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ORIGINAL INVESTIGATION

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An evaluation of the sensitivity of the standardised field sobriety tests to detect the presence of amphetamine

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Abstract *Rationale:* The Standardised Field Sobriety Tests (SFSTs), designed and validated to assess impairment associated with alcohol intoxication, are currently being employed by the Victoria Police (Australia) for the identification of driving impairment associated with drugs other than alcohol. *Objectives:* The aim of this study was to evaluate whether the SFSTs are a sensitive measure for identifying the presence of dexamphetamine and methamphetamine. *Methods:* Three studies each employed a repeated-measures, counterbalanced, double-blind placebo-controlled design. In each study, 20 healthy volunteers completed two treatment conditions: either 0.42 mg/kg *d*,*l*-dexamphetamine and placebo, 0.42 mg/kg *d*,*l*-methamphetamine and placebo, or 0.42 mg/kg *d*-methamphetamine and placebo. Performance was assessed using the SFSTs, consisting of the Horizontal Gaze Nystagmus test, the Walk and Turn test, and the One Leg Stand test. Blood and saliva samples were obtained before and immediately after the administration of the SFSTs (120 and 170 min post drug administration). *Results:* At 120 and 170 min post drug administration, *d*,*l*-dexamphetamine blood levels were 83.16 and 98.42 ng/ml, respectively; *d*,*l*-methamphetamine levels were 90 and 95 ng/ml, respectively; and *d*-methamphetamine blood levels were 72 and 67 ng/ml, respectively. None of the three amphetamine doses impaired performance on the SFSTs. Using the SFSTs, the presence of dexamphetamine was identified in 5% of cases, *d*-methamphetamine in 5%, and *d*,*l*-methamphetamine in 0% of cases. *Conclusions:* Under these conditions, the SFSTs are not a sensitive measure for detecting the presence of low levels of amphetamine.

Keywords Dexamphetamine · Methamphetamine · Standardised Field Sobriety Tests (SFSTs) · Sobriety tests

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Introduction

Research has indicated that over the last decade the number of drug-related road accidents in Australia has been steadily increasing (Drummer et al. 2003a,b), with the most recent published report indicating that 23.5% of Australian road fatalities are drug related (Drummer et al. 2003a,b).

Although currently there are several alternative methods for determining drug use, such as urine, sweat and saliva tests (Samyn et al. 2002; Samyn and van Haeren 2000), many countries continue to employ performance tests in drug-detection programs because existing national and state laws prevent police officers from obtaining specimens from drivers. In December 2000, the Victorian Government passed legislation authorizing Victoria Police officers to administer the Standardised Field Sobriety Tests (SFSTs), referred to in Australia as Performance Impairment Tests (PIT), to detect driving impairment associated with the consumption of a drug other than alcohol (Victorian Government Gazette 2000). The SFSTs were designed specifically for the detection and assessment of alcohol intoxication (Burns and Moskowitz 1977), and only limited empirical research has been conducted to assess whether these tests are efficient in identifying impairment associated with the consumption of drugs other than alcohol. It is the purpose of the present three studies to address this issue.

The SFSTs, pioneered in the USA, are tests designed to assess psychomotor and cognitive functioning, and also include a divided attention component. The SFSTs comprise the Horizontal Gaze Nystagmus (HGN), the Walk and Turn (WAT) and the One Leg Stand (OLS) test (Burns and Moskowitz 1977; O'Keefe 2001; see Materials and methods for details). Several studies indicate that performance

on the SFSTs provide an accurate indicator of impairment associated with alcohol consumption (Tharp et al. 1981; Compton 1986; Stuster and Burns 1998). The test has been demonstrated to be a sensitive measure of impairment associated with a blood alcohol concentration (BAC) of 0.08% or more (Burns and Moskowitz 1977; Burns 1987).

