Self-assessment of drivers with brain pathologies: reported habits and self-regulation of driving

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Abstract

The objective of this paper is to analyze the self-reported driving behaviour of older drivers with brain pathologies, through an extensive questionnaire assessment. More specifically, the brain pathologies examined include Alzheimer's disease, Parkinson's disease, and Mild Cognitive Impairment (some other cognitive diseases are included too). The questionnaire that was answered by 137 drivers with similar demographic characteristics, out of which 44 were healthy individuals and 93 had some brain pathology, includes questions about their driving routines, their possible avoidance of driving and their emotions while driving. The participants were also asked about their opinion about in-vehicle driver distraction and how they deal with it. Kruskal-Wallis and One-Way ANOVA techniques were used in the analysis, producing several statistically significant results for the comparison of the two examined groups: Patients self-report, that they are likely to avoid using their vehicle because they are afraid of their driving abilities. Regarding the distraction, patients find it too dangerous either to converse with a passenger or, even more, to use the mobile phone and for that reason they avoid to do so. Patients with brain pathologies seem to be quite calm while driving, but on the other side, they use the seat-belt at a lesser extent compared to the controls. Overall, drivers with brain pathologies are aware of their deterioration in their driving performance, and thus they try to compensate their driving behaviour either by conservative driving, or even they avoid driving.

Keywords

Brain pathologies; self-assessment; self-regulation; driving habits; questionnaire

Disclosure of conflicts of interest

The authors declare no financial or other conflicts of interest.

Highlights

- Self-reported driving behaviour of older drivers with brain pathologies, was analyzed through an extensive questionnaire assessment; 44 healthy controls vs 93 patients
- Drivers with brain pathologies are aware of their deterioration in their driving performance
- Patients try to self-regulate their driving either by conservative driving, or even they avoid driving.
- Patients forget to use their seat-bet
- Patients avoid in-vehicle distraction (conversing with passenger or conversing through mobile phone)

1. Introduction

1.1. Brain pathologies and driving performance

Driving requires possessing sufficient cognitive, visual and motor skills and drivers must have adequate motor strength, speed and coordination. Every driver must have adequate motor strength, speed and coordination and perhaps more importantly, higher cognitive skills: concentration, attention, adequate visual and perceptual skills, insight, judgement and memory. Higher cortical functions required for driving include strategic and risk taking behavioral skills, including the ability to process multiple simultaneous environmental cues in order to make rapid, accurate and safe decisions. The task of driving requires the ability to receive sensory information, process the information, and to make proper, timely judgments and responses (Waller, 1980; Freund et al., 2005).

As a result, the ability to drive can be affected by various motor, visual, cognitive and perceptual deficits which are either age-related or caused by neurologic disorders. Drivers suffering from a brain pathology may have difficulties in their usual activities, including driving ability. However, scientists cannot agree to what extend mild cognitive impairment is affecting driving behaviour and driving safety. The greater the dementia severity, the greater the likelihood of poor driving ability (Hunt et al. 1993) and drivers with dementia are one of the groups considered at greatest risk for unsafe driving performance (Langford et al. 2007). Road accidents, while infrequent, are also of concern for drivers with dementia, whose crash risk is two to five times that of unimpaired older drivers (Charlton et al. 2003). Driving skills predictably worsen (Adler et al. 1999) and will ultimately require individuals with dementia to stop driving (Adler et al. 2005). Due to the variability in driving performance of persons with dementia, driving decisions need to be made not on diagnosis but on an assessment of the dementia's progress and the disease's effects on functional abilities (Duchek et al. 2003, Eby et al. 2009).

1.2. Self-regulation of driving and driving habits of patients with brain pathologies

Self-regulation of driving is associated with lower levels of driving confidence of older adults (Baldock et al., 2006). Awareness of functional difficulties may be another critical factor for determining self-regulation among older drivers (Charlton et al., 2006). Many older drivers do not regulate their driving to meet their functional decline, as shown by lack of differences in reported (?) driving habits of older drivers when faced with challenging driving situations (Baldock et al., 2008). Ackerman et al. (2010) found that self-rated driving ability failed to predict older drivers' functional performance on measures of cognitive, visual and physical abilities, consistent with the above finding.

