

# SIGNS AND SYMPTOMS PREDICTIVE OF DRUG IMPAIRMENT

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## Abstract

A double blind study was performed to evaluate the ability of police officers to detect drug impairments and to identify the type of drug responsible for the impairment, on the basis of observed symptoms and psychophysical measurements of performance. The officers were not allowed to interview the subjects. Results showed that even with this partial information the officers are able to detect drug impairment at better-than-chance levels, but the association between drug ingestion and identification of the specific impairing drug was not very high. Drug identification was best for alprazolam impairment, noticeably poorer for cannabis and codeine impairment, and no better than chance for amphetamine impairment. To improve identification, the officers should always list the two most probable impairing drugs (rather than one), and be more consistent in their use of observed signs and symptoms.

## Introduction

The use of drugs is a significant traffic safety issue. In a 1996 survey of American households, 4 percent of the licensed respondents reported that in the past year they have driven within two hours of ingesting alcohol and drugs, and an additional 1 percent reported that they have driven after using drugs only (Townsend et al., 1998) Joint efforts by the Los Angeles Police Department, the International Association of the Chiefs of Police, and the National Highway Traffic Safety Administration, have yielded a Drug Evaluation and Classification Program (DECP). The program trains police officers to become Drug Recognition Experts (DREs) who can (a) detect impairment from alcohol and drugs, and (b) classify the type of drug as one of seven categories. The categories are CNS stimulants, CNS depressants, narcotic-analgesics, phencylidine (PCP), cannabis, hallucinogens, and inhalants.

This study evaluated the DREs' actual performance in detecting drug impairment and in identifying the impairing drug category, solely on the basis of the tests and observable signs and symptoms. Four drugs were evaluated in this study: (a) Cannabis (b) Depressant, (c) Narcotic analgesic, and (d) Stimulant. The validation criteria were particularly severe relative to the setting in which DREs typically detect and identify drug impairment. Still, since the scientific basis of the DECP is the physical evidence, it was important to see to what extent the physical signs and symptoms alone account for specific drug impairments, and how well do the DREs utilize the information retrieved from the physical signs and symptoms.

## Method

The subjects were paid volunteers, self-admitted regular users of the study drugs, who assured the staff that they never had, nor did they currently intend to seek substance-abuse treatment. They were judged to be in good health, based on a blood analysis and a routine

examination of the vital signs. All gave written informed consent according to guidelines for the protection of human subjects of the U.S. Department of Health and Human Services. A detailed description of the experimental procedure and collection and analysis of blood samples is provided by (Heishman et al., 1998). The testing session started with a pre-dosing test battery that included cognitive performance tests and tests of oculo-motor control. After the tests' completion the subject was given one more examination of vital signs, and if all signs were normal, then the subject was dosed by a nurse under a doctor's supervision. The DREs were told that the subjects may be under the influence of none, one, or a combination of two or more drugs of any type except hallucinogens and inhalants.

The DRE evaluation of drug impairment was an abridged form of the standard procedure used in the Drug Evaluation and Classification Program (DECP). The complete evaluation consists of a series of tests that include examination of vital signs, psychophysical tests for motor control, nystagmus, pupil response to light, and an interview. For the present study, the interview was omitted so that the only verbal interactions between the DRE and the subject were the instructions for the tests and the subject's verbal responses to these tests. A detailed description of the DRE tests is provided elsewhere (Kosnoski, 1998; NHTSA, 1991).

Each of the subjects was recruited as an in-patient for a period of up to three weeks. Within that period each subject was tested on six sessions, separated from each other by at least 48 hours. This analysis included all of the data available from 54 subjects who were entered into the study. The total number of sessions available was 302, but two sessions in which the DREs identified PCP as the impairing drug were omitted from the analysis. The total number of sessions with each drug and each level varied from 23 to 28.

## Results and Discussion

The analyses presented below focus on two issues: a) how well the DREs detect drug impairment and identify the drug class that is responsible for that impairment, based on observable signs and symptoms, and b) how useful are the DECP evaluation procedure and signs and symptoms noted by that procedure, in detecting drug impairment and correctly classifying the source of that impairment.