In terms of drugs other than alcohol, the SFSTs have been implemented within several drug-impaired-driver detection programs to test for the presence of drugs other than alcohol in drivers. One such program, the Drug Evaluation and Classification Program (DECP) (a 12-step procedure that includes the administration of the SFSTs in addition to other tests), has been shown to be over 90% accurate in identifying whether individuals have consumed a drug other than alcohol (Bigelow et al. 1984; Compton 1986). However, since the DECP employ the SFSTs in conjunction with other behavioural and physiological tests, these validation studies do not provide an accurate evaluation of the effectiveness of the SFSTs themselves in identifying drug intoxication or impairment.

Amphetamines are increasingly recognised as potentially important causes of driving fatalities, with the most recent report indicating that 4.1% of Australian drivers killed over a 10-year period tested positive to stimulants (Drummer et al. 2003b). This percentage increased to 23% in truck driver fatalities (Drummer et al. 2003b). The amphetamines are commonly abused for their central stimulant properties. One of the most popular abused stimulants is methamphetamine, commonly referred to as 'speed', 'ice', or 'crank', which is widely used both recreationally and occupationally by truck drivers. Within the transport industry, particularly long-distance drivers, methamphetamine has long been used for its functional use of allowing longer and more sustained work performance. Dexamphetamine is also a commonly used stimulant amongst truck drivers as it is more readily available and simpler to self-administer. Amphetamine use by truck drivers has thus become a major issue of public concern, as 20% of Australian road deaths involve heavy vehicles (Australian Transport Safety Bureau Website 2004).

These figures highlight that it is important that there are measures to accurately detect the presence of amphetamine. This would allow for more informed decisions on countermeasures. Although previous research indicates that low doses of dexamphetamine impair simulated driving performance (0.42 mg/kg; Silber et al 2004), the cognitive literature suggests that within therapeutic doses ranging from 5 to 30 mg, amphetamine can improve performance on tasks. For example, amphetamines appear to improve performance on some cognitive and psychomotor processes, such as alertness, attention, and reaction time (de Wit et al. 2002; Wachtel and de Wit 1999; Cami et al. 2000; Halliday et al. 1994; Fleming et al. 1995 Shenberger et al. 1998; Weiss and Laties 1962).

Following from this research it would be expected that at low doses (30 mg) amphetamines should not impair performance on the SFSTs but possibly improve performance. This is consistent with previous research that has reported improvements on the OLS test after the administration of dexamphetamine (Heishman et al. 1998).

As the SFSTs have been implemented in Victoria Police 'drugged-driver detection' procedures and limited research has been conducted examining the effectiveness of the SFSTs alone in identifying amphetamine consumption, the following three studies examined the efficiency of the SFSTs in detecting the presence of *d*,*l*-dexamphetamine, *d*,*l*-methamphetamine and *d*-methamphetamine.

Study 1: *d*,*l*-dexamphetamine

Materials and methods

Participants

Twenty healthy participants (10 men; 10 women) aged between 21 and 32 years (M=25.4 years, SD=3.3 years), with an average male weight of 82.1 kg (SD=10.6) and an average female weight of 62.2 kg (SD=10.4) were recruited through community advertisements. All participants had a minimum of 11 years education and a valid, full drivers licence (minimum 3 years' driving experience). The Swinburne University Human Research Ethics Committee approved the research and all participants provided written informed consent.

All participants were screened by a medical practitioner to ensure that they had no history of substance abuse, had no pre-existing physical or neurological conditions, no history of psychiatric, cardiac, endocrine, gastrointestinal, or bleeding disorders, that they were not pregnant or lactating, not taking any prescription medication (excluding the contraceptive pill), and that they were not regular amphetamine users (i.e. they used less than once a month). However, for ethical reasons only participants who had previously experimented with amphetamines were permitted to participate.

Drug

d,*l*-Dexamphetamine sulphate (5-mg *d*,*l*-dexamphetamine tablets, Sigma Pharmaceuticals Pty Ltd, Victoria, Australia) was prepared by mixing 0.42-mg/kg dose of *d*,*l*-dexamphetamine tablets with flour, which was encapsulated in three soft gelatine capsules, to render them visually indistinguishable from the placebo capsules (which contained only flour).

