

The Effects of Dexamphetamine on Driving Performance

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Background

As the number of drug related road fatalities is not decreasing in Australia (Drummer, 1994; Drummer 1998; Drummer & Gerostamoulos, 1999), considerable research is being conducted to reduce mortality and morbidity caused by driving under the influence of drugs other than alcohol. Stimulants are increasingly recognised as potentially important causes of driving fatalities in Australia, with the most recent report indicating that 4.1% of drivers killed over a 10-year period, tested positive to stimulants (Drummer, *et al.*, 2003).

Determining the relationship between drug consumption and driving impairment is intrinsically fraught with difficulties. Generally, driving ability is assessed through either epidemiological investigations or experimental approaches. Epidemiological studies provide the most accurate representation of driving patterns *in situ*, however, as they lack experimental control, inferring causation remains problematic. Conversely, experimental studies employing simulated driving and/or cognitive tasks have the advantage of greater control over causation but may not easily translate to real-life driving situations.

Epidemiological research demonstrating the likely effects of amphetamine on driving performance has generally involved the analysis of specimens and driving behaviours observed from drivers that have been arrested for traffic violations or killed in road crashes. However, such data generally combines all subtypes of amphetamines as one class, ignoring subtle differences between the related compounds or drivers who are not involved in dangerous driving or accidents.

Epidemiological studies that have observed driving patterns while under the influence of amphetamines is scarce. However, of the little literature available, typical driving behaviours that have been observed in drivers under the influence of methamphetamine include drifting out of the lane, erratic driving, weaving, speeding, drifting off the road, an increase in risk taking, and high speed collisions (Logan, 1996). Whereas, in terms of MDMA, reckless driving, disturbance of equilibrium, and impaired tracking ability have been reported (Omtzigt *et al.*, 1994).

Similar to epidemiological research, there is little published experimental research evaluating the effect of amphetamines on simulated driving. In terms of MDMA, vehicle control has been shown to be only marginally affected after self-administration of MDMA, whereas, accepting higher levels of risk while under the influence has been more readily observed (De Waard, *et al.*, 2000). However, this lack of gross impairment seen in De Waard's *et al* study may have been due to the considerably low dose of MDMA consumed. It is thus difficult to draw conclusions in relation to whether amphetamine administration causes driving impairment, as the available data is limited and relates only to MDMA doses considerably lower than those typically used recreationally.

In contrast to epidemiological and simulated driving studies, there is a considerable body of knowledge relating the effects of amphetamines on cognitive and behavioural processes believed to be related to driving. However, the literature also varies, with some studies reporting a notable improvement in performance following dexamphetamine administration (de Wit *et al.*, 2002; Wachtel and de Wit, 1999; Cami, *et al.*, 2000; Halliday *et al.*, 1994; Fleming *et al.*, 1995), whilst other studies reporting a decrease in performance with dexamphetamine (Ward *et al.*, 1997; Mills *et al.*, 2001; Hurst, 1962, 1967; Logan, 1996; de Waard *et al.*, 2000; Logue, *et al.* 1992; Evenden & Ryan, 1996). The inconsistency in research findings indicates that cognitive functioning appears to vary as a function of dose, where at lower doses, amphetamines seem to either promote cognitive functioning or have little effect, whereas, at much higher doses, the literature indicates that amphetamines impairs performance.

In summary, it may be tentatively hypothesised from the epidemiological, behavioural and driving simulation research that amphetamines are related to reckless driving, which may in turn contribute to drug-related driving fatalities. However, as that research is limited and inconsistent, further research directly assessing the effect of amphetamines on driving behaviours is required to experimentally confirm this hypothesis. Therefore, in order to help clarify whether amphetamine, specifically dexamphetamine, does impair driving abilities and if so which abilities, the present study examined the effects of dexamphetamine on a range of simulated driving processes.

Methodology

Twenty healthy non-fatigued participants (10 males; 10 females) aged between 21 and 32 years ($M = 25.4$ years, $SD = 3.3$ years) with a valid, full drivers license, completed two treatment conditions: placebo and 0.42mg/kg Dexamphetamine tablet. Dexamphetamine sulphate (5mg Dexamphetamine tablets, Sigma Pharmaceuticals Pty Ltd, Victoria, Australia) was prepared by mixing 0.42mg/kg dose of Dexamphetamine tablets with flour, which was encapsulated in three soft gelatine capsules, to render them visually indistinguishable from the placebo capsules. A repeated measures counter-balanced, double blind, placebo controlled design was employed.

