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ORIGINAL PAPER

Neuropsychological assessment of driving ability and self-evaluation: a comparison between driving offenders and a control group

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Abstract The relationship between performance in neuropsychological tests and actual driving performance is unclear and results of studies on this topic differ. This makes it difficult to use neuropsychological tests to assess driving ability. The ability to compensate cognitive deficits plays a crucial role in this context. We compared neuropsychological test results and self-evaluation ratings between three groups: driving offenders with a psychiatric diagnosis relevant for driving ability (mainly alcohol dependence), driving offenders without such a diagnosis and a control group of non-offending drivers. Subjects were divided into two age categories (19–39 and 40–66 years). It was assumed that drivers with a psychiatric diagnosis relevant for driving ability and younger driving offenders without a psychiatric diagnosis would be less able to adequately assess their own capabilities than the control group. The driving offenders with a psychiatric diagnosis showed poorer concentration, reactivity, cognitive flexibility and problem solving, and tended to overassess their abilities in intelligence and attentional functions, compared to the other two groups. Conversely, younger drivers rather underassessed their performance.

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Introduction

In Germany and Switzerland, the assessment of driving ability after committing a driving offence involves a medical check-up, documentation of the medical history and a psychological examination [1, 2, 38]. The psychological part of a driver's assessment has to assess with the highest possible probability whether the driver will be able to avoid further misconduct in the future. The psychological examination includes a careful exploration of the driving history, living circumstances and favourable attitude changes, and personality tests and the measurement of cognitive abilities [10]. Areas relevant for driving are visual information processing, concentration, attention, reactivity and intelligence, whereby attentional functions are of special importance [3, 19, 33, 39, 47].

Ideally, a practical driving test should complement the neuropsychological assessment since results of studies on the relationship between performance in neuropsychological tests and in a practical driving test differ (for review see Ref. [11]). In a study by Niemann and Hartje [26], more than half of 196 subjects with a neurological disorder had cognitive deficits but passed the practical driving test. Welzel [51] found that individuals with good neuropsychological test results committed more driving offences in the following years. The results of these studies underline the importance of personality traits as a mediator variable between cognitive functions and driving behaviour. Personality traits considered relevant for driving ability are novelty seeking, extraversion, narcissism, low self-esteem and emotional instability [43, 44].

Undeutsch [49] assumed that an above average test performance may induce a sense of competence: these drivers have more confidence in their abilities and therefore tend to take more risks in road traffic, especially if any of the above mentioned personality traits are present. According to Moe [24], young men with only 2–3 years of driving experience are actually the most confident in their competence. This finding is contrary to a study by Ritz [32] in which mainly older men rated themselves as 'very good car drivers'. A low level of self-criticism was also found in drivers older than 55 by Hartenstein [14], a result that could be replicated by Schlag [35].

Research on drivers with marginal deficits in cognitive function, mainly older drivers [4, 17, 23, 28, 37], also point to the possibility of compensation of these deficits, e.g. by driving more defensively and carefully. However, in order to compensate for one's own deficits, one has to be aware of them. This requires a critical attitude towards one's own weaknesses and impairments, and the willingness to behave accordingly, too [34, 36]. In fact, some study results show that healthy older drivers adjust their driving behaviour if they know about their deficits [8, 50]. The denial of impairments therefore seems to have a higher risk potential than the impairments themselves [18, 45], and driving behaviour in a concrete traffic situation seems mainly to be determined by the driver's personality traits. A study by Kruger and Dunning [20] found that people who are unskilled in social and intellectual domains suffer a dual burden: their incompetence robs them of the metacognitive ability to realise it.

A loss of self-criticism may be assumed in serious psychiatric diseases (e.g. alcohol or drug addiction), which often lead to pathological alterations in personality [22]. Cognitive deficits cannot be recognised and driving ability may thus be affected.

