Effects of injury severity and cognitive exaggeration on olfactory deficits in head injury compensation claims

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The purpose of this study was to examine the relationship between exaggeration and scores on a test of olfactory discrimination in patients being assessed in connection with a claim for financial benefits. Participants were 448 patients referred to a private practice in Edmonton, Alberta, Canada for psychological or neuropsychological assessment, related to evaluation of impairment and disability resulting from a work-related or non-work related accident. All patients were involved in some form of compensation claim at the time of their evaluation. All patients completed two tests designed to detect exaggerated cognitive deficits, the Computerized Assessment of Response Bias (CARB) and the Word Memory Test (WMT) as part of their evaluation. The diagnostic groups included 322 head injury cases, varying from very minor to very severe. Normative data for the smell test were derived from 126 patients with orthopedic injuries who passed both the CARB and the WMT. Patients with more severe traumatic brain injuries were 10-12 times more likely to have olfactory deficits than persons with trivial to mild head injuries. In a subgroup of patients who failed either the CARB or the WMT, there was no relationship between injury severity and total scores on the smell test. Therefore, the dose-response relationship between brain injury severity and olfactory deficits is severely attenuated when patients who are probably exaggerating their cognitive deficits are included in the analyses. Those patients with trivial to mild head injuries who demonstrated adequate effort on both the CARB and the WMT were no more likely to show olfactory deficits than the non-head-injured orthopedic control subjects. Therefore, anosmia following mild traumatic brain injury should not be concluded from self-reports or from tests of smell unless tests of effort have been passed. Effort should also be controlled in group studies of olfaction.

Keywords: Olfaction, neuropsychological assessment, brain injury, anosmia

1. Introduction

In the past decade it has become increasingly recognized that some patients exaggerate cognitive impairment when performing neuropsychological tests and that this seriously distorts and invalidates test results in individual cases. For this reason, it is essential to employ specific methods to identify invalid test results caused by exaggeration of impairment, especially when a person is assessed in the context of a financial claim for disability [1–3]. In contrast, little attention has been paid to the influence of exaggeration on data and conclusions drawn from group studies. In the past, most studies were conducted without controlling for the validity of results by measuring effort and then removing cases with presumed invalid test results. Instead, typically, good effort on testing was assumed. Yet, a sufficient number of undetected exaggerators in a sample could lead to the conclusion that patients with a certain diagnosis suffer from cognitive impairment when they do not. Alternatively, exaggeration of impairment could lead to an overestimate of the degree or prevalence of impairment in a particular sample.

Veiel [4], for example, concluded from a meta-analysis of many studies of depression that impaired scores on cognitive tests are common in groups of patients with depression. A surprising degree of impairment was illustrated by the fact that depressed patients summarized by Veiel [4] scored a mean of at least 90 seconds on Trail Making B. In contrast, Dikmen and colleagues, in a one-year outcome study, reported that

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the mean Trail Making B score was 71 seconds for patients with traumatic brain injuries who had loss of consciousness of up to an hour, and it was 101 seconds for patients with very severe brain injuries who were unable to respond to commands for up to two weeks after head injury [5]. Slower Trail Making B scores in patients with depression compared to patients with brain injuries begs the question of whether the depressed patients actually had greater cognitive impairment than people with severe brain injuries? It should be noted that such an assumption was not made by Veiel [4], who simply reported the test findings without interpreting their underlying causes. It is possible that the impaired test scores in depressed patients arose partly from exaggeration of impairment or lack of motivation to do well on tests. One study controlled for effort by removing all cases who failed symptom validity tests (SVTs) from an initial sample of 658 outpatients, predominantly patients with head injuries, neurological diseases, major depression, and orthopedic injuries. In the 452 remaining patients, who passed the SVTs, Rohling et al. [6] concluded that there were no significant differences on any neuropsychological tests between those with very high levels of self-reported symptoms of depression versus those with very few depressive symptoms.

Rohling and colleagues showed that, in a large neuropsychological test battery applied to 904 consecutive patients claiming compensation for disability, a composite variable derived from two SVTs and a third effort measure explained 53% of the variance in all 43 neuropsychological test scores combined [7]. In contrast, years of education, which is known to be an important determinant of test scores, explained only 11% of the variance in the same data. Such findings raise the possibility of widespread but heretofore unidentified adverse effects of poor effort in group studies. This is especially true for studies involving patients for whom financial compensation is potentially available, such as in cases involving chronic pain, chronic fatigue syndrome, psychiatric illnesses, or head injuries. This possibility is supported by a study in which significantly more chronic fatigue syndrome cases failed an effort test, compared to patients with multiple sclerosis [8]. The authors cautioned against assuming that abnormal test findings necessarily imply cerebral impairment and they urged the use of effort tests (SVTs) in future research.

