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Impulsivity and risky decision making among taxi drivers in Hong Kong: An event-related potential study

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ABSTRACT

Taxi drivers play an important role in providing safe and professional public transport services. However, they tend to be more involved than other professional driver groups in accidents caused by deliberate recklessness. This study used an event-related potential (ERP) experiment to examine risk-taking behavior arising from impulsivity by comparing the underlying neural processes of taxi drivers with and without traffic offence records in Hong Kong. A sample of 15 traffic offenders and 15 nonoffenders, matched by sociodemographic characteristics, was recruited. The results show that the offender group demonstrated significantly less negative-going (less negative) feedback-related negativity but more positive-going (more positive) feedback-related P300 when than with their nonoffending counterparts. These findings show that taxi drivers with traffic offence records were less sensitive to the consequences of behavior and more attuned to the magnitude of potential reward. In addition, behavioral data revealed that they were more willing to make risky decisions. All these characteristics pertain to impulsive personality traits. Based on these findings, we can conclude that the offenders in this sample were more impulsive than their nonoffending counterparts.

1. Introduction

Taxi driving is a high-risk occupation (Johnson et al., 1999). Taxi drivers are particularly at risk of motor vehicle crashes and related injuries due to their high occupational exposure to the hazardous road environment (Lam, 2004; Tseng, 2013). A number of studies show that people who drive as part of their occupation are at higher risk of accidents than the general driving population (Broughton et al., 2003; Dimmer and Parker, 1999; Lynn and Lockwood, 1998). In Hong Kong in 2012, the crash rate per 100,000 registered taxis was 23.38, 16.8 times higher than for registered private cars (Transport Department of Hong Kong, 2013). This statistic represents only the more serious types of collisions that can occur on the road; that is, accidents causing fatal, serious, or minor injuries. It does not include minor incidents that did not involve a fatality, injury, or towing of the vehicle(s).

Taxi drivers play an important role in providing safe and professional public transport. They spend much more time on the road than the average driver. As a result, they have generally been regarded as a unique group of drivers by researchers, with several studies having looked at their behavior behind the wheel. For example, Burns and Wilde (1995) report that taxi drivers who used excessive speed and were careless in changing lanes were characterized by high-risk personality traits. Clarke et al. (2009), in their study of work-related road traffic collisions in the UK, conclude that taxi drivers are the only group of professional drivers (including users of company cars, vans/pickups, heavy goods vehicles, and buses, as well as emergency vehicles such as police cars, fire/rescue trucks, and ambulances) to demonstrate over involvement in collisions caused by deliberate recklessness. It is easy for the ordinary person to observe that many taxi drivers tend to drive quickly towards waiting passengers in order to pick them up, and then carry them to their destination at high speed; to stop in restricted areas; and to make illegal U-turns. Taxi drivers' income depends mainly on the number of fares they pick up. In the circumstances, it is

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common for them to engage in risky driving (Peltzer and Renner, 2003; Rosenbloom and Shahar, 2007).

Other than the nature of the job itself, studies also show that having an impulsive personality contributes significantly to risk-taking behavior (Dahlen et al., 2005; Oltedal and Rundmo, 2006; Schwebel et al., 2007; Ulleberg and Rundmo, 2003). Impulsivity has even been suggested as the characteristic that most reliably differentiates offenders from nonoffenders (Pallone and Hennessy, 1996). It is a multidimensional personality construct that has been defined variously as an inability to wait, a tendency to act without forethought, an insensitivity to consequences, and an inability to inhibit inappropriate behaviors (Eysenck, 1993). A person with a preference to act impulsively tends to focus on immediate rewards (McClure et al., 2004). Risky driving behavior is well known to be associated with driving violations (Junger et al., 2001; Machin and Sankey, 2008) and traffic accidents (Lucidi et al., 2010). Such behavior presents a danger not only to taxi drivers themselves, but also to their passengers and other road users.

Studies examining risk-taking behavior among drivers have at least two methodological limitations. Firstly, most employ self-report questionnaires. It is well known that self-reported data have shortcomings. They are subject to response styles, demand characteristics, and imperfect recall of retrospective events. The socially-desirable answers are clear, and individuals may therefore seek to present themselves in a positive manner. Secondly, most of the measures used in such research are general inventories unrelated to the specific behavior under study. The internal validity of findings obtained using this hypothetical proxy for risk-taking behavior or making risky decisions is open to question. However, more recently, objective behavioral measures have gained prominence, since they enable researchers to assess risk-taking behavior directly, in real-life situations. For instance, the Iowa Gambling Task (IGT) has been shown to correlate significantly with risk-taking behaviors as well as the likelihood of participating in illegal or dangerous activities (Lev et al., 2008).