Experimental design

A repeated-measures, counterbalanced, double-blind, placebo-controlled design was employed. Participants completed two treatment conditions: (1) placebo and (2) 0.42 mg/kg *d*,*l*-dexamphetamine capsule. Participants completed the two sessions 1 week apart to reduce any residual effects of the drug from the first session. All participants

consented to refrain from consuming alcohol for at least 24 h before each session, and illicit drugs for at least 7 days before each session.

Measures

The Standardised Field Sobriety Tests (SFSTs) is composed of three tests: the Horizontal and Vertical Gaze Nystagmus (HGN and VGN), the Walk and Turn (WAT) and the One Leg Stand (OLS).

Horizontal and Vertical Gaze Nystagmus Participants were required to focus on a pen located 30 to 36 cm in front of their nose as the experimenter moved the pen horizontally and vertically. The signs recorded were as follows (left and right eye were recorded separately): lack of smooth pursuit (LSP); distinct Nystagmus at maximum deviation (Nmax); Nystagmus onset before 45° (N45); Vertical Gaze Nystagmus (VGN). If a total of four signs or more were observed out of a maximum of eight, the participant was classified as impaired on the test. An additional sign, head movements and/or jerks (HMJ), was also recorded. Previous research has reported that head movements were observed in the highest percentage of participants in both low and high THC conditions compared to any other sign recorded (Papafotiou et al. 2004). For this reason, this sign was recorded in the present study to investigate its pertinency to amphetamine intoxication. HMJ was recorded as a sign if the participant was not able to keep their head stationary two or more times while following a moving stimulus with their eyes.

Walk and Turn This test required the participant to take nine heel-to-toe steps along a straight line, turn in a prescribed manner, and take nine heel-to-toe steps back along the line. This test assessed a variety of aspects including divided attention, balance, and coordinating body movements. The signs noted were the following: cannot keep balance while listening to the instructions of the test (NB); started the test before the instructions were completed (STS); stopped walking during the test (SW); Did not touch heel-to-toe while walking (MHT); stepped off line (SOL); used arms to maintain balance (AB); turned incorrectly (not as demonstrated during instruction phase; IT); and took incorrect number of steps (more or less than nine in first or second nine steps; INS). If two or more signs were observed, the participant was classified as impaired on the test. If the participant failed to complete the test, all eight signs of the WAT test were recorded.

One Leg Stand This task required the subject to stand on one leg, with the other leg extended to the front held approximately 15 cm above the ground. The participant was required to maintain this stance while counting out loud for 30 s by thousands. The signs recorded were as follows: Swayed while balancing on one leg (S); used arms to maintain balance (AB); hopped during test to maintain balance (H); put raised foot down (FD). If signs or more were observed, the participant was classified as impaired on the test. If the participant failed to complete the test, all signs of the OLS test were recorded.

Overall performance on the SFSTs

Overall performance on the SFSTs was calculated by summing the performance on the three tests (HGN, WAT, and OLS). In accordance with Victoria Police implementation training procedures, if the participant was identified as impaired on two or more of the tests, the participant was subsequently classified as impaired on the SFSTs.

Blood and saliva samples

Two blood and two saliva samples were taken from each participant during each session. A 10-ml blood sample was obtained using a syringe, by venipuncture from the antecubital vein, and a 1-ml saliva sample was obtained using a collection swab at 120 and 170 min after drug administration. Blood and saliva samples were immediately stored in a −20°C freezer and subsequently transported to a −70°C freezer after 5–7 days. Blood and saliva samples were analysed for amphetamine levels using the gas chromatography/mass spectroscopy method.

Procedure

For each of the two experimental sessions, participants were asked to eat a normal breakfast or lunch before arrival. The experimenter and participant were blind to the treatment condition. A medical practitioner was on-call and a registered nurse was on-site throughout the experimental sessions. Upon arrival, the research nurse administered the treatment. Two and a half hours after consumption of the drug the SFSTs were completed. As dexamphetamine has a peak blood concentration between 120 and 180 min (Angrist et al. 1987; Kupietz et al. 1985), the first blood and saliva sample was obtained 120 min after drug administration and the second sample was obtained 170 min after drug administration. The only reported adverse reaction to dexamphetamine consumption was difficulty with falling asleep and/or disturbed sleep on the night after that session.