It is well known that traumatic brain injuries can cause anosmia or lesser forms of olfactory dysfunction. In persons who sustain severe traumatic brain injuries, the olfactory system can be compromised by several mechanisms. Trauma to the face can cause a fracture of the ethmoid bone, which is one mechanism for severing of olfactory fibres that pass through the cribriform plate to the olfactory bulbs. The olfactory nerves run within these bulbs on the surfaces of the orbital-medial aspects of each frontal lobe, so damage to this region (e.g., contusions or edema) can compromise olfaction. Moreover, damage to areas underlying the ventromedial aspects of the temporal lobes, including the olfactory cortex, can compromise olfaction. Over the years, olfactory deficits have been well-recognized in the traumatic brain injury literature [9–12].

It is essential, however, to consider alternative explanations when a person with a history of traumatic brain injury reports olfactory problems. Certainly, the most common causes of bilateral anosmia or hyposmia (diminished sense of smell) are the common cold or trauma to the nose (Pourmand [13]). Moreover, because loss of sense of smell is a compensable loss that can only be determined by self-report or by tests of odor discrimination, anosmia is susceptible to exaggeration or faking. Green and Iverson [14] reported that persons involved in mild head injury litigation were much more likely to perform poorly on a smell discrimination test if they also demonstrated biased responding on a symptom validity test. The strong association between exaggeration during neuropsychological testing and poor smell discrimination was not seen in persons with severe traumatic brain injuries who were also involved in litigation. Thus, it is apparent that deliberate exaggeration should be considered when interpreting the results of smell discrimination tests in persons involved in head injury litigation.

Doty and colleagues reported poor smell test scores in 87.3% of 268 people complaining of olfactory dysfunction secondary to head trauma [15]. In this study, smell test performance did not appear to be related to severity of brain injury. There was no reported difference in the incidence of olfactory deficits in people with mild head injury with no LOC and those with more than 24 hours of LOC. There are two reasons why the results of this study have limited generalizability. First, the sample was unique in that patients complaining of olfactory problems were self-referred to a smell and taste clinic. Second, Doty et al. [15] did not employ symptom validity tests to identify the possibility of deliberate exaggeration, and they did not address or control for compensation seeking.

The purpose of this study was to examine the relationship between exaggeration and scores on a test of olfaction in patients being assessed in connection with a claim for financial benefits. It was hypothesized that patients who showed exaggeration of impairment by failing tests of effort (SVTs) would score lower on a smell test than those who passed the effort tests. As in previous studies [16,17], it was expected that failure on symptom validity tests would be more frequent in cases of mild head injury than in moderate to severe brain injuries. It was also hypothesized that, after removing cases showing negative response bias or exaggeration of impairment, smell test scores would be related to brain injury severity. Patients with more severe brain injuries were expected to perform more poorly than patients with mild head injuries on a smell discrimination test.

2. Method

2.1. Subjects

Participants were 448 patients referred to a private practice in Edmonton, Alberta, Canada for psychological or neuropsychological assessment, related to evaluation of impairment and disability resulting from a work-related or non-work related accident. All patients were involved in some form of compensation claim at the time of their evaluation. The diagnostic groups included 322 head injury cases, varying from very minor to very severe. The average age of the patients was 38.7 years ($SD = 12.1$) and their average education was 11.8 years ($SD = 2.7$). The sample was 79% male and 21% female. In order to establish relevant norms for comparison purposes, we also included a group of 126 people with recent orthopedic injuries not involving the head. These orthopedic patients all passed two tests designed to detect exaggerated cognitive deficits, the Computerized Assessment of Response Bias and the Word Memory Test (described in the next section). The average age of the sample was 36.9 years ($SD = 8.9$) and their average education was 11.0 years ($SD = 2.3$).

2.2. Assessment procedures

As part of a comprehensive neuropsychological assessment, all outpatients were given a test of odor discrimination and two separate SVTs designed to detect exaggeration of cognitive impairment or inadequate effort. The Alberta Smell Test [14] involves ten trials in each nostril, in which the person is required to identify the odor presented. Subjects were required to close their eyes, close one nostril at a time and sniff when told to do so. Scented markers with authentic essences of lemon, orange, licorice, cinnamon, mint, raspberry, grape, and melon were presented half an inch below one nostril at a time. Subjects were asked to identify the odors from a list of eight options printed on a sheet of paper. The results were the number of correct responses out of ten for each nostril. The non-toxic scented water-color markers are widely available, very inexpensive, and have been manufactured by Sanford USA since 1972 under the trade name “Mr. Sketch” scented markers for use by young children.