During each session participants completed a driving simulator task and sobriety tests. The driving test consisted of four tasks, 'freeway traffic driving' and 'city traffic driving' in both day and night conditions. A subset of 34 relevant variables was analysed, each reflecting an error that can occur during the driving tasks, and subsequently all adjusted variable scores were summed to give an overall impairment score (Papafotiou *et al.*, 2001). The variables were summed separately for the day and night conditions. Two blood and saliva samples were obtained at 120 and 170 minutes after drug administration during each session.

Analyses and Results

Data was analysed separately for the day (freeway and city combined) and night driving tasks (freeway and city combined). For each of the day and night conditions, a test of difference in proportions based on paired data (Newcombe, 1998) was performed to establish whether there was any relationship between overall driving ability and the presence of dexamphetamine. The second set of analyses conducted was a series of Wilcoxon signed-rank tests. These explored the effects of dexamphetamine on each individual driving simulator variable.

The level of dexamphetamine in blood and saliva at 120 minutes after drug administration was 83.16 ng/ml and 78.77 ng/ml respectively, and at 170 minutes after drug administration was 98.42 ng/ml and 80.72 ng/ml respectively.

Overall driving impairment was significantly greater in the dexamphetamine condition relative to placebo condition for the day time driving condition, $p < 0.05$, 95% CI = -0.528 to -0.028. However, dexamphetamine did not affect overall driving ability during the night time driving condition, $p > 0.05$, 95% CI = -0.230 to 0.230.

During the day time driving tasks there were a number of signalling impairments observed in the dexamphetamine condition, such as at intersections, when entering a freeway, and during lane changes. Additionally, drivers in the dexamphetamine condition failed to stop at a red traffic light more frequently than during the placebo condition. A difference was also found between both treatment conditions in the speed the vehicle was travelling on a freeway when an emergency situation occurred, with more drivers in the dexamphetamine condition travelling at a slower speed than during the placebo condition.

During the night driving task a trend towards a decrease in reaction time was observed in the dexamphetamine condition.

Discussion

The findings indicated that 0.42mg/kg dexamphetamine significantly impaired simulated driving performance for the day driving condition only, when blood and saliva dexamphetamine concentration levels were approximately 90 ng/ml and 80 ng/ml respectively. This driving impairment was observed with relatively low dexamphetamine blood concentration levels compared to the levels found in drivers involved in road accidents and fatalities. Specifically during the daytime driving tasks, dexamphetamine was found to affect signalling and traffic light adherence, and drivers were found to travel significantly slower on the freeway. Although no significant impairment was found for the night driving condition, there was a trend to decreased reaction time in the dexamphetamine condition.

It is difficult to directly relate the results of the present investigation to previous research as no simulated driving studies examining the effects of dexamphetamine on driving performance have been previously conducted. However, one link that can be drawn between the present results and the literature is with the perceptual narrowing that has been observed following dexamphetamine administration (Mills *et al.* 2001). 'Tunnelling' or 'tunnel vision', first described by Easterbrook (1959), is a phenomenon in which attentional processes become over-whelmed, producing a decrease in an individual's ability to gather information efficiently. Dexamphetamine can cause this sympathetic arousal resulting in a restriction of perception to the focal point (Mills *et al.* 2001), which consequently may impair driving ability.

The dexamphetamine-induced tunnel vision effect (Mills *et al.*, 2001) may also help elucidate why a driving impairment was observed during the day but not night driving condition. Tunnelling may be more relevant during the daytime driving task as visibility is much clearer and more information is available than during the night. To avoid an overload of information, drivers thus need to appropriately select what information is relevant and subsequently attend to it, a process that requires attention to move between the fovea and periphery.

Conclusion

In conclusion, the results indicate that dexamphetamine does impair driving performance in a daytime driving scenario. Contributing to the overall daytime driving impairment, incorrect signalling was found to increase with dexamphetamine and drivers failed to stop at a red traffic light more frequently in the dexamphetamine condition. Additionally, drivers travelled at a slower speed on the freeway during the dexamphetamine condition. Although these results are consistent with dexamphetamine-induced tunnel vision effects, further research is needed to clarify this issue.