Statistical analyses

A series of difference in proportions tests based on paired data were performed to establish whether the sobriety tests accurately detect the presence of dexamphetamine (Newcombe 1998; Method 10). These use a z statistic that tests the hypothesis that the number of people that changed as a function of experimental condition in one direction (i.e. not impaired in placebo but impaired in dexamphetamine), and the number of people that changed in the opposite direction (i.e. impaired in placebo but not impaired in

dexamphetamine) is equal to zero in the population. The corresponding *z* statistic is then used to calculate 95% confidence intervals around the point estimate (i.e. the numerical difference between the proportions). For these tests the independent variable was the drug condition (placebo vs dexamphetamine) and the classification of impairment (present or not present) for overall SFSTs and each individual sobriety test were the dependent variables.

Results

The level of *d*,*l*-dexamphetamine detected in blood and saliva at 120 min after drug administration was 83 and 236 ng/ml, respectively, and at 170 min after drug administration was 98 and 242 ng/ml, respectively.

Dexamphetamine did not significantly impair overall performance on the SFSTs (dexamphetamine, 1/20 impaired; placebo, 0/20 impaired), $p>0.05$, 95% CI −0.24 to 0.17. Dexamphetamine did not significantly impair performance on the HGN test (dexamphetamine 0/20 impaired; placebo 0/20 impaired), $p>0.05$, 95% CI −0.17 to 0.17. Dexamphetamine did not significantly impair performance on the WAT test (dexamphetamine 2/20 impaired; placebo 2/20 impaired), $p>0.05$, 95% CI −0.20 to 0.20. Finally, dexamphetamine was not found to significantly impair performance on the OLS test (dexamphetamine 1/20 impaired; placebo 2/20 impaired), $p>0.05$, 95% CI −0.13 to 0.24.

Including HMJ in the HGN scoring procedure did not change the result for the HGN test. It should be noted that HMJ was observed more frequently than any other HGN test sign in the dexamphetamine condition; however, this difference was not found to be significant (dexamphetamine 7/20 impaired; placebo 2/20 impaired), $p>0.05$, 95% CI −0.49 to 0.04.

Study 2: *d*,*l*-methamphetamine

Materials and methods

The measures, procedure and statistical analyses for study 2 are the same as reported in study 1. The experimental design was the same with the exception of a 2-week washout period, rather than 1 week. The participants and the treatment administered in study 2 differ and will be described below.

Participants

Twenty healthy participants (10 men; 10 women) aged between 21 and 34 years (M=24.3 years, SD=3.4 years), with an average male weight of 81.2 kg (SD=12.6) and an average female weight of 59.7 kg (SD=6.9) were recruited. All participants had a minimum of 11 years education, and a valid, full drivers license. The Swinburne University Human Research Ethics Committee approved the research and all participants provided written informed consent. All participants completed a medical examination and the exclusion criteria was the same as for study 1.

Drug

d,*l*-Methamphetamine (Lipomed, Arlesheim, Switzerland) was prepared by mixing *d*,*l*-methamphetamine with magnesium carbonate, which was encapsulated in soft gelatine capsules to render them visually indistinguishable from the placebo capsules, which contained only magnesium carbonate. Capsules contained either 2, 5 or 10 mg *d*,*l*-methamphetamine. Each participant was administered 0.42 mg/kg *d*,*l*-methamphetamine.