The SVTs or tests of effort employed were the Computerized Assessment of Response Bias [18–20] and the Word Memory Test [16,17,21,22]. The CARB is a computerized forced choice digit recognition test with three blocks of 37 trials each. In the revised version used in this series, the subject has to watch a five digit number, (e.g., 58761) for two and a half seconds and then select that number from two options shown on the screen either 1.5, 2.5, or 3.5 seconds later. Patients with severe brain injury have been found to be able to score easily above the CARB cut-offs published in the test manuals and test scores are uncorrelated with age and intelligence [18–20]. Therefore, CARB is considered to be a test of effort and not ability.

The Word Memory Test [21] is a computerized or orally administered test with six subtests, some measuring effort applied to testing and others measuring memory for words. In the computerized version, which was used in this study, the subject is instructed to watch and remember a list of twenty simple word pairs (e.g., dog/cat, man/woman, pig/bacon, fish/fin). The list is presented twice on the screen and each word pair appears for six-seconds. After the second presentation of the list, the person is shown word pairs containing only one of the words from the original list (e.g., dog/rabbit) and the person selects the word from the original list by pressing the left or right shift key. A similar recognition test employing different foil words (e.g., dog/rat) is administered after a 30-minute delay. The WMT effort measures are the percent correct scores from each recognition trial and the level of consistency of responses between these two trials. These subtests are thought to measure effort rather than ability because patients with moderate to severe traumatic brain injury have been found to score well above the published cut-offs and the test scores are unrelated to age and years of education [20]. They are unaffected by level of post-traumatic amnesia, Glasgow Coma Scale scores, or the presence or absence of impaired verbal memory or CT abnormalities of the brain in samples of patients with head injury [23] and neurological diseases [24]. The WMT also includes subtests measuring verbal memory, which are the multiple choice, paired associates, free recall, and delayed free recall subtests. Only the effort measures were used in this study. The criteria used to determine the presence of response bias were those published in the test manual for WMT and were based on failing any one or more of the WMT immediate recognition, delayed recognition, or consistency scores.

3. Results

Normative data for the smell test were derived from the 126 patients with orthopedic injuries who passed both the CARB and the WMT. There was a modest correlation between smell test performance and age (e.g., the correlation between age and total test score was $r = -0.26$, $p = 0.003$). Scores in the right and left nostril (naris) correlated with each other at 0.6 in the orthopedic controls and, in the larger sample of 435 patients described in the study of Rohling et al. [7], the correlation was 0.68. Normative data for the smell test by age group and for the total sample are provided in Table 1. In this study, there were no significant differences between men and women on the smell test. However, 83% of cases in the orthopedic group and 79% of the cases in the head injury sample were men and, in the larger clinical population studied ($n = 435$), including many different diagnoses, there was a significant superiority of smell test scores in women.

The relations among smell test scores, effort test scores, and injury severity variables were analyzed in the entire head injury sample using bivariate correlations. A very small, yet significant, correlation was found between the delayed recognition on the WMT (WMT-DR) and the total smell score ($r = 0.15$, $p < 0.008$). Larger, but still modest, correlations were found between total smell test performance and Glasgow Coma Scale scores ($r = 0.28$, $p < 0.001$, $n = 188$), duration of post-traumatic amnesia ($r = -0.20$, $p < 0.002$, $n = 288$), and presence of CT-scan abnormalities ($r = 0.31$, $p < 0.001$, $n = 229$).

The total sample was then divided into binary head injury severity groups based on the following criteria: (a) Trivial – Mild Injury Group: loss of consciousness for less than 10 minutes and post-traumatic amnesia for less than one hour; and (b) Definite TBI Group: loss of consciousness for more than 30 minutes or post-traumatic amnesia for more than 24 hours, or an abnormality on brain CT. There were 137 patients who met criteria for the very mild group and 126 patients who met criteria for the definite TBI group. As hypothesized, there was a greater proportion of patients who scored below the cutoffs on the CARB or WMT in the very mild group as compared to the definite TBI group (37.2% vs. 26.2%; Fisher's Exact Test, one-tailed, $p = 0.037$). A subsample of the most severely injured patients was selected from the definite TBI group who met the following criteria: (a) abnormal CT and duration of PTA > 72 hours, or (b) abnormal CT and GCS < 9, or (c) PTA > 7 days. These 51 patients comprised a severe brain injury group. Of these patients, 21.6% scored below the cutoff on either the CARB or the WMT.

