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Risky driving and the persistent effect of a randomized intervention focusing on impulsivity: The role of the serotonin transporter promoter polymorphism

Diva Eensoo[a], Marika Paaver[b], Mariliis Vaht[c], Helle-Mai Loit[d], Jaanus Harro[c,*]

[a] Division of Public Health, Department of Family Medicine and Public Health, University of Tartu, Estonia
[b] Department of Psychiatry, University of Tartu, Estonia
[c] Division of Neuropsychopharmacology, Department of Psychology, University of Tartu, Estonia
[d] National Institute for Health Development, Tallinn, Estonia

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ABSTRACT

Road traffic accidents are a serious public health issue, and real-life traffic offences are an excellent indicator of the behavioural tendencies of impulsivity and risk-taking. We have previously reported on short-term efficacy of a brief intervention in driving schools to reduce traffic risks (Paaver et al., Accid. Anal. Prev., 2013; 50, 430–437), and have now addressed the question of whether does the impact of the intervention last for a few years, and whether traffic behaviour and the intervention effect are associated with the serotonin transporter polymorphism (5-HTTLPR) genotype as the central serotonin system is strongly associated with impulse control. Participants of the study were 1866 novice car-drivers (mean age 23.0, SD = 7.2 years). Data on traffic violations were obtained four years after intervention from the police database and on traffic collisions from the national traffic insurance database. DNA samples were available for 767 participants and 5-HTTLPR genotypes were classified using the triallelic model. For the observation period after the intervention, speeding, drunk driving and involvement in traffic accidents were significantly lower in the intervention group. 5-HTTLPR genotype was associated with traffic behaviour: The S'-allele carriers had significantly lower odds for speeding offences and traffic accidents. The lower prevalence of S'-allele carriers among those who had committed speeding offences was statistically significant in females, while the lower prevalence of having been involved in a traffic accident was rather observed in males. Statistically significant intervention effects were observed only in the L'/L' homozygotes who had higher prevalence of traffic incidents. Conclusively, the brief intervention in traffic schools had a significant impact on traffic safety within subsequent four years, and traffic behaviour was associated with the serotonin transporter genotype. These findings suggest that subjects who are less likely to self-regulate their driving habits while gaining experience would benefit from training of impulsivity recognition.

1. Introduction

Road traffic injuries are a leading cause of preventable death, and changing road user behaviour is critically important in enhancing traffic safety (World Health Organization, 2015). While many factors contribute to unsafe practices in traffic behaviour (Ouimet et al., 2015; Panayiotou, 2015; Sagberg et al., 2015; Smorti and Guarnieri, 2016; Fuermaier et al., 2017), impulsive action appears as a common denominator in many violations and accidents (Bicaksiz and Özkan, 2016), and may be particularly significant in young people (Hatfield et al., 2017). We have previously shown that a brief psychological intervention may significantly decrease speeding, drunk driving and traffic accidents in novice drivers during their first year in traffic (Paaver et al., 2013). This intervention was theoretically guided by the affective neuroscience concept (Panksepp, 1998) and aimed at acknowledging of personal impulsive tendencies, so that subjects of intervention could build their own strategies to reduce personal risk. The technique is simple and straightforward and could potentially bring about substantial benefits to public health, but whether the effect of intervention would persist for longer periods after obtaining the driver's licence has remained a salient but unanswered question. Further, it appears important to figure out whether the efficacy of this kind of

* Corresponding author at: Jaanus Harro, Division of Neuropsychopharmacology, Department of Psychology, University of Tartu, Estonian Centre of Behavioural and Health Sciences, Ravila 14A, 50411 Tartu, Estonia.
E-mail address: jaanus.harro@ut.ee (J. Harro).

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intervention is predictable as based on inter-individual differences.

The serotonin system of the brain is strongly associated with impulse control (Evenden, 1999; Kreek et al., 2005; Cunningham and Anastasio, 2014). Substantial deviations from the average level of serotonergic function, as indirectly indicated by platelet monoamine oxidase measures (Harro & Oreland, 2016), have also been associated with police-referred drunk driving and speeding violations (Eensoo et al., 2004, 2005; Paaver et al., 2006). The most universal regulator in serotonergic neurotransmission is the serotonin transporter that carries out the reuptake of serotonin from synaptic clefts. The serotonin transporter gene has a promoter polymorphism that directly influences serotonin transporter expression, with the short (S) allele associated with less expression as compared to the long (L) allele (Heils et al., 1996). In turn, the L-allele has been found to contain a single nucleotide polymorphism leading to two isoforms, L_A and L_G, the latter being functionally similar to the S allele (Hu et al., 2006). Since the original report that the S-allele is associated with vulnerability to anxiety and depression (Lesch et al., 1996), several thousands of investigations have been conducted on the association of this functional gene variant with brain function and behaviour. Conclusively, the S-allele carriers have higher expression of anxiety-related traits and increased activity in corticolimbic brain structures potentially underlying the hypervigilance and increased social conformity (Homberg and Lesch, 2011). Given that the sensitivity to adverse life events is related to the number of S-alleles (Caspi et al., 2003), it is not surprising if the S-allele carriers and in particular S/S homozygotes appear as striving towards a more protected lifestyle (Kiive and Harro, 2013). This could lead to safer practices in traffic behaviour. However, there are reports that the S-allele may under some circumstances be associated with high impulsivity (Steiger et al., 2005; Paaver et al., 2007, 2008) and this in theory should be associated with premature actions and potentially with risk-taking, including in traffic. Indeed, one study has found that the S/S homozygotes drink more at bars, and have higher level of intention to drive thereafter while intoxicated (Thombs et al., 2011). Taking into consideration that the bulk of evidence suggests 5-HTTLPR to be the "plasticity genotype", carriers of the S-allele being more adaptive to the environment (Homberg and Lesch, 2011), we hypothesized that the S-allele carriers should have lower frequency of traffic incidents severe enough to be recorded as violations or accidents.

