Methods to evaluate the Fitness to Drive

The role of spatial skills and personality traits

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Abstract

A growing research interest has been devoted to the field of fitness-to-drive (FTD). While engineering sciences contributed developing immersive driving simulators for the evaluation of FTD, the contribution of psychological sciences has been less striking. The present contribution examines the results of a series of studies which investigated the role of spatial cognitive skills (study 1 and 2) and personality traits (study 3 and 4) in the evaluation of psychological FTD. The efficiency of driving simulators was compared with other FTD evaluation methods through a selective review and a scientometric analysis (study 5). Finally, the relationships between personality traits and aberrant driving were studied through the mediation of mind-wandering tendency in a multi-group analysis (study 6). Results suggests that the employment of measures of spatial skills and personality traits in the evaluation of FTD provides a cost-effective assessment supplement and a psychometric-standardized way to assess the psychological prerequisites of the driver.

Keywords

Driving behaviour; Fitness-to-drive; Spatial skills; Personality traits; Mind-wandering

General introduction

This series of studies investigated the contribution of spatial cognitive skills and personality traits to the assessment of psychological Fitness-to-Drive (FtD) during the driver's lifespan. Cognition and Personality are driving-related psychological dimensions influencing the driving performance and driving behaviour with effects on the risk of being involved in motor-vehicle crashes. Measures of spatial skills and personality traits are predictive of driving behaviours and can be used for both assessing and monitoring of FtD.

Three couple of studies are included. The first couple deal with the influence of spatial cognitive skills on the execution of complex driving behaviours. The predictive capability of spatial mental transformation skills (e.g., mental rotation and perspective taking) on prerequisites of FtD was investigated in a sample of young and old adults, controlling for both demographic variables and cognitive functioning (Study One). The relationship between measures of cognitive screening and prerequisites of FtD was investigated by studying the mediation role of spatial transformation skills in a sample of young, adult, and old male drivers (Study Two).

The second couple of studies examined the influence of normal and pathological personality traits on driving measures. Two models of driving-related personality traits (e.g., normal, and pathological) were compared twofold - with and without the influence of demographic variables - in predicting FtD in young and adult drivers (Study Three). Results were used to develop an assessment protocol for the evaluation of FtD able to discriminate Drinker Drivers from non-Drinker controls (Study Four).

The third couple includes secondary experimental studies respectively examining methodological and cultural aspects complementing the topic of the FtD assessment. In particular, the effectiveness of driving simulators in assessing FtD was compared – through a scientometric analysis and a selective review of reviews on simulated driving research - with other assessment methods in research and practice (i.e., on-road driving test and psychometric tests; Study five). Finally, the relationships between personality traits and driving behaviours were investigated in a cross-national perspective by studying the mediation role of Mind-Wandering in two samples of Australian and Italian drivers (Study Six).

Studies from one to four have been carried out within the project “Apulia Smart Drivers” granted by the Apulia Region, Italy (grant code: B34I19000180002). Study six was performed in collaboration with the Monash University Accident Research Centre, Melbourne (Australia).

Spatial skills

Spatial reasoning underlies many daily activities such as walking, arrange the dishwasher, or driving. It involves the ability to mentally represents features of objects in the environment as well as their movement through space. Spatial reasoning is assessed by examining spatial transformation skills. They involve the ability to imagine/monitor the movement of 3-dimensional objects in the space (i.e., object-based transformations) or to mentally change the personal perspective (i.e., self-based transformations). Object-based and self-based spatial mental transformations, often measured by using the Mental Rotation Task (Vandenberg and Kuse, 1978) and Perspective Taking Task (Kozhevnikov and Hegarty, 2001), play a key role in mentally transforming spatial and are related to spatial updating during navigation (Wolbers and Hegarty, 2010; Wolbers and Wiener, 2014). Ruginski et al. (2019) demonstrated that long-term GPS use negatively affects mental rotation and perspective taking skills that, in turn, were found to be associated with negative environmental learning outcomes (Muffato et al., 2017). Both Mental rotation and perspective taking skills could gain importance also in navigation by car, supporting complex behaviors connected to driving when speed is significantly higher and therefore decision times must decrease.

Despite the visuo-spatial domain is considered 'as classic' in the assessment of FTD, little is known about the relationship between basic spatial mental transformation processes, namely—mental rotation and spatial perspective taking—and measures of FTD.

Study 1

The relationships between measures of cognitive screening, self-and object-based spatial transformation skills, and driving performance were investigated in a sample of younger and older adult drivers (Tinella et al., 2020). One hundred younger and 83 older adult Italian drivers completed a computerized driving test which assessed the resilience of attention to traffic stress, visual and motor reaction times, and the perceptual speed. The Mental Rotation Test (MRT) and the Object Perspective Taking Test (OPT) were administered to assess object-based and self-based spatial transformation skills while the Montreal Cognitive Assessment Test (MoCA) was administered as cognitive screening. The effects of age, gender, and education were also controlled in the analysis. Analysing results, the effect of age, favouring younger participants, was found in all driving skills. The influence of global cognitive functioning was found in resilience of attention and perceptual speed. The effect of the spatial transformation tests was found on resilience of attention, reaction speed (mental rotation only), and perceptual speed (perspective-taking only). Taken together, these results have shown the specific contribution of spatial mental transformation skills in the execution of complex behaviors connected to the fitness to drive. The results relating spatial mental transformation skills and driving processes may be a valuable source of knowledge for researchers dealing with the relationship between cognitive resources and navigation aids.