**The validity of the DREs' conclusions based on signs and symptoms only.** To evaluate the DREs' performance in the detection of impairment and in the correct diagnosis of the drug category, the DREs' conclusions were cross-tabulated with the actual drug dosing. For the determination of the existence of an association and its strength, Chi Square analysis was used, followed by Phi coefficient of correlation and the Contingency Coefficient, for 2x2 tables, and Cramer's V measure of association and the Uncertainty coefficient for larger tables. To determine actual levels of agreement, Kappa coefficient was used. DREs' ability to detect drug impairment was significantly better than chance ( $p = .009$ ). However the measures of association which describe HOW well the DREs perform in detecting drug impairment were disappointing. The analysis of the DREs' sensitivity and specificity showed that the sensitivity (the detection of impairment given drug dosing) was moderate at 72% (=143/198). The specificity (the ability to assess unimpairment in the placebo condition) was near chance at 43%(=44/102). The complementary miss rate was 28%(=55/198) and the complementary false alarm rate was 57%(=58/102). In summary, the different analyses were all consistent, showing the DREs' ability to differentiate between drug impaired and unimpaired subjects was moderate at best.

The DREs' ability to identify the psychoactive drug classes was assessed by cross-tabulating their principal conclusion (first choice) relative to the actual dosing. The results of this analysis are summarized in Table 1. For perfect performance the only non-zero entries

would be in the diagonal cells. Although this is not the case, performance is definitely much better than chance, as supported by a Chi Square = 72.27,  $p < .001$ . Identification appears to be best for the depressant alprazolam and placebo (i.e., lack of impairment), and worst for the amphetamine stimulant.

Table 1: Drug administered (low and high doses combined) vs. first drug category listed by DRE. (Numbers in parentheses represent percent identified relative to actual administration)

DRUG DOSING	DREs' DECISION					Total
	Cannabis	Depressant	Narcotic	Stimulant	Unimpaired	
Marijuana (Cannabis)	15 (30.6)	8 (16.3)	10 (20.4)	4 (8.2)	12 (24.5)	49 (100)
Alprazolam (Depressant)	4 (8.2)	21 (42.9)	18 (36.7)	1 (2.0)	5 (10.2)	49 (100)
Codeine (Narcotic)	7 (14.3)	6 (12.2)	18 (36.7)	1 (2.0)	17 (34.7)	49 (100)
Amphet. (Stimulant)	20 (39.2)	4 (7.8)	2 (3.9)	4 (7.8)	21 (41.2)	51 (100)
Placebo (Unimpaired)	21 (20.6)	20 (19.6)	15 (14.7)	2 (2.0)	44 (43.1)	102 (100)
TOTAL	67 (22.3)	59 (19.7)	63 (21.0)	12 (4.0)	99 (33.0)	300 (100)

Two summary measures of association - the contingency coefficient (0.44), and Kappa coefficient of agreement (0.152) - show that although specific drug impairments are distinguishable from each other, the actual attribution may not always be correct. However, what these statistics fail to reveal is that when the DREs err, the error is not a random one. This is evidenced in the following: (1) Cannabis is most often either correctly recognized, or impairment is not evident at all; i.e., it is not often confused with other drugs. (2) Depressants are as likely to be mistaken for narcotic analgesics as correctly recognized as depressants. However, they are not confused with other drugs or with placebo. (3) Narcotic-analgesics are most - and equally - likely to be either correctly identified or totally missed (in which case the subjects are judged as unimpaired). (4) Stimulants - at least d-amphetamines at the doses administered here - are the most difficult to identify. Subjects under its effects are more likely to be erroneously classified as either cannabis-impaired, or not impaired at all. (5) Under placebo subjects are more likely to be judged unimpaired than impaired by any other drug.

The DREs' confusions among drug categories were also apparent from their choice of a second category of impairment. In approximately 50% of the 201 cases where the DREs noted an impairment, they also selected a second category. The most common joint citations were cannabis and narcotic-analgesics (33%) and cannabis and depressant (30%). Also, probably because of their biased past exposure, the DREs cited cannabis - either as a primary or secondary drug category - in half of all cases where they noted impairment.

To assess the DREs' ability to identify each of the specific drug categories, we analyzed the data using 2x2 tables of the actual dosing vs the DRE decision. (correct if the drug administered belonged to either the first or second drug category identified by the DRE). The summary statistics for each of the drugs are presented in Table 2. Although the Phi correlation, Contingency coefficient, and Kappa coefficient measure different characteristics of association, their numerical values were quite similar, and therefore only the Phi correlations - the most familiar of these statistics - are reproduced in Table 2.