The total head injury sample was divided into two groups on the basis of their performance on the CARB or the WMT. Those patients who scored below the cutoff on either test were placed in a group considered to have poor effort ($n = 107$) whereas those who scored above the cutoff on both tests were considered to have put forth adequate effort ($n = 215$). The smell test scores were then correlated with the injury severity variables in these two groups. Those patients in the poor effort group showed no significant correlations between injury severity and total smell test performance. In contrast, patients in the adequate effort group showed modest correlations between smell test total scores and duration of post-traumatic amnesia ($r = -0.23$, $p = 0.001$, $n = 192$), Glasgow Coma Scale scores ($r = 0.30$, $p < 0.001$, $n = 129$), and the presence of brain abnormality on CT ($r = -0.40$, $p < 0.001$, $n = 143$).

The 137 patients with very mild injuries were separated into two groups on the basis of their CARB and WMT performance; namely, poor effort subjects ($n = 51$) and adequate effort subjects ($n = 86$). The two groups did not differ in age, education, GCS scores, duration of loss of consciousness, or duration of post-traumatic amnesia. However, the groups did differ in their smell test performances with their right nostrils ($Z = -2.6$, $p = 0.009$) and left nostrils ($Z = -2.8$, $p = 0.005$), and on their total scores ($Z = -3.1$, $p = 0.002$). Descriptive statistics for the Smell Test in these two patient groups are presented in Table 2. Using a total score cutoff of 5 or less, 21.6% of the patients in the poor effort group demonstrated impaired olfaction compared to only 5.8% in the adequate effort group.

The odds of having impaired olfaction for the two groups were computed using the formulae provided by

Table 1
Normative data for the Alberta Smell Test derived from 126 patients with orthopedic injuries

	Smell right nostril	Smell left nostril	Smell total score
Ages 20–29 ($n = 30$)			
Mean	5.9	6.2	12.1
Median	6	6	12
Standard Deviation	1.9	1.8	2.9
10th Percentile	3	4.1	8.1
5th Percentile	2.6	2.1	6.0
Ages 30–39 ($n = 50$)			
Mean	5.8	6.4	12.1
Median	6	7	13
Standard Deviation	2.5	2.2	4.2
10th Percentile	2.1	3.1	6.0
5th Percentile	1.0	1.0	3.7
Ages 40–59 ($n = 46$)			
Mean	5.0	5.2	10.2
Median	5	5	10
Standard Deviation	2.2	2.7	4.5
10th Percentile	2.7	1.7	5.0
5th Percentile	1.0	0.4	3.4
All ages ($n = 126$)			
Mean	5.5	5.9	11.4
Median	6	6	12
Standard Deviation	2.2	2.4	4.1
10th Percentile	3.0	2.0	6.0
5th Percentile	1.4	1.0	5.0

Table 2
Descriptive statistics for the Alberta Smell Test by head injury severity group

	Smell right nostril	Smell left nostril	Smell total score
Trivial – mild adequate effort ($n = 86$)			
Mean	5.8	6.2	12.0
Median	6	6	12.5
Standard Deviation	2.2	2.2	3.9
10th Percentile	2.7	3.0	7.0
5th Percentile	1.4	2.0	3.1
Definite TBI adequate effort ($n = 93$)			
Mean	3.6	3.7	7.3
Median	4.0	4.0	8.0
Standard Deviation	2.9	3.0	5.4
10th Percentile	0	0	0
Severe TBI adequate effort ($n = 40$)			
Mean	3.7	3.4	7.0
Median	4	3	7
Standard Deviation	3.1	3.2	5.9
10th Percentile	0	0	0
Trivial-Mild TBI poor effort ($n = 51$)			
Mean	4.7	4.9	9.6
Median	5.0	5.0	9.0
Standard Deviation	2.8	2.7	4.9
10th Percentile	1.0	1.2	3.2
5th Percentile	0	0	1.2

Dawson-Saunders and Trapp [25]. Head injury litigants with very mild injuries who performed below the cutoffs on cognitive tests of effort were 4.5 times more likely to demonstrate impaired olfaction than patients who were believed to be giving adequate effort during testing. Those providing adequate effort were no more likely than the non-injured normative subjects to have impaired olfaction (5.8% versus 6.3%, respectively).