Study 2

In study two (Tinella et al., 2021a) the hypothesis that the relationship between general cognitive status and FtD is mediated by spatial transformation skills along the lifespan was tested. The performance in the MRT and the OPT of 175 male active drivers (aged from 18 to 91 years), was collected by administering the MoCA as cognitive screening. As in the previous study, all participants were submitted to a computerized driving assessment measuring resilience of attention, reaction speed, motor speed, and perceptual speed. Significant results were found for the effect of global cognitive status on perceptual speed through the full mediation of both mental rotation and perspective-taking skills. The indirect effect of global cognitive functioning mediated by mental rotation was only found to significantly predict resilience of attention whereas the indirect effect mediated by perspective taking was found to significantly predict perceptual speed only. Finally, the negative effect of age was found on each driving measure. Despite limited to male drivers, results suggested that general cognitive efficiency is linked to spatial mental transformation skills and, in turn, to driving-related cognitive tasks, contributing to fitness-to-drive along the driver's lifespan.

Personality traits

Personality significantly affects much of what we do as humans (Nichols, 2012). Research on driving behaviour established that personality traits are distal (Sümer, 2003) or extrinsic-to-driving factors (Elander et al., 1993) which indirectly influence the likelihood of being involved in traffic accidents through their effects on more proximal (or intrinsic-to-driving) factors. Several studies examined the relationships between some personality traits and aberrant driving tendency by showing as measures of neuroticism, extraversion, sensation seeking, and impulsivity are significantly associated with driving behaviours of young and old drivers. Yet, less is known on the effects of pathological personality traits (i.e., individual differences in personality traits that could affects clinical problems). Since psychopathological personality traits may adversely affect cognitive and motor skills involved in driving performance, the assessment and detection of pathological traits in the non-clinical driving population might be a key aspect in a preventative perspective.

Study 3

The third study (Tinella et al., 2021b) compared two MMPI-2-based models of normal and pathological personality traits (i.e., Inventory of Driving-related Personality Traits - IVPE-MMPI vs. Personality Psychopathology Five - PSY-5 scale) in predicting cognitive prerequisites of FtD. One hundred young and eighty-seven adult active drivers completed the MMPI-2 questionnaire as a measure of personality and completed the above-mentioned computerized driving task. The effects of age, gender, and education were also controlled. Results showed that the models controlled for demographic variables overperformed those neglecting them for each driving outcome (resilience of attention, motor speed, reaction speed, and perceptual speed). A negative effect of age was found on each driving task; the effect of gender, favouring males, was found in both the reaction and the motor speed, and the effect of education was found on the resilience of and the perceptual speed. Concerning personality traits, significant effects were found of sensation seeking (IVPE-MMPI) on each outcome; of anxiety (as a measure of emotional instability; IVPE-MMPI) and introversion (PSY-5) on motor speed; and of psychopathic deviation (as a measure of self-control; IVPE-MMPI) on the resilience of attention. The study confirmed the key role of demographic factors in influencing the FtD, further suggesting the usefulness of some MMPI2-based personality scales of normal and pathological traits in the assessment of driving-related personality determinants.

Study 4

The fourth study (Tinella et al., 2021) aimed to investigate the effectiveness and the consistency of selected variables of different psychological driving-related psychological dimensions (i.e., cognition, personality, behaviour) in discriminating ninety male drinker drivers (DD) from matched non-drinkers drivers. The MoCA, the MRT, and the OPT were administered to assess global cognitive functioning, and object- and self-based spatial transformation abilities, respectively. Participants completed the aforementioned computerized driving test. The Personality Psychopathology Five scales, the validity scale, and the dissimulation index were scored from the MMPI-2. A logistic binomial regression analysis (backward subtraction method) was used to identify discriminant predictors. A prediction analysis (ROC curve method) was performed on the final model. Results showed that the performance in mental rotation test, resilience of attention task, and the personality measures of Psychoticism, Discostraint, Negative-Emotionality, and Introversion significantly discriminated Drinker drivers from their matched controls with moderate to good values of accuracy (0.79), sensitivity (0.80), and specificity (0.79), as well as a good AUC value (0.89). In some cases, the personality dimensions provided-reliable-unexpected results. Low scores of Psychoticism, Negative-Emotionality, and Introversion were found to predict the membership to the DD group; the tendency to response management seemed to influence the responses of DD. In sum, personality measures should be assessed with particular attention in a forensic context because they are more prone to be feigned than cognitive ones. Overall, the present study confirmed the relevance of integrating different driving-related psychological dimensions in the evaluation of fitness-to-drive showing the usefulness of standardized tools for the reassessment of drinker drivers.