This study examined whether three groups of drivers (driving offenders with a psychiatric diagnosis relevant for driving ability, driving offenders without such a diagnosis and a control group of non-offending drivers) differ in a neuropsychological test battery and in self-evaluation of test performance. We assumed that the difference between the objective and subjective assessments represents a risk potential and hypothesised that this may be greater in driving offenders with a psychiatric diagnosis relevant for driving ability and in younger driving offenders without a psychiatric diagnosis than in a control group.

Methods

Subjects

A total of 226 subjects were enrolled in the study. One part of the sample consisted of $n = 174$ drivers who had to undergo a psychiatric–psychological assessment of their driving ability because of traffic offences, e.g. driving while intoxicated (alcohol, drugs), speeding or self-induced accidents. This assessment took place at the Integrated Forensic-Psychiatric Institute (IFPD) of the University of Bern. All subjects gave informed consent to participate in the study.

On the basis of the psychiatric expert assessment, the sample of driving offenders was divided into two subsamples: one with a psychiatric diagnosis relevant for driving ability (group 1, $n = 63$) and one without such a diagnosis (group 2 $n = 111$). Fifty-three drivers of these subsamples (group 1, $n = 28$; group 2, $n = 25$) also performed a self-assessment of their test results.

In group 1, 53 subjects were diagnosed according to ICD-10 as alcohol dependent, five had a polytoxicomania, two a personality disorder, two an affective disorder and one a psychosis. These diagnoses are a priori exclusion criteria for driving ability.

The control group (group 3) consisted of 45 drivers without self-reported psychiatric treatment and who did not report any traffic offences in their past. They were recruited via an advertisement in the journal of the 'Touring Club Switzerland' (TCS), an organisation for traffic assistance. Each control person received 60 Swiss Francs for participation. After each test, all subjects of the control group had to assess their own performance.

The sample was divided into two age groups (19–39, 40–66 years).

The study was performed in accordance with the ethical standards laid down in the Declaration of Helsinki.

Procedure

Both experimental groups were tested during the regular psychiatric–psychological assessment of their driving ability. A date for testing was arranged with each control subject by telephone. Testing lasted 90 min per person.

Each person was assessed in the following cognitive domains, which are relevant for driving ability.

Intelligence

Intelligence of German-speaking subjects younger than 50 was measured using the short version of the 'Performance Test System' (LPS-K; 'Leistungsprüfsystem') [16, 46] or the reduced Wechsler Intelligence Test [5, 13]. The short version of the 'Performance Test System 50+' (LPS 50 + ; Leistungsprüfsystem 50 ++) [48] was used for persons aged 50 years and older. Individuals not fluent in German were tested using the standard progressive matrices [30].

Information processing

Speed of information processing was measured by the 'Number Connection Test' (ZVT; 'Zahlen-Verbindungs-test') [27].

Problem-solving and cognitive flexibility

A computerised version of the Modified Card Sorting Test (MCST) [15, 25] was used to assess problem solving, reasoning, cognitive flexibility and learning from feedback. The MCST is sensitive to brain dysfunctions.

Attention

Attentional functions were measured using five subtests from the Test battery for Attentional Performance (TAP) [52]: Alertness, Divided Attention, Go/Nogo, Flexibility and Visual Scanning.

Alertness measures simple reaction time and the ability to maintain attention as well as to raise attention in anticipation of a stimulus. *Divided Attention* includes a classical dual-task: subjects have to perform a visual and an acoustical task at the same time. In *Go/Nogo*, reaction to irrelevant stimuli has to be suppressed. *Flexibility* assesses the ability to change the attentional focus and *Visual Scanning* tests for scanning of the visual field and the maintenance of attention for a longer time period.

After each test, the subjects had to rate their performance on a five-step rating scale (poor, rather poor, average, rather good, good).

Statistical analysis

Statistical analyses were performed using Statistical Package for Social Science, version 12.0 (SPSS Inc., Chicago, 2004). Data were analysed by means of univariate covariance analyses with Bonferroni adjustment and Chi-square test.