Descriptive statistics for the Smell Test in patient groups with definite traumatic brain injuries and severe traumatic brain injuries are presented in Table 2. Of the patients with definite traumatic brain injuries who provided adequate effort ($n = 93$), 37.6% demonstrated impaired olfaction (on their total test scores). The patients with definite TBI who were providing adequate effort during testing were 9.8 times more likely to demonstrate impaired olfaction than the patients with very mild injuries who were providing adequate effort ($n = 86$). Of the subgroup of subjects ($n = 40$) with severe traumatic brain injuries who provided adequate effort, 42.5% demonstrated impaired olfaction. The patients with severe TBI who were providing adequate effort during testing were 12.0 times more likely to demonstrate impaired olfaction than the patients with very mild injuries who were providing adequate effort ($n = 86$).

4. Discussion

In those who passed the effort tests in the present study, people with more severe traumatic brain injuries were 10 to 12 times more likely to have olfactory deficits than those with trivial to mild head injuries, using the formulae provided by Dawson-Saunders and Trapp [25]. In a subgroup of patients who failed either the CARB or the WMT, there was no relationship between brain injury severity and total scores on the smell test. Therefore, the dose-response relationship between brain injury severity and olfactory deficits is severely attenuated when patients who are probably exaggerating their cognitive deficits are included in the analyses. Those patients with trivial to mild head injuries who demonstrated adequate effort on both the CARB and the WMT were no more likely to show olfactory deficits than the non-head-injured orthopedic control subjects.

The current results, therefore, differ from those of Doty et al. [15], whose data showed no differences in the incidence of olfactory deficits between those who had a head injury with no loss of consciousness, head injury with minor loss of consciousness, or head injury with loss of consciousness of more than a day. It is possible that the lack of an association between head injury severity and olfactory deficits in Doty et al.'s [15] study was the result of sampling characteristics, since all subjects were self-referred for olfactory problems. This would also partly explain the very high incidence of anosmia in Doty's patients with the least severe head injuries, which was much higher than in the current sample. It is also possible that some of the patients with mild head injury in the Doty et al. [15] sample were exaggerating their impairment on smell testing and, if so, this would further inflate the apparently high incidence of anosmia in mild head injury cases. Because men tend to be over-represented in groups with severe brain injuries, exaggeration of impairment might also be relevant to their finding of atrophy of the olfactory bulbs in the MRI scans of eight men with anosmia but no atrophy in seven women with anosmia. Alternatively, Costanzo and Zasler [12] state that it is possible that "the most prevalent cause of post-traumatic olfactory dysfunction is damage to olfactory brain centers". If so, differences in degrees of atrophy of the olfactory bulb could reflect different underlying causes of olfactory dysfunction.

Our data are in keeping with those presented by Costanzo and Zasler [12], showing increasing impairment of olfactory discrimination with increased head injury severity. However, the rate of impaired olfaction in the mild head injuries in the current study (5.8%) was no different than that of orthopedic controls, whereas 40% of the mild head injury cases in the Constanzo and Zasler study had some impairment on an olfactory identification screening test and 13% were anosmic. Further studies controlling for effort would be helpful in determining what level of severity of head injury is required to produce impaired olfaction and through what mechanisms. Comparative studies of the Alberta Smell Test and other instruments for measuring olfaction will also be needed to make appropriate comparisons between rates of olfactory dysfunction across studies. It should also be pointed out that the current head injury sample was selected because all patients were referred for assessment in the context of a compensation claim. For this reason, it is likely that the rate of exaggeration was higher than might be expected if a consecutive series of all admissions for head injury were seen in a primary care hospital.

The current findings illustrate the general principle that, in studies of perceptual or cognitive deficits using behavioral tests, failing to control for effort during testing can lead to test scores that overestimate the actual impairment in the sample. In this study, the relationship between smell test scores and head injury severity was evident in the cases making a good effort but it was partially obscured or absent in those making an inadequate effort to produce valid results. Therefore, as well as testing for effort in individual clinical cases, it is advisable to include measures that allow us to control for effort in clinical research designs, as recommended by Van der Werf et al. [8]. Otherwise, important relationships between the variables of interest, such as diagnosis, drug effects, or acquired cognitive impairment, may be obscured by error introduced into test scores by exaggeration in a subgroup of cases studied.

Controlling for exaggeration is clearly important when studying alleged anosmia following mild traumatic brain injury. Patients with very mild head injuries who scored below the cutoff on either CARB or WMT were 4.5 times more likely to demonstrate olfactory deficits on the Alberta Smell Test than patients who gave adequate effort on the SVTs. In contrast, those mildly injured patients who performed adequately on the effort tests were no more likely to have olfactory deficits than non-injured control subjects.

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