With advances in cognitive neuroscience, the underlying neural processes of risk taking and risky decision making can be objectively explored. Brain imaging studies indicate that the frontolimbic brain circuits involving the ventromedial prefrontal cortex, amygdala, insula, ventral striatum, and anterior cingulated cortex (ACC), are all implicated in risk processing. In particular, the ACC is important for detecting and evaluating unfavorable outcomes (Bush et al., 2000; Luu et al., 2000), and risk assessment (Ernst et al., 2004; Fukui et al., 2005; McCoy and Platt, 2005). Greater ACC activity predicts less risk-taking behavior (Paulus and Frank, 2006). Studies using event-related potentials (ERP) show that the human brain is able to evaluate the outcome of actions within a few hundred microseconds. Specific brain potentials are elicited by self-generated responses and performance feedback (Holroyd and Coles, 2002). The feedback-related negativity (FRN), defined as the mean amplitude of the ERP response to the loss or gain outcome in the 250–350 ms time window post onset of feedback, has been found to be sensitive to outcome valence. The violation of expectations and smaller magnitude elicit more negative FRN (Wu and Zhou, 2009). FRN is believed to originate from the ACC (Debener et al., 2005; Gehring and Willoughby, 2002), so it may reflect similar mechanisms of monitoring and controlling behavior. It has been suggested that the ACC uses reinforcement learning (RL) signals conveyed by the midbrain dopamine system to optimize future decision making (Holroyd and Coles, 2002). According to RL theory, FRN reflects a consequence prediction error signal in the ACC that occurs when ongoing events turn out worse than expected. Subsequently, the ACC triggers an adaptive modification of behavior by relating actions to their consequences (Holroyd and Coles, 2002; Rushworth et al., 2004).

Another component of ERP that has been shown to carry important information about decision making and reward processing is the feedback-related P300. This is a parietally distributed positivity occurring at approximately 300–400 ms post onset of feedback (Ma et al., 2008; Yeung and Sanfey, 2004). According to Nieuwenhuis et al. (2005), the P300 is linked to the noradrenergic system and locus coeruleus activity, and its amplitude is thought to reflect the evaluation of an immediate stimulus and the resulting decision making. It is sensitive to the magnitude of reward, with a more positive amplitude (positive-going P300) linked to a larger rather than smaller reward (Sato et al., 2005; Wu and Zhou, 2009; Yeung and Sanfey, 2004).

In light of these considerations, this paper reports on a laboratory-based ERP experiment using a modified version of the IGT to examine the risk-taking behavior of taxi drivers with a record of traffic offences. This approach was chosen in order to explore the role of impulsivity as well as the underlying neural processes involved in such decision making. The findings from the taxi drivers were then compared with a sample of their nonoffending counterparts. We predict that taxi drivers with a record of traffic offences would be more sensitive to the amplitude of reward but less sensitive to outcome consequences, and be more willing to take risks than nonoffenders.

2. Methods

2.1. Participants

All participants were recruited by convenience sampling from taxi companies and driving improvement courses at designated driving schools in Hong Kong. The general inclusion criteria for all participants were: (1) having at least five years of post-license taxi driving experience; (2) having worked as a full-time taxi driver for the last three years with an annual mileage of at least 50,000 km; (3) willingness to give written informed consent to participate in the study and have their driving record checked; and (4) sufficiently literate to read and understand simple questions. Specific inclusion criteria for traffic offenders were: (1) having committed and been held legally responsible for at least four traffic offences during the past two years and (2) having accumulated 12 or more Driving Offence Points (DOP)[1] during the same period of time, leading to a requirement to attend and complete a driving improvement course at a designated driving school. The sociodemographic characteristics of the control (nonoffender) group were matched with those of the traffic offender sample. They were also screened by telephone in order to ensure that they had not received any DOP during the preceding two years. However, participants were not informed that they had been selected for the study on the basis of their driving records.

With reference to the sample size of previous ERP studies (Fort et al., 2013; Martin and Potts, 2009; Wester et al., 2008), 15 traffic offenders were matched with 15 nonoffenders in this study. The majority of the participants were male. The mean age of the traffic offenders was 49.21 years (SD: 8.45), mean post-license driving experience was 27.87 years (SD: 7.92), and mean annual taxi mileage was 75,302.27 km (123,658.91). The mean age of the nonoffenders was 46.53 years (SD: 10.13), mean post-license driving experience was 23.21 years (SD: 8.78), and mean annual mileage was 72,560.48 km (147,239.25). Table 1 summarizes the demographic characteristics of the two groups. No statistically significant differences were found between them. Ethical approval was obtained (reference number: HSEARS20130104001) from the

[1] DOP are issued for discrete driving violations such as, for example, crossing double white lines (3 points) and “jumping” a red light (5 points).