Results

The level of *d*,*l*-methamphetamine detected in blood and saliva at 120 min after drug administration was 90 and 343 ng/ml, respectively, and at 170 min after drug administration was 95 and 475 ng/ml, respectively.

d,*l*-Methamphetamine did not significantly impair performance on overall SFSTs (*d*,*l*-methamphetamine 0/20 impaired; placebo 0/20 impaired), $p>0.05$, 95% CI −0.19 to 0.16. *d*,*l*-methamphetamine was not found to significantly effect performance on the HGN test (*d*,*l*-methamphetamine 0/20 impaired; placebo 0/20 impaired), $p>0.05$, 95% CI −0.17 to 0.17. *d*,*l*-methamphetamine did not significantly effect performance on the WAT test (*d*,*l*-methamphetamine 4/20 impaired; placebo 1/20 impaired), $p>0.05$, 95% CI −0.36 to 0.05. Finally, *d*,*l*-methamphetamine was not found to significantly impair performance on the OLS test (*d*,*l*-methamphetamine 1/20 impaired; placebo 1/20 impaired), $p>0.05$, 95% CI −0.19 to 0.19.

Including HMJ in the HGN scoring procedure did not significantly change the result for the HGN test. Although *d*,*l*-methamphetamine was not found to significantly induce HMJ (*d*,*l*-methamphetamine 6/20 impaired; placebo 3/20 impaired), $p>0.05$, 95% CI −0.37 to 0.09, it was observed more frequently in the *d*,*l*-methamphetamine condition than any other sign of the HGN test.

Study 3: *d*-methamphetamine

Materials and methods

The measures, experimental design, procedure and statistical analyses for study 3 are the same as in study 2. However, the participants and the treatment administered in study 3 differ and are described below.

Participants

Twenty healthy participants (10 men; 10 women) aged between 21 and 32 years (M=25.4 years, SD=3.28 years),

with an average male weight of 75.55 kg (SD=11.47) and an average female weight of 62.9 kg (SD=4.48) were recruited. All participants had a minimum of 12 years education, and a valid, full drivers license. The Swinburne University Human Research Ethics Committee approved the research and all participants provided written informed consent. All participants completed a medical examination and the exclusion criteria were the same as for study 1 and study 2.

Drug

d-Methamphetamine (Lipomed, Arlesheim, Switzerland) was prepared by mixing *d*-methamphetamine with lactose, which was encapsulated in soft gelatine capsules to render them visually indistinguishable from the placebo capsules, which contained only lactose. Capsules contained 20, 10, 5 or 2 mg *d*-methamphetamine. Each participant was administered 0.42 mg/kg *d*-methamphetamine.

Results

The level of *d*-methamphetamine detected in blood and saliva at 120 min after drug administration was 72 and 285 ng/ml, respectively, and at 170 min after drug administration was 67 and 223 ng/ml, respectively.

d-Methamphetamine did not significantly impair performance on overall SFSTs (*d*-methamphetamine 1/20 impaired; placebo 1/20 impaired), $p>0.05$, 95% CI −0.17 to 0.17. *d*-Methamphetamine did not significantly impair performance on the HGN test (*d*-methamphetamine 1/20 impaired; placebo 0/20 impaired), $p>0.05$, 95% CI −0.24 to 0.12. *d*-Methamphetamine did not significantly impair performance on the WAT test (*d*-methamphetamine 5/20 impaired; placebo 2/20 impaired), $p>0.05$, 95% CI −0.35 to 0.45. Finally, *d*-methamphetamine was not found to significantly impair performance on the OLS test (*d*-methamphetamine 3/20 impaired; placebo 5/20 impaired), $p>0.05$, 95% CI −0.12 to 0.32.

Including HMJ in the HGN scoring procedure did not significantly change the result for the HGN test. Although *d*-methamphetamine was not found to significantly induce HMJ (*d*-methamphetamine 4/20 impaired; placebo 3/20 impaired), $p>0.05$, 95% CI −0.29 to 0.19, it was observed more frequently in the *d*-methamphetamine condition than any other sign of the HGN test.

Table 1 depicts the accuracy of the SFSTs in identifying the presence of dexamphetamine, *d*,*l*-methamphetamine, and *d*-methamphetamine.

Discussion

The present study found that neither 0.42 mg/kg *d*,*l*-dexamphetamine, *d*,*l*-methamphetamine and *d*-methamphetamine significantly impaired performance on the SFSTs. Using these sobriety tests, the presence of dexamphetamine was identified in only 5% of cases when blood and saliva amphetamine concentration levels were approximately 90 and 240 ng/ml, respectively. The presence of *d*-methamphetamine was detected in only 5% of cases when blood and saliva amphetamine concentration levels were approximately 70 and 250 ng/ml, respectively. The presence of *d*,*l*-methamphetamine was not reported in any cases when blood and saliva amphetamine concentration levels were approximately 90 and 400 ng/ml.