Drivers with cerebral diseases tend to qualitatively limit their driving as part of a gradual progress of driving cessation (Croston et al., 2009). However, some continue to drive when it is no longer safe, and exercise poor judgment about their abilities (Brown et al., 2005). Research findings suggest that complex driving situations could pose safety concerns for MCI patients. However, it is not clear whether individuals with clinically-defined MCI report that they reduce their driving to compensate for declines of their abilities (Weston et al., 2011, Farias et al., 2005, Frittelli et al. 2009).

It is therefore of critical significance to examine the self-regulation patterns that drivers with brain pathologies report that they use in their everyday driving life in different

conditions of driver distraction, which constitutes an important human factor related to road accident causation.

2. Objectives

The objective of this paper is to examine the self-reported driving behaviour of older drivers with brain pathologies, through an extensive questionnaire assessment. Several brain pathologies that were examined include Alzheimer's disease (AD), Parkinson's disease (PD), Mild Cognitive Impairment (MCI) and some other cognitive disorders. Hence, a group of patients with brain pathologies was compared to a healthy control group of similar demographics. The questionnaire that was developed and used in order to compare the two groups, included 24 questions about: a) **their usual driving routines** (driving and alcohol use, seat belt use etc.), b) **their self-assessment about their driving frequency and their driving performance**, c) **their possible avoidance of driving**, d) **their opinion about in-vehicle distraction** (conversation with passenger or mobile phone use), e) **how they deal with in-vehicle distraction** and f) **their emotions while driving**.

3. Methodology

For the purpose of this study, a large driving simulator experiment was carried out, common for two research projects: the DISTRACT and the DriverBrain research project: the DISTRACT research project, entitled "Analysis of causes and impacts of driver distraction", (http://www.nrso.ntua.gr/distract) and the DriverBrain research project, entitled "Analysis of the performance of drivers with cerebral diseases", (http://www.nrso.ntua.gr/driverbrain).

A large driving simulator experiment was designed by an interdisciplinary research team of transportation engineers, neurologists and psychologists, which included four types of assessment:

a) *Medical/neurological assessment*: The first assessment included the administration of a full medical, neurological and ophthalmological evaluation, in order to document the presence of a disorder and its characteristics.
b) *Neuropsychological assessment*: The second assessment included the administration of a series of neuropsychological tests and psychological-behavioural questionnaires to the participants.
c) *Driving on the simulator assessment*: After dividing the sample into healthy controls and patients with brain pathologies, participants completed a set of driving tasks on a driving simulator for different driving scenarios.
d) *Questionnaire assessment*: The fourth type of assessment, which is the focus of this study, was the measuring of behaviour via self-report questionnaires, partly developed by our research team and is presented thoroughly in this section. The questionnaire (Table 1) includes 24 questions which cover the following fields:
    - **Driving experience** (developed by our research team),
    - **Self-assessment of driving behaviour** (developed by our research team),
    - **Driving under the effect of in-vehicle distraction** (developed by our research team),

- **State-trait driver feeling & behavior questionnaire** (Deffenbacher J.L., et al., 2001),
- **Driving anger expression inventory, DAX** (Deffenbacher J.L., et al., 2002) and
- **History of incidents** (developed by our research team).

(Table 1 to be inserted here)

4. Participants

The sample consisted of 137 participants of similar demographic characteristics, comprising two distinct groups:

- **93 participants were included in the group of "patients",** with a mean age of 68.7 years (s.d.=8.7), 60% males. This group included individuals with cognitive impairments due to various brain pathologies. More specifically, the brain pathologies examined include early Alzheimer's disease (AD), early Parkinson's disease (PD), and Mild Cognitive Impairment (MCI).
- **44 participants were included in the "healthy" group,** with a mean age of 63.1 years (s.d.=7.1), 65% males. This group included participants who were medically evaluated and found to have no pathological condition.

The between-group comparisons in several demographics is presented in Table 2; age, driving experience, driving exposure, years of education, and accidents in the past two years. The two groups were not statistically different in terms of demographic characteristics.

(Table 2 to be inserted here)

All the participants had a valid driving license, drove for more than 3 years, had driven more than 2500 km during the last year, drove at least once a week during the last year and drove at least 10km/week during the last year. Participants who did not meet one or more of the above criteria were eliminated from the experiment.