Males are more likely to be injured and killed in traffic accidents (European Commission Directorate General for Transport, 2016). Indeed, occurrence of injuries is strongly related to risk-taking behaviour (Catalano et al., 2012) and many studies suggest that males display more risky behaviour in traffic (Ibrahim et al., 2015; Paaver et al., 2013; Twisk et al., 2013). Because the intervention method used was aiming at acknowledgement of personal impulsive tendencies and their implications to own behaviour, it was assumed that male traffic record could be improved to a larger extent. As to the potential role for the 5-HTTLPR genotype as a predictor of intervention effect, gender-related differences could also be expected: Interaction effects have demonstrated that gender strongly modulates the relationship between 5-HTTLPR genotype and expression of anxiety by moderating the function of amygdala, one region of the affective neural network specifically involved in the anxiety-like behaviours (Cerasa et al., 2014). Furthermore, health-related behaviours had previously been found to associate with the 5-HTTLPR genotype in a gender-dependent manner (Vaht et al., 2014).

In summary, we had the following aims: First, to re-examine the efficacy of the intervention four years later; second, to clarify whether or not is the 5-HTTLPR genotype associated with traffic offences and accidents; third, to examine whether the impact of intervention on risky driving depended on the 5-HTTLPR genotype. In all analyses, gender was considered as a potentially salient factor.

2. Methods

2.1. Participants

The sample was formed as a part of the Estonian Psychobiological Study of Traffic Behaviour for the module of intervention studies as previously described in detail (Paaver et al., 2013). In brief, 1866 students in a total of 113 successive training groups of 24 driving schools participated in this study. All members of these groups (n = 1977) had been invited to participate, and of these 94.4% signed informed consent form and returned filled questionnaires. The driving school training groups consisted of 20–25 attendees and were randomized into intervention and control condition according to the starting time of the classes: Every first and second group of students was assigned to the intervention condition (initial n = 1349) and every third group was assigned to the control condition (initial n = 517). Students who should have belonged to the intervention group but missed the intervention seminar (n = 291) were separated from the intervention group and were classified as "lost", making the size of the intervention group n = 1058. Subjects also filled in self-reported personality and behavioural measures. Blood samples were drawn from 767 subjects (41% of the whole sample). All the subjects were of Caucasian origin, and signed an informed consent form. This study was approved by the Tartu University Ethics Review Committee on Human Research.

2.2. Intervention procedure

In brief, the intervention was carried out as a regular driving school lesson that was not provided to the control group (Paaver et al., 2013). It was administered as a seminar composed of a lecture (45 min) and group work (45 min). Lectures were carried out by skilled psychologists with a PhD or MSc degree, and with experience in teaching and leading teamwork. The lecture focused on three themes: (1) impulsivity as a personality feature and information processing style that is biologically determined and can lead to risky behaviour in traffic; (2) different types of impulsivity, how these are related to risk-taking and how to recognize own impulsive tendencies; and (3) potential situational factors triggering impulsive behaviour, with encouragement to note such situations in which the participants themselves are likely to behave impulsively or take excessive risks. The lecture was interactive, provoking subjects to evaluate their level of impulsiveness on worksheets in their handouts. In groupwork, participants identified the psychological factors involved in real life traffic accident cases, estimatied their own risk for each kind of traffic accident, and generated ideas how to mitigate risks.

2.3. Traffic behaviour outcome measures

Traffic violations and traffic accidents were recorded for the period of four years following the intervention using databases of the traffic police and traffic insurance fund. The traffic behaviour measures analyzed were speeding (penalties for exceeding the speed limit) and drunk driving (penalties for drunk driving with an estimated blood alcohol level of 0.2‰ or more). The accidents where the subject was at fault were classified as active and other accidents as passive.

2.4. Genotyping

Seven hundred and sixty seven participants (41% of the sample) had agreed to donate a blood sample and all but one were successfully genotyped. The proportion of participants agreeing with blood sampling was similar in control and intervention groups. Genomic DNA was extracted from whole blood samples using the QIAamp Midi Kit (Qiagen), and genotyping for the triallelic classification was performed according to Anchordoquy et al. (2003) as described in detail elsewhere (Tomson et al., 2011). Genotype frequencies were in Hardy-Weinberg