We used the raw test scores for all cognitive domains except intelligence, for which we used age-normed IQ values. For MCST, we used the mean of four raw scores (number of right answers, number of errors, number of perseverations and number of completed categories). The reliability analysis revealed a Cronbach's α of 0.82, showing that the aggregation of these variables was legitimate [6]. A single variable was computed for the TAP subtest *Alertness* (mean of standard deviation with/without sound, median with/without sound and phasic alertness; Cronbach's $\alpha = 0.77$) and *Flexibility* (errors, standard deviation, median; Cronbach's $\alpha = 0.68$). For the TAP subtests, *Divided Attention*, *Go/Nogo* and *Visual Scanning*, we kept two variables each (errors and reaction time) because of the low internal consistency of these variables; the total number of variables was thus 11.

Results

Subject characteristics

The mean age of group 1 was 43.4 years (SD = 10.2, range 23–63 years), of group 2, 37.6 years (SD = 12.0, range 19–66 years) and of group 3, 40.8 years (SD = 13.7, range 20–66 years). There was a significant difference in mean age between groups 1 and 2 ($P = 0.01$). The group, age category and gender composition of the sample are shown in Table 1.

Differences in cognitive function between groups and age categories

Table 2 shows the mean values and standard deviations of the raw scores for each group. Some sum scores were inversed in order to obtain consistent scores in the sense of 'the higher the score the better the performance'.

The covariance analyses with IQ and age as covariates are displayed in Table 3. Group 1 performed worse than group 2 in Go/Nogo (errors) and worse than the control group in ZVT, MCST, Alertness, Go/Nogo (errors) and Visual Scanning (reaction time). Group 2 had lower results in the ZVT than group 3.

Table 1 Composition of the sample

Age in years	Group 1		Group 2		Group 3	
	n (Men)	*n* (Women)	*n* (Men)	*n* (Women)	*n* (Men)	*n* (Women)
19–39	16 (6)	3 (1)	60 (15)	4 (2)	18 (18)	4 (4)
40–66	36 (16)	8 (2)	42 (11)	5 (0)	21 (21)	2 (2)
Total	52 (22)	11 (3)	102 (26)	9 (2)	39 (39)	6 (6)

Number in brackets indicates number of subjects with self-assessment data. Group 1 denotes experimental group with psychiatric diagnosis relevant for driving ability, group 2 denotes experimental group without such a diagnosis, group 3 denotes control group

Table 2 Mean values (SD) of the test raw scores for the three groups

Test variables	Group 1 ($n = 63$)	Group 2 ($n = 111$)	Group 3 ($n = 45$)
IQ	100.0 (11.5)	103.4 (10.1)	107.5 (5.9)
ZVT	−98.9 (34.9)	−84.5 (27.3)	−70.6 (17.7)
MCST	5.2 (4.4)	7.5 (3.4)	8.3 (2.6)
Alertness	−151.1 (59.8)	−138.8 (27.5)	−124.3 (18.1)
Divided Attention: reaction time in seconds	−678.5 (91.0)	−676.4 (83.4)	−658.1 (52.6)
Divided Attention: errors	−2.7 (2.9)	−2.0 (3.1)	−1.1 (1.5)
Go/Nogo: reaction time in seconds	−563.5 (75.6)	−550.8 (71.5)	−530.3 (58.6)
Go/Nogo: errors	−4.3 (6.1)	−2.0 (3.5)	−1.2 (2.8)
Visual Scanning: reaction time in seconds	−5493.7 (1696.8)	−4845.7 (1328.8)	−4507.6 (1516.4)
Visual Scanning: errors	−7.0 (6.5)	−6.3 (6.2)	−3.6 (4.0)
Flexibility	−512.6 (327.6)	−415.8 (231.1)	−362.0 (154.2)

Group 1 denotes experimental group with psychiatric diagnosis relevant for driving ability, group 2 denotes experimental group without such a diagnosis, group 3 denotes control group

Table 3 Results of the covariance analysis (IQ and age as covariates) with Bonferroni adjustment