This study was approved by the Ethics Committee of the University General Hospital "ATTIKON". Informed consent was obtained from all individuals studied.

5. Results and discussion

The 137 questionnaires were analyzed through Kruskal-Wallis One-Way Analysis of Variance techniques using SPSS Statistics 22. Kruskal-Wallis test is a nonparametric test that assesses for significant differences on a dependent variable by a grouping independent variable. Under the Kruskal-Wallis One-Way ANOVA procedure the null hypothesis was assumed, namely that "*the distribution is the same across Controls and Patients*" at a significance level < .05. The null hypothesis, then, was finally rejected or retained; regarding the questions in which the significance level was under .05, the null hypothesis was rejected, meaning that the difference between the two groups was statistically significant, and on the other hand regarding the questions in which the significance level was over .05, the null hypothesis was retained, meaning

that the difference between the two groups was not statistically significant. The statistical analysis results are presented in Table 3.

(Table 3 to be inserted here)

Statistically significant differences between the control group and the group of patients with cerebral diseases were found in 14 out of 24 questions: *Q2, Q3, Q4, Q6, Q7, Q8, Q9, Q10, Q17, Q18, Q20, Q21, Q23, and Q24*. Before analyzing and discussing the results, for a more distinct picture, box-plots were extracted in order to identify the differences between control group and patients' group in the specific questions that the analysis indicated statistical differences (Fig. 1). The spacing between the different parts of the box plot indicate the degree of dispersion (spread) and skewness in the data and identify outliers. More specifically, regarding box plots: The line in the middle of the boxes is the median. The bottom of the box indicates the 25th percentile. Twenty-five percent of cases have values below the 25th percentile, whereas the top of the box represents the 75th percentile. Twenty-five percent of case have values above the 75th percentile (50% of the cases lie within the box).

(Figure 1 to be inserted here)

Regarding Q1, in comparison with 5 years ago, the frequency of the driving seem to have the same distribution between the two examined groups and no significant differences were detected. Overall, the driving of both healthy participants and patients with brain pathologies is limited, compared to 5 years ago.

Regarding Q2, over the last 6 months, the patients with brain pathologies avoided driving because they were afraid of their driving skills. On the other hand, the healthy participants claimed that they never did so.

Moving on to Q3, patients with cerebral diseases assessed their driving performance at the present time, as slightly worse, in comparison to 5 years ago. On the contrary, their healthy counterparts self-reported to have the same or even slightly better driving performance in comparison to 5 years ago. This difference between the two groups was statistically significant.

The next two questions (Q4-Q5) regard the participants' opinion about in-vehicle distraction. In Q4 significant differences in participants' answers were extracted. Patients with brain pathologies believe that conversing with a co-passenger while driving is a quite dangerous act, but the healthy control group claimed that this condition is "a little dangerous" or even not dangerous at all. On the other hand, conversing through the hand-held mobile phone while driving is considered as a very dangerous situation by all participants and thus in this distraction condition no significant differences were detected.

Significant differences were extracted in the next two questions (Q6-Q7). Patients with brain pathologies claimed that they sometimes or rarely converse with a co-passenger while driving, nut they rarely or never converse through their mobile phone while driving. On the contrary, their healthy counterparts drive under these two distraction conditions more often (sometimes or even many times for the conversation with a co-passenger and rarely or even sometimes for the mobile phone use).

The next three questions regard the action which the participant makes under the distraction though conversing with a co-passenger (Q8-Q9-Q10). Significant differences were detected in all these three answers between the two examined groups. More specifically, when conversing with a passenger while driving the patients

with brain pathologies usually speed down, they are more careful, they usually try to keep larger headways and they usually drive to the "right" border of the road more often in comparison to the healthy controls who less often (even rarely) make these actions when conversing with a co-passenger while driving.

On the contrary with how participants deal with distraction through conversation with a co-passenger, all participants from both examined groups seem to deal with distraction through hand-held mobile phone while driving through the same patterns. Both groups often speed down, are more careful, keep larger headways from the vehicle ahead and drive to the “right border” but patients with cerebral diseases sometimes even stop the vehicle in a safe place in order to converse through mobile phone.