The DRE performance was quite variable: from moderately adequate (alprazolam), through marginal (cannabis and codeine), to no better than chance (amphetamine). In the case of amphetamine, the high specificity (91%) is due to the tendency to avoid citing that category, so that the likelihood of not citing amphetamine when in fact it was not administered was spuriously high. Amphetamine dosing (as seen in Table 1), was most often either mistaken for cannabis impairment or missed altogether. Most revealing are the Uncertainty coefficients, which were either low or actually zero (for amphetamine).

Table 2. Comparative evaluations of the DREs' performance in correctly identifying the four different drugs (using both high-dose and low-dose drug administrations, and both 1<sup>st</sup> and 2<sup>nd</sup> categories of impairment).

Drug	Chi-Square	Sensitivity	Specificity	False Alarms	Misses	Phi Correl	Uncert Coeff
Cannabis	5.86*	49%	69%	31%	51%	0.14	0.02
Alprazolam	16.24**	47%	80%	20%	53%	0.23	0.05
Codeine	5.58*	45%	72%	28%	55%	0.14	0.02
Amphetamine	0.02	10%	91%	9%	90%	0.01	0.00

\*p <.05, \*\*p<.001

**DREs' Reliance on Specific Signs and Symptoms.** To provide some insights into the DREs' decision processes, an analysis was done to see which specific signs and symptoms they used to identify the different drug categories. The mean performance score of all the signs and symptoms for which interval-scaled measures could be derived; namely, nystagmus, pupil diameter under the different light conditions, pulse and blood pressure, temperature, and the sobriety tests of one-leg-stand, Romberg balance test, walk-and-turn, and finger-to-nose test for each of the drug categories was compared to the mean score in the "unimpaired" condition. The results of these analyses indicate two features of the DREs' evaluation process: First, the DREs relied on all four psychophysical tests and horizontal gaze nystagmus to conclude that a person is impaired, regardless of the selected impairing drug category. (The average performance scores on the nystagmus test and on all of the psychophysical tests were significantly poorer whenever any impairment was identified than when the DREs concluded the subject was not impaired). This reliance was not always appropriate. For example, the DECP guidelines indicate that nystagmus is characteristic only of depressants, but not of the other three categories. Yet the DREs occasionally noted nystagmus and still concluded that the impairment was due to one of these latter categories. In this respect the DREs often reached conclusions that were inconsistent with the DECP. Second, In making a specific diagnosis of the impairing drug category the DREs apparently used only one or two 'pivotal' signs/symptoms to guide their decision. Thus, in addition to the psychophysical tests and nystagmus, they typically noted only one or two measures that were significantly different from their 'unimpaired' judgement: a raised pulse rate for cannabis, a raised temperature (and possibly reduced pupil diameter under direct light) for a depressant, a lower temperature and a slightly constricted pupil under direct light for narcotic/analgesic, and an enlarged pupil in the dark and an increase in horizontal gaze nystagmus for a stimulant. Although this simplifies their task, it is insensitive to the true complexities of drug effects, and consequently, it is likely to lead to erroneous conclusions.

In summary, it appears that the DREs tend to base their diagnosis primarily on one or two signs or symptoms, and then ignore the remaining signs and symptoms even if they are inconsistent with the DECP recommended guidelines for identification of that drug impairment. This reinforces the conclusion that the DREs have a difficulty in simultaneously evaluating all of the information available in all of the observed signs and symptoms.

## Conclusions

This study focused on the validity of the Drug Recognition Experts' conclusions concerning drug impairment. The validation effort was limited to conclusions that were reached by the DREs on the basis of manifest signs and symptoms without the benefits of interviewing the subjects, and without knowledge of the a-priori probabilities for the presence of the different drugs. It is important to note that the DREs' performance is limited by the data they have been trained to collect and its interpretation according to the DECP. Thus there is a ceiling level of performance that the DECP enables. In a separate analysis (Shinar and Schechtman, 1998) it was shown that the DECP – with the data collected by these same DREs – correlates moderately with actual impairments from cannabis, alprazolam, and amphetamine (with Phi Correlations of 0.57-0.62), but correlates poorly with codeine impairment (Phi=0.13).