Test variables	*F*	*df*	*P* (group 1 vs. group 2)	*P* (group 1 vs. group 3)	*P* (group 2 vs. group 3)
ZVT	**10.04****	2	0.73	0.00**	0.00**
MCST	**4.79***	2	0.07	0.01*	0.70
Alertness	**3.35***	2	1.0	0.04*	0.13
Divided Attention: reaction time	1.57	2	0.48	1.0	0.43
Divided Attention: errors	1.53	2	1.0	0.24	0.81
Go/Nogo: reaction time	1.27	2	1.0	0.40	0.62
Go/Nogo: errors	**4.28***	2	0.05*	0.02*	1.0
Visual Scanning: reaction time	**5.12***	2	0.16	0.01*	0.39
Visual Scanning: errors	2.27	2	1.0	0.21	0.18
Flexibility	0.81	2	1.0	0.62	1.0

Group 1 denotes experimental group with psychiatric diagnosis relevant for driving ability, group 2 denotes experimental group without such a diagnosis, group 3 denotes control group

* $P < 0.05$, ** $P < 0.001$

Over- and underassessment of test performance between groups

Table 4 displays the mean values and standard deviations of the self-assessment scale. There were no significant mean differences between the three groups.

To obtain a measure for over- and underassessment of test performance, the test results were divided into a rank order from 1 to 5. The difference between the rank of the test result and the rank of self-rating was then calculated. This difference was again divided into three ranks: rank 1 represented an underassessment, rank 2 an accurate assessment and rank 3 an overassessment of performance. Chi-square tests were used to compare the frequency of these ranks between the groups and age categories. Results are shown in Tables 5, 6, 7 and 8.

Significant group differences were found for the intelligence test ($\chi^2 = 15.23$, $df = 4$, $P < 0.01$), the MCST ($\chi^2 = 16.92$, $df = 4$, $P < 0.01$) and the TAP subtests *Divided Attention* (errors $\chi^2 = 15.21$, $df = 4$, $P < 0.01$) and *Visual Scanning* (reaction time: $\chi^2 = 11.26$, $df = 4$, $P < 0.05$). More subjects in group 1 overestimated their performance in the intelligence test and *Divided Attention* (errors). Group 1 was underrepresented in rank 3 in the intelligence test, MCST and *Divided Attention* (errors). In group 2, fewer subjects than expected underestimated their performance in *Visual Scanning* (reaction time).

Over- and underassessment of test performance between age categories

To obtain an acceptable cell occupation for the Chi-square test, groups 1 and 2 were pooled. There was a significant result for the experimental group in the ZVT ($\chi^2 = 6.35$, $df = 2, P < 0.05$). More drivers in the younger age category underassessed their performance. In the control group, the

Table 4 Mean values (SD) of the self-ranking values for the three groups

Self-ranking value	Group 1 ($n = 28$)	Group 2 ($n = 25$)	Group 3 ($n = 45$)
IQ	3.38 (0.97)	3.52 (0.83)	3.37 (0.56)
ZVT	3.68 (0.84)	3.77 (0.83)	3.70 (0.73)
MCST	2.86 (1.20)	3.41 (0.88)	3.23 (0.88)
Alertness	3.84 (0.72)	3.96 (0.78)	3.88 (0.70)
Divided Attention	3.48 (0.85)	3.59 (0.92)	3.42 (0.94)
Go/Nogo	3.66 (0.90)	3.98 (0.81)	3.76 (0.90)
Visual Scanning	3.52 (0.86)	3.80 (0.93)	3.50 (0.72)
Flexibility	3.62 (0.97)	3.75 (1.0)	3.50 (0.87)

Group 1 denotes experimental group with psychiatric diagnosis relevant for driving ability, group 2 denotes experimental group without such a diagnosis, group 3 denotes control group