The following questions (Q15- Q16) regard the anger expression of the drivers. Patients with brain pathologies and healthy controls never or rarely argue with a co-passenger or another driver while driving. No significant differences were detected in these questions.

Moving on to the next question (Q17), significant differences were detected between the two examined groups. Patients with a brain pathology use their seat belt while driving in a lesser extent than their healthy counterparts who claimed they always use the seat belt while driving.

In Q18 significant differences were extracted; healthy drivers self-reported they rarely drive under the influence of alcohol. “Never” was the answer of patients with cerebral diseases in this question.

In the next question (Q19) no statistical differences were detected. Both examined groups claimed that never or rarely drive without being concentrated.

Finally, the 5 next questions regard the history of incidents of the participants as drivers. Healthy controls self-reported that they have experienced more accidents, they have avoided an accident "at the very last moment" more times, they have violated the Traffic Code as a driver more times, and they have been fined because they violated the Traffic Code as a driver more times, in the last two years, compared to the drivers with a brain pathology.

6. Conclusions

This paper aimed to examine the self-reported driving behaviour of older drivers with brain pathologies and their possible self-regulation of their driving, through an extensive questionnaire assessment. Brain pathologies that were examined include AD, PD, MCI and some other cognitive disorders. The questionnaire that was developed and applied in order to compare the two examined groups (93 patients with brain pathologies vs 44 healthy controls of similar demographics), included 24 questions about their usual driving routines, their self-assessment about their driving frequency and their driving performance, their possible avoidance of driving, their opinion about in-vehicle driver distraction and how they deal with it and their emotions while driving. In 14 questions there were statistically significant differences between the two examined groups’ answers.

Summarizing the results regarding the usual driving routines of the participants, the self-assessment about their driving frequency, their driving performance, and their possible avoidance of driving, several interesting comments could be extracted; 34% of patients self-reported, that they are likely to avoid using their vehicle because they are afraid of their driving abilities which they admit that have been deteriorated over

the years. This awareness of deteriorated driving performance due to brain pathologies is of notable significance; it means that this group of drivers tries to self-regulate their driving. On the other hand, they seem to use the seat belt significantly less times than controls with similar demographics, because of their cognitive decline. This finding is important in terms of road safety, because the absence of the seat-belt in a possible road accident could have a detrimental impact on the injury severity especially when taking into consideration the age of these drivers.

Moving on to the results regarding their opinion about in-vehicle driver distraction (conversation with passenger or mobile phone use) and how they deal with it, patients believe that conversing with passenger is dangerous and they avoid to do so. Almost half of patients claim that conversing with a co-passenger is at least a quite dangerous action regarding road safety. Additionally, patients with brain pathologies self-report that when conversing with passenger while driving, they speed down, keep larger headways, and drive to the “right” border of the road in order to compensate their driving behaviour. The control group, on the contrary, claim that this kind of distraction is a little or no dangerous at all.

On the other hand both groups self-report that conversing through a hand-held mobile phone is at least quite dangerous. The two examined groups have the same compensatory behaviour when using the mobile phone while driving (speed down, be more careful, keep larger headways from the vehicle ahead and drive to the “right border”). However it is notable that 50% of patients claim they stop the vehicle in order to use the mobile phone. This behaviour is explained by the fact that patients are aware of the negative effect of the mobile phone as a distractor and taking into consideration that they are aware of their mental condition they try to compensate their driving behaviour.

Finally, all participants claim they are quite calm and concentrated, and they never argue with a co-passenger or another driver when driving. Moreover, patients with cerebral diseases never drive under the influence of alcohol. Overall, patients claim they don’t have accidents and don’t violate the Traffic Code. On the other hand, healthy controls self-reported that they have experienced more accidents, they have avoided an accident "at the very last moment" more times, they have violated the Traffic Code as a driver more times, and they have been fined because they violated the Traffic Code as a driver more times, in the last two years, compared to the drivers with a brain pathology.

The take-home message of the current study is that drivers with brain pathologies are aware of their deterioration of their driving performance, and they try to compensate their driving behaviour by either conservative driving, or even they avoid driving. They consider in-vehicle distraction as quite dangerous and taking into account that they are aware about their cognitive decline, they avoid such driving conditions or they follow compensatory patterns. Finally, they are quite calm when driving, they almost never violate the Traffic Code, but they sometimes avoid using their seat-belt, which is very dangerous.