With these limitations in mind, we can conclude that:

1. DREs are able to detect drug impairment at statistically significant levels above chance, even at therapeutically safe dose levels, which are typically lower than levels in drug abuse.
2. The identification levels of specific impairing drug categories are quite variable and depend on the specific drugs/categories: they are moderate with the depressant alprazolam, lower for cannabis and codeine, and essentially not better than chance for amphetamine.
3. Based on their first choice of impairing drugs, the DREs correctly identified cannabis impairment in 31 % of cannabis impaired subjects; depressant-based impairment in 43% of the alprazolam impaired subjects; and narcotic impairment in 37% of the codeine impaired subjects. The DREs performed much worse with amphetamine impairment, identifying only 8% of them as stimulant-impaired. When the subjects were not drugged (placebo) the DREs correctly identified them as unimpaired in 43% of the cases. (Table 1).
4. When the DREs determined that the subject was impaired, they listed only one drug category in 47 % of the cases. When they named two possible categories of drug impairment, their correct identifications improved to 49% for cannabis, 47% for alprazolam, 45% for codeine, and 10% for amphetamine (Table 2 vs. Table 1).
5. The DREs' errors were not random but systematic, and the confusions were consistent with DECP common signs and symptoms. Thus, when two drug categories were allowed, cannabis was confused in approximately 20% of the cases with a depressant and in approximately 20% of the cases with a narcotic. Alprazolam was more likely to be confused with a narcotic (50%) than to be correctly identified as a depressant. Codeine was more likely to be correctly identified (45%) than to be missed (30%). Amphetamine was most likely to be either totally missed (45%) or identified as cannabis (35%).
6. Identifying amphetamine-dosed subjects was actually worse than chance. The DREs rarely named a stimulant as the impairing drug (9% of all impairments).
7. The DREs relied on the psychophysical tests and horizontal gaze nystagmus almost exclusively to detect impairment in general, rather than to distinguish among drug categories.
8. In order to identify specific drug impairments the DREs tended to rely on one or two specific 'pivotal' symptoms. The pivotal symptoms were all consistent with the DECP manual. For cannabis - raised pulse rate. For depressant - low blood pressure. For narcotic - lower body temperature and constricted pupil (but only under direct light). For stimulant - an enlarged pupil under direct light (i.e., little constriction in response to light). Unfortunately

this approach limited their ability to utilize the wealth of information they had observed and recorded.

### **Recommendations**

The simplest recommendation to apply – and one that would definitely raise the DREs' performance levels, is that they should be strongly encouraged to always list two drug categories. This is important because it is a legitimate way of increasing probability of correct identification.

The DECP training procedures should also put more emphasis on analyzing combinations of signs and symptoms rather than tending to rely on a single conspicuous sign. Although the training examples already do that, it appears that this is not sufficiently instilled. On the basis of separate analysis of the DECP validation (Shinar and Schechtman, 1998), it is recommended that the DRE training should include the use of formal models for combining the data from signs and symptoms. Functions they obtained for identifying impairments due to cannabis, alprazolam, and amphetamine, are easy to apply to actual evaluations. Finally, a follow-up evaluation study should be attempted in which the DREs' would be required to first evaluate the physical signs and symptoms and on their basis make an evaluation about impairment. Then they should study the arresting officer's report and interview the subject and on the basis of the additional information be given a chance to revise their conclusions. This method would provide a means of (a) field validation of the results obtained in this study, and (b) quantifying the added value of the officer's report and interview information.

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### **References**

Heishman, SJ, Singleton, EC, and Crouch, DJ. Laboratory validation study of Drug Evaluation and Classification Program: alprazolam, d-amphetamine, codeine, and marijuana. *Journal of Analytical Toxicology* 1998; 22: 503-514.

Kosnoski, EM, Volton, RL, Citek, K., Hayes, CE, and Evans, RB The drug evaluation classification program: using ocular and other signs to detect drug intoxication. *Journal of the American Optometric Association* 1998;69(4): 211-227.

NHTSA Drug Evaluation and Classification Program. Briefing paper. 1991, National Highway Department of Transportation, U.S. Department of Transportation, Washington D.C.

Shinar, D. and Schechtman, E. Modeling the DRE evaluation of signs and symptoms to improve the validity of drug impairment diagnosis Final Report submitted to the National Safety Council and the U.S. 1998 Department of Transportation, National Highway Traffic Safety Administration.

Townsend, TN, Lane, J, Dewa, CS, Brittingham, AM Driving after drug or alcohol use: Findings from the 1996 National Household Survey on Drug Abuse. Department of Health and Human Services, Substance Abuse and Mental Health Services Administration, December 1998, DHHS Publication No. (SMA) 99 3273. Washington DC