Methods to evaluate the FTD

The assessment of FtD aims at both evaluating the driver's possession of requirements (i.e., perceptual, physical, and cognitive abilities) needed to safely manage the vehicle and at detecting potential sources of dangerous driving (i.e., physical, and mental impairments). To this end, several assessment methods have been employed in both clinical practice and research including the on-road driving test, the simulated driving test, and laboratory tests (i.e., psychometric neuropsychological evaluation). An important distinction can be made between on-road and off-road assessment methods. While the former refers to the actual driving of a motor-vehicle in the real world the second includes laboratory-based psychometric evaluation of both cognitive abilities (i.e., paper and pencil tests) and/or driving skills (i.e., computerized driving tests and driving simulators).

Study 5

The study five (Caffò et al., 2020) proposed a scientometric analysis and a selective review of reviews on simulated driving research with the aim of investigating both the academic productivity in the field and the effectiveness of driving simulator as a tool for the assessment of FtD. The performance analysis has shown as, within the last forty years, United States and Germany were the first two Countries for number of driving simulation reviews. United States was the leading Country with 5 Institutes in the top ten (i.e., University of Florida, Yale University, University of Iowa, University of Massachusetts, and University of Michigan). Top Authors wrote from 3 to 7 reviews each and belong to Institutes located in North America and Europe. A cluster analysis on authors' keywords was performed to identify relevant associations between different research topics revealing three clusters and eight keywords. The selective review of reviews showed a substantial agreement for supporting validity of driving simulation with respect to neuropsychological and on-road testing, while for fidelity with respect to real-world driving experience a blurred representation emerged. The most relevant critical issues were the a) lack of a common set of standards, b) phenomenon of simulation sickness, c) need for psychometric properties, lack of studies investigating d) predictive validity with respect to collision

rates and e) ecological validity. Overall, results clearly demonstrated that driving simulation represents a cross-cutting topic in scientific literature on driving, and there are several evidence for considering it as a valid alternative to neuropsychological and on-road testing. Further research efforts could be aimed at establishing a consensus statement for protocols assessing fitness to drive, in order to (a) use standardized systems, (b) compare systematically driving simulators with regard to their validity and fidelity, and (c) employ shared criteria for conducting studies in a given sub-topic.

Distracted driving

Drivers can be distracted by either external or internal sources of distraction. External distractions include secondary tasks initiated by the driver (e.g., texting) and specific events/cues that attract the driver's attention (e.g., advertising signs). Internal distractions, instead, include inattention to driving tasks due to shifted focus toward internal thoughts (i.e., worries). The 'mind wandering' (MW), an internal distraction, describes the attention diversion away from the current primary task toward internal mentation (Smallwood & Schooler, 2006). Despite MW is associated with some personality traits and it may determine risky behaviours, the relationships between these three variables have not been previously investigated together.

Study 6

The last study (Tinella et al., 2022) of the contribution was an attempt to study the influence of personality on both mind-wandering tendency behind the wheel and on aberrant driving behavior in a cross-cultural perspective. To this aim, the collaboration with the Monash University Accident Research Centre (MUARC), a well-recognized research institution for its multidisciplinary approach to safe mobility, allowed to compare Australian and Italian groups of drivers. This study represented a stopgap to deal with the COVID-19 outbreak proceeding through safe survey methods of data collection. In particular, the research examined the relationships between personality traits (i.e., neuroticism, extraversion, openness, agreeableness, and conscientiousness) and aberrant driving behavior in a sample of Australian and Italian drivers by investigating the mediation effect of Mind Wandering (MW) tendency. Nine-hundred-four active drivers (50% Australians, 50% Italians) completed an online survey evaluating self-reported personality traits, driving behaviors, and MW tendency. A multi-group path analysis showed that MW tendency significantly mediated the effects of neuroticism, extraversion, and conscientiousness on aberrant driving behavior with invariances across nationality groups. Results suggested that the association between personality and driving behaviors is partially explained by the driver's tendency to MW while driving.

General conclusions

Concluding, the employment of measures of spatial skills and personality traits in the evaluation of FtD provides a cost-effective assessment supplement and a psychometric-standardized way to assess the psychological prerequisites of the driver. These measures may be useful in the clinical practice for the screening of 'at-risk' drivers necessitating more in-dept assessments such as when a subtle cognitive weakness or a pathological personality trait may have a detrimental impact on safety driving skills. Moreover, occupational therapists may consider measures of both spatial transformation skills and personality traits employed in this study for the training/rehabilitation of driving abilities (i.e., for learner drivers and impaired driving skills), for the discrimination of drinkers drivers, and the determination of the tendency to mind-wandering behind the wheel.

The adoption of spatial transformation tests and driving-related personality questionnaires seems a promising way to approach clinical, training, and rehabilitation needs. They can be employed in addition to standard FtD assessment tools and to plan driving safety interventions.

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