* $P < 0.05$, ** $P < 0.001$

Table 5 Results of the Chi-square test for self-rating in intelligence and group

Group	Rank of self-rating			Total
	1	2	3	
Experimental group with diagnosis				
Observed	3	8	13	24
Expected	7.9	8.4	7.7	
Std. residual	−1.7	−0.1	**1.9**	
Experimental group without diagnosis				
Observed	11	5	11	27
Expected	8.9	9.4	8.7	
Std. residual	0.7	−1.4	0.8	
Control group				
Observed	20	23	9	52
Expected	17.2	18.2	16.7	
Std. residual	0.7	1.1	**−1.9**	
Total	34	36	33	103

$\chi^2 = 15.23$, $df = 4$, $P = 0.00$

Table 6 Results of the Chi-square test for self-rating in the MCST and group

Group	Rank of self-rating			Total
	1	2	3	
Experimental group with diagnosis				
Observed	6	8	11	25
Expected	10.3	7.9	6.7	
Std. residual	−1.3	0.0	**1.6**	
Experimental group without diagnosis				
Observed	8	8	12	28
Expected	11.6	8.9	7.5	
Std. residual	−1.1	−0.3	**1.6**	
Control group				
Observed	29	17	5	51
Expected	21.1	16.2	13.7	
Std. residual	**1.7**	0.2	**−2.4**	
Total	43	33	28	104

$\chi^2 = 16.92$, $df = 4$, $P = 0.00$

Table 7 Results of the Chi-square test for self-rating in Divided Attention (errors) and group

Group	Rank of self-rating			Total
	1	2	3	
Experimental group with diagnosis				
Observed	6	5	14	25
Expected	8.7	8.9	7.5	
Std. residual	−0.9	−1.3	**2.4**	
Experimental group without diagnosis				
Observed	8	10	10	28
Expected	9.7	10	8.3	
Std. residual	−0.5	0.0	0.6	
Control group				
Observed	22	22	7	51
Expected	17.7	18.1	15.2	
Std. residual	1.0	0.9	**−2.1**	
Total	36	37	31	104

$\chi^2 = 15.21$, $df = 4$, $P = 0.00$

older drivers overassessed their test results for *Divided Attention* (errors) significantly more often than the younger drivers ($\chi^2 = 6.83$, $df = 2$, $P < 0.05$), see Tables 9 and 10.

Differences in self-assessment between drivers who reached the official criteria and those who did not

In total, 119 subjects reached the official criteria for fitness to drive in the neuropsychological tests; 48 subjects did not reach these criteria.

In a further analysis, differences in self-assessment between drivers of groups 1 and 2 who reached the official criteria for driving ability (group A, $n = 32$) and those who did not (group B, $n = 19$) were examined. Correlations between self-ranking and test results were calculated and transformed into Fisher's Z-values to allow comparison of the correlations. In MCST and Go/Nogo (errors), the correlation between self-ranking and test result in group A was significantly higher than in group B (MCST: group A, Fisher's $Z = 0.72$; group B, Fisher's $Z = 0.19$; $z = 1.73$; Go/Nogo, errors: group A, Fisher's $Z = 0.63$; group B, Fisher's $Z = -0.28$; $z = 2.93$).

Table 8 Results of the Chi-square test for self-rating in Visual Scanning (reaction time) and group

Group	Rank of self-rating			Total
	1	2	3	
Experimental group with diagnosis				
Observed	8	6	11	25
Expected	0.2	8.4	8.4	
Std. residual	−0.1	−0.8	0.9	
Experimental group without diagnosis				
Observed	3	14	10	27
Expected	8.8	9.1	9.1	
Std. residual	**−2.0**	**1.6**	0.3	
Control group				
Observed	23	15	14	52
Expected	17	17.5	17.5	
Std. residual	**1.5**	−0.6	−0.8	
Total	34	35	35	104

$\chi^2 = 11.26$, $df = 4$, $P = 0.02$

Table 9 Results of the Chi-square test for self-rating in the ZVT and age category