Overall, these observations could have significant practical use because they provide important information in order to formulate efficient driving recommendations and countermeasures to reduce the accident probability in a sensitive group of car drivers.

Further research should include the comparison of the driving patterns of patients (through a simulator experiment or an on-road test) with their self-evaluation of their driving skills in the particular conditions where they reported perceived difficulties and

investigate whether in those areas they actually perform worse than other driving conditions.

Disclosure of conflicts of interest:

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Appendix

Table 1. Questionnaire

Q1	***In comparison with 5 years ago, the frequency of your driving has been…***
A1	1. Limited, 2. The same, 3. Increased, 4. Don't know
Q2	***How many times, in the last 6 months, did you avoid driving because you were afraid of your driving skills?***
A2	1. Never, 2. Rarely, 3. Sometimes, 4. Many times
Q3	***How would you assess your driving performance now, in comparison to 5 years ago?***
A3	1. Worse, 2. Slightly worse, 3. The same, 4. Slightly better, 5. Better
Q4	***When you drive, do you believe that conversing with a passenger is dangerous?***
A4	1. Not at all, 2. A little, 3. Quite, 4. Very
Q5	***When you drive, do you believe that conversing through your handheld mobile phone is dangerous?***
A5	1. Not at all, 2. A little, 3. Quite, 4. Very
Q6	***During the last month, how often do you converse with a passenger while driving?***
A6	1. Never, 2. Rarely, 3. Sometimes, 4. Many times
Q7	***During the last month, how often do you converse through your handheld mobile phone while driving?***
A7	1. Never, 2. Rarely, 3. Sometimes, 4. Many times
Q8	***When conversing with a passenger while driving, do you usually speed down and be more careful?***
A8	1. Never, 2. Rarely, 3. Sometimes, 4. Often, 5. Always
Q9	***When conversing with a passenger while driving, do you usually try to keep larger headways?***
A9	1. Never, 2. Rarely, 3. Sometimes, 4. Often, 5. Always
Q10	***When conversing with a passenger while driving, do you usually drive to the "right" border of the road?***
A10	1. Never, 2. Rarely, 3. Sometimes, 4. Often, 5. Always
Q11	***When conversing through your handheld mobile phone while driving, do you usually speed down and be more careful?***
A11	1. Never, 2. Rarely, 3. Sometimes, 4. Often, 5. Always
Q12	***When conversing through your handheld mobile phone while driving, do you usually stop your vehicle in a safe place?***
A12	1. Never, 2. Rarely, 3. Sometimes, 4. Often, 5. Always
Q13	***When conversing through your handheld mobile phone while driving, do you usually try to keep larger headways?***
A13	1. Never, 2. Rarely, 3. Sometimes, 4. Often, 5. Always
Q14	***When conversing through your handheld mobile phone while driving, do you usually drive to the "right" border of the road?***
A14	1. Never, 2. Rarely, 3. Sometimes, 4. Often, 5. Always
Q15	***How many times, in the last year, have you experienced an argument with a passenger while driving?***
A15	0, 1, 2, 3, 4, 5, 6, 7, 8, 9+
Q16	***How many times, in the last year, have you experienced an argument with another driver while driving?***
A16	0, 1, 2, 3, 4, 5, 6, 7, 8, 9+
Q17	***How often do you use your seat belt while driving?***
A17	1. Never, 2. Rarely, 3. Sometimes, 4. Often, 5. Always
Q18	***How often do you drive under the influence of alcohol?***
A18	1. Never, 2. Rarely, 3. Sometimes, 4. Many times
Q19	***How often do you drive without being concentrated?***
A19	1. Never, 2. Rarely, 3. Sometimes, 4. Many times
Q20	***How many accidents have you experienced as a driver?***
A20	0, 1, 2, 3, 4, 5, 6, 7, 8, 9+
Q21	***How many times did you avoid an accident "at the very last moment", in the last two years?***
A21	0, 1, 2, 3, 4, 5, 6, 7, 8, 9+
Q22	***How many accidents with only material damages have you experienced as a driver, in the last two years?***
A22	0, 1, 2, 3, 4, 5, 6, 7, 8, 9+
Q23	***How many times have you violated the Traffic Code as a driver, in the last two years?***
A23	0, 1, 2, 3, 4, 5, 6, 7, 8, 9+
Q24	***How many times have you been fined because you violated the Traffic Code as a driver, in the last two years?***
A24	0, 1, 2, 3, 4, 5, 6, 7, 8, 9+