It is difficult to relate the present findings to previous research as the SFSTs in the present investigations were not administered in conjunction with other behavioural and physiological tests, as have been done previously (i.e. the DEC Program; Bigelow et al. 1984; Compton 1986). However, the extremely low percentage of participants correctly identified with the presence of a drug is consistent with previous research on amphetamines that have highlighted that the stimulant drug class is notably difficult to detect. Heishman et al. (1998) reported that the majority of subjects dosed with dexamphetamine were classified as 'not impaired' by the Drug Recognition Examiners (DREs), and that in only 2% of cases where dexamphetamine was administered the classification was correct. Furthermore, the DREs classified subjects as dosed with other drugs more frequently than with the amphetamine dose administered. Shinar et al. (2000) also found stimulants, specifically dexamphetamine, to be the most difficult to identify, with only 7.8% of cases correctly classified. The authors concluded that the likelihood of identifying the presence of stimulants was no better than chance.

Dexamphetamine, *d*,*l*-methamphetamine, and *d*-methamphetamine were not found to significantly impair performance on the HGN test. In fact, many of the traditionally scored signs were not observed, suggesting that these signs are not typically induced after the consumption of amphetamines. These findings are consistent with the DRE instructor's manual (1993) and other research, which report

Table 1 Number of participants classified as impaired or not impaired on the SFSTs after the administration of either dexamphetamine, *d*,*l*-methamphetamine, or *d*-methamphetamine

	Dexamphetamine		*d*,*l*-Methamphetamine		*d*-Methamphetamine	
	Impaired	Not Impaired	Impaired	Not Impaired	Impaired	Not Impaired
HGN	0	20	0	20	1	19
WAT	2	18	4	16	5	15
OLS	1	19	1	19	3	17
Overall SFSTs	1	19	0	20	1	19
HMJ	7	13	6	14	4	16

that stimulants do not affect performance on Horizontal Gaze Nystagmus, Lack of Smooth Pursuit, Vertical Gaze Nystagmus, and Lack of Convergence tests (Kosnoski et al. 1998; Adler and Burns 1994). Including HMJ in the HGN scoring procedure did not increase the percentage of correct classifications. However, this sign was observed more frequently in the amphetamine condition than any other sign. Although the findings suggest that including HMJ as a sign of impairment does not increase the efficiency of the SFSTs, this may be due to the traditional signs not being appropriate for detecting the presence of low-level amphetamine.

Dexamphetamine, *d*,*l*-methamphetamine, and *d*-methamphetamine did not impair performance on the WAT test, suggesting that this test may not be appropriate for identifying the presence of amphetamine. Improper Turn (IT) occurred frequently across both the placebo and the amphetamine conditions. This is consistent with previous research, in which IT was observed similarly across both placebo and cannabis conditions (Papafotiou et al. 2004). Finally, the three amphetamine doses administered did not impair performance on the OLS test. Although not significant, some improvements on the OLS test were observed in the amphetamine conditions. This is consistent with previous research where Heishman et al. (1998) found that a decrease in errors on the OLS test was the third best predictor for the presence of dexamphetamine, indicating that the OLS test may not be an appropriate measure of drug presence.

In conclusion, the results of the present study suggest that the administration of 0.42 mg/kg of *d*,*l*-dexamphetamine, *d*,*l*-methamphetamine, or *d*-methamphetamine does not impair performance on the SFSTs. Using the SFSTs, the presence of *d*,*l*-dexamphetamine was identified in 5%, *d*-methamphetamine in 5%, and *d*,*l*-methamphetamine in 0% of cases. These findings indicate that the SFSTs are not efficient in identifying the presence of low levels of amphetamines and support previous research that the tests are not appropriate for the stimulant class of drugs at these levels.

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