it has been missed to calculate and analyze the sensitivity and specificity of the TOMM and the DCT combined. Doing so would have contributed to an informative insight into the classification accuracy of both tests together as a part of a test battery.

Implications of the study. The present study is of value for several reasons. Many studies about the TOMM have been conducted by the test originator, so this study is an independent, unbiased experiment with an objective view on test outcomes (Teichner & Wagner, 2004). Furthermore, the study deals with a very prominent issue of today's clinical assessment. Because of tremendous consequences of undetected feigning on the individual, the society and economy, targeted research on specific symptom validity tests is of utmost importance in order to be able to compile a standardized assessment battery for neuropsychological malingering testing. Based on our results and previous research, both the TOMM and the DCT certainly appear to be promising

measures for standardized malingering assessments. Furthermore, since studies on the DCT in the TBI context are rare so far, we contribute to an increased knowledge base for this test.

Future research. By reflecting on the present study, a few recommendations can be made for future research. With regard to coaching, assessing the influence of knowledge about the tests themselves might be promising, since information about existing symptom validity tests might increasingly become available on the internet. Also, because of that issue, new measures and detection methods such as reaction times and event related potentials should be further developed in order to identify individuals who feign their neurological deficits (Vagnini, Berry, Clark, & Jiang, 2008). Additionally, the knowledge of participants about TBI and its consequential damages to a patient's life should be assessed by open questions, so that firstly, one can control for the level of knowledge about the condition and, secondly, this step might help with the internalization of the simulation scenario in future research. Regarding the DCT, it has been stated that the sum of errors is also a useful value in discriminating between patients and simulators (Binks, Gouvier, & Walters, 1997). This should be further investigated, since our study does not prove the E-score to be a promising value in this regard in the context of mild TBI, at least with its established cut-off score.

Also of importance is to assess the tests' discriminatory ability between genuine patients and simulators of other neurological conditions and different degrees of severity as well, i.e. as it has been done for the TOMM regarding mild dementia (Rees et al., 1998) and severe dementia (Green, 2011), in order to include them in a standard battery to test malingering. Additionally, a major challenge of great value would be the integration of genuine patients simulating or exaggerating their deficits since the robustness of the tests could be assessed in authentic clinical situations. Furthermore, litigation seems to have an influence on the TOMM scores of TBI

patients, where litigating patients had significantly lower scores than healthy controls, control patients and non-litigating TBI patients (Tombaugh, 1997). So, litigation may be a moderator and should be focused on in future research as well.

In conclusion, both the TOMM and the DCT appear as useful tools in the detection of individuals feigning cognitive symptoms after (mild) TBI. If future research comes to similar conclusions regarding other neurological conditions with varying degrees of severity, both tests have the potential to be integrated in standardized neuropsychological assessments to discriminate between individuals showing credible and non-credible effort. Whereas the TOMM indicates robust results across studies in the context of TBI, further research needs to be conducted on the DCT regarding its cut-off score for head injuries. In general, tests to detect feigning should always be applied in a battery to increase classification accuracy.

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Appendix A

Simulation instructions

TBI

Scenario

Three weeks ago you were involved in an accident that was not your fault. You were on your bike crossing an intersection, and a car ran a stop sign and hit you. You fell down and hit your head against the pavement and were knocked out for about 15 minutes. Afterwards, you felt dizzy for a while and the doctor told you that you experienced a concussion. They decided to keep you in the hospital for one night for observation. Gradually, over the next few days you started to feel normal again.

Try to imagine that a year after the accident, you are involved in a lawsuit against the driver of the other car because he caused the accident. If you are found to have experienced significant injuries as a result of the accident, you are likely to receive a bigger settlement. **You have decided to fake or exaggerate symptoms of a brain injury in order to increase the settlement you will receive.**

As part of the lawsuit a psychologist is about to examine you using several cognitive tests to determine whether or not you have experienced a brain injury. If you can successfully convince the examiner that you have experienced significant brain damage, you are likely to get more money.

Your goal is to convince your examiner, by your performance on these tests, that you have suffered brain damage from the accident. When you take the following tests, try to mimic the performance of a person who is truly head injured to convince the examiner that you suffer from brain damage.

Note:

Your test results will be analyzed after the study and compared to data of genuine patients with acquired brain damage. If you manage to simulate "brain injury" better than any of the other participants you will be rewarded with a top of the range **Tablet PC**. Therefore we would like to ask you to leave your email address in order to contact you later on.

Appendix B

Simulation instructions

TBI

Coaching

In order to convince the examiner that you have brain damage, your symptoms must be believable. Below is a list of common problems following brain injury, which may help you in your simulation of head injury. Keep this in mind when taking the tests:

- Slowed down thinking and responses
- Problems with paying attention and concentration
- Problems with remembering things
- Problems with learning new material well

However, produce the most severe problems that you can **without making it too obvious** to the examiner. That means major exaggerations, such as doing all tasks wrong, are easy to detect. **If you magnify your symptoms too much, your testing profile will be detected as that of someone who fakes symptoms**, not someone who is head injured. If the examiner does not believe that you have any problems you will not win your lawsuit and you will not get anything for your injuries.

Be careful: At least one of the tests you will be given is specifically designed to catch you faking! Tests to catch faking are usually designed that they appear difficult, but are much easier to perform than they look! In fact, they are often so easy that even people with brain damage can perform well.

Remember, you are trying to feign symptoms of "brain injury" and perform the following tests as you truly suffer from brain damage.

Note:

Your test results will be analyzed after the study and compared to data of genuine patients with acquired brain damage. If you manage to simulate "brain injury" better than any of the other participants you will be rewarded with a top of the range **Tablet PC**. Therefore we would like to ask you to leave your email address in order to contact you later on.