Table 2. Comparison of patients with brain pathologies and of a Control group with the use of the Wilcoxon Rank Sum Test

	Group of patients	Control group	P-values
Age, y, mean±SD	68.7±8.7	63.1±7.1	0.226
Driving experience, y, mean±SD	41.4±5.7	35.9±3.2	0.412
Kilometers driven/week[a], median (range)	3 (2-5)	3 (2-5)	1.000
Accidents (2 years) - reported, median (range)	0 (0-0)	0 (0-0)	1.000
Education, y, mean±SD	11.9±3.3	14.9±3.9	0.778

[a]1=1-20km; 2=21-50km; 3=50-100km; 4=100-150 and 5>150

Table 3. Questionnaire - Hypothesis Test Summary - Independent-Samples Kruskal-Wallis Test

ID	Question	Null Hypothesis	Sig.	Decision
Q1	In comparison with 5 years ago, the frequency of your driving has been…	The distribution **is the same** across "Controls" and Patients"	0,166	Retain the null hypothesis.
Q2	**How many times, in the last 6 months, did you avoid driving because you were afraid of your driving skills?**		**0,006**	Reject the null hypothesis.
Q3	**How would you assess your driving performance now, in comparison to 5 years ago?**		**0,000**	Reject the null hypothesis.
Q4	**When you drive, do you believe that conversing with a passenger is dangerous?**		**0,002**	Reject the null hypothesis.
Q5	When you drive, do you believe that conversing through your handheld mobile phone is dangerous?		0,563	Retain the null hypothesis.
Q6	**During the last month, how often do you converse with a passenger while driving?**		**0,048**	Reject the null hypothesis.
Q7	**During the last month, how often do you converse through your handheld mobile phone while driving?**		**0,000**	Reject the null hypothesis.
Q8	**When conversing with a passenger while driving, do you usually speed down and be more careful?**		**0,024**	Reject the null hypothesis.
Q9	**When conversing with a passenger while driving, do you usually try to keep larger headways?**		**0,006**	Reject the null hypothesis.
Q10	**When conversing with a passenger while driving, do you usually drive to the "right" border of the road?**		**0,000**	Reject the null hypothesis.
Q11	When conversing through your handheld mobile phone while driving, do you usually speed down and be more careful?		0,195	Retain the null hypothesis.
Q12	When conversing through your handheld mobile phone while driving, do you usually stop your vehicle in a safe place?		0,174	Retain the null hypothesis.
Q13	When conversing through your handheld mobile phone while driving, do you usually try to keep larger headways?		0,332	Retain the null hypothesis.
Q14	When conversing through your mobile phone while driving, do you usually drive to the "right" border of the road?		0,777	Retain the null hypothesis.
Q15	How many times, in the last year, have you experienced an argument with a passenger while driving?		0,397	Retain the null hypothesis.
Q16	How many times, in the last year, have you experienced an argument with another driver while driving?		0,847	Retain the null hypothesis.
Q17	**How often do you use your seat belt while driving?**		**0,044**	Reject the null hypothesis.
Q18	**How often do you drive under the influence of alcohol?**		**0,048**	Reject the null hypothesis.
Q19	How often do you drive without being concentrated?		0,213	Retain the null hypothesis.
Q20	**How many accidents have you experienced as a driver?**		**0,022**	Reject the null hypothesis.
Q21	**How many times did you avoid an accident "at the very last moment", in the last two years?**		**0,022**	Reject the null hypothesis.
Q22	How many accidents with only material damages have you experienced as a driver, in the last two years?		0,626	Retain the null hypothesis.
Q23	**How many times have you violated the Traffic Code as a driver, in the last two years?**		**0,049**	Reject the null hypothesis.
Q24	**How many times have you been fined because you violated the Traffic Code as a driver, in the last two years?**		**0,047**	Reject the null hypothesis.
	Asymptotic significances are displayed. The significance level is ,05.			

Figure 1. Questionnaire Box-Plots