Group	Age category	Rank of self-rating			Total
		1	2	3	
Experimental group	19–39 years				
	Observed	10	6	7	23
	Expected	6.2	9.3	7.5	
	Std. residual	**1.5**	−1.1	−0.2	
	40–66 years				
	Observed	4	15	10	29
	Expected	7.8	11.7	9.5	
	Std. residual	−1.4	1.0	0.2	
	Total	14	21	17	52

$\chi^2 = 6.35$, $df = 2$, $P = 0.04$

Table 10 Results of the Chi-square test for self-rating in Divided Attention (errors) and age category

Group	Age category	Rank of self-rating			Total
		1	2	3	
Control group	19–39 years				
	Observed	12	10	0	22
	Expected	9.8	9.3	2.9	
	Std. residual	0.7	0.2	**−1.7**	
	40–66 years				
	Observed	8	9	6	23
	Expected	10.2	9.7	3.1	
	Std. residual	−0.7	−0.2	**1.7**	
	Total	20	19	6	45

$\chi^2 = 6.83$, $df = 2$, $P = 0.03$

Discussion

The aim of this study was to investigate possible differences in cognitive function and self-assessment of performance in a sample of driving offenders compared to a control group of drivers who had not committed a driving offence.

Group 1 (drivers with a psychiatric diagnosis relevant for driving ability) had clearly lower results than the control group in five tests (ZVT, MCST, Alertness, Go/Nogo, Visual Scanning). Given the high rate of alcohol dependence in group 1, it is not surprising that the cognitive functions affected are typical alcohol-related deficits, e.g. concentration, reactivity, cognitive flexibility and problem solving [29, 31, 40], and visual scanning [21]. The performance of group 2 (drivers without a psychiatric diagnosis relevant for driving ability) is between that of group 1 and the control group. This may be due to the fact that there are subjects in group 2 who probably have a substance abuse (but not yet a dependence) that is already affecting their cognitive functions.

A more differentiated analysis of the three subsamples and four age categories was not possible because of the rather small number of subjects. Nevertheless, in some tests (intelligence test, MCST, *Divided Attention*, *Visual Scanning*) results were consistent with our hypotheses. The driving offenders, especially those with a psychiatric diagnosis, showed a tendency to overassess their abilities while the control group rather underassessed its competency. According to Friedel and Lappe [9] and Luthe [22], the overestimation of one's own capabilities may be part of pathological alterations in personality as a consequence of alcohol dependence or other psychiatric disorders.

Contrary to our assumption, in both the experimental and control groups the younger drivers (19–39 years) did not overassess their performance, although this result was only found for ZVT and *Divided Attention* (errors). No significant effects could be found for the other test variables. A possible explanation for the finding that older drivers with more cognitive impairment tended to overassess their abilities can be found in Groeger and Grande [12]. These authors assume that the repetition of an activity (driving a car) leads to the development of a consolidated 'driving self' that can hardly be influenced by a decline in capacities or an isolated feedback.

These findings imply that, besides cognitive function, personality traits play a central role in the assessment of driving ability in drivers without a psychiatric diagnosis relevant for driving ability. Personality traits in drivers with such a psychiatric diagnosis are confounded with the disorder and accompanied by cognitive loss. Moreover, medication may impair cognitive functions that are relevant for driving ability, as could be shown in substituted opioid addicts and schizophrenic patients [7, 41, 42].

There are several limitations to this study. First, the sample may have been too small to obtain reliable results concerning over- and underassessment. Second, the control group may be a selective one. It consists of persons who are very interested in their driving abilities and may therefore not represent the 'average' driver. Thirdly, we did not control for medication, which may influence cognitive performance. Fourth, group 1 is quite heterogeneous; the subjects may differ in the length of their substance dependence and of their probable abstinence before the assessment. Fifth, the mixture of intelligence tests used is not ideal as they have different norm samples.

Prospective studies are necessary to show whether subjects with better cognitive function also have a better prognosis for driving behaviour, and whether subjects who overassess their abilities commit more driving offences.

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