U.S. Department of Justice
Office of Justice Programs
National Institute of Justice

National Institute of Justice

Drug Recognition and Impairment Research Meeting

August 24, 2015
Washington, D.C.

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Drug Recognition and Impairment Research Meeting

Meeting Notes

August 24, 2015

Washington, D.C.

NIJ

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Meeting Objectives

NIJ's Office of Research and Evaluation, in partnership with its Office of Investigative and Forensic Sciences (OIFS), held a meeting to review research on drug recognition and impairment. Concern about drug recognition and impairment has grown with diversion and illegal use of prescription drugs, changes in medical and other marijuana use legislation, and evolution of novel psychoactive substances (NPS or synthetic drugs). NIJ collaborated with two federal agencies that also support research in this area — the National Highway Traffic Safety Administration (NHTSA) and the National Institute of Drug Abuse (NIDA).

The meeting's objectives included disseminating information on current projects to practice experts, exchanging information with other agencies, and soliciting feedback that will inform federal plans for future research that are responsive to the field's information and practice needs.

Meeting Agenda

The one-day meeting was designed to solicit feedback by means of presentations by NHTSA, NIJ, and NIDA followed by a roundtable discussion including state and local practitioners and federal experts. The broad scope of topics addressed many aspects of drug recognition and impairment practice: detection of illegal drugs including quantitation (purity) of drug seizures; forensic toxicology post-use; reliable measurement of drug impairment; investigative leads for case building; collection and submission of drug evidence for laboratory analysis; tools for drug detection in the field; expert witness/testimony; confirmation of toxicological and chemical analysis; and protocols for prosecution and court case management.

Research Presentations and Project Information

NHTSA presented information on projects supported by its Office of Behavioral Safety Research related to drugged driving. NIJ provided an overview of research projects supported by OIFS. NIDA presented information on intramural and extramural research related to drug testing and impairment. More detailed information on relevant research funded by each agency was made available through project descriptions.

- Presentation — Overview of NHTSA's Current Drugged Driving Research (Dereece Smither, Ph.D.)
- NHTSA's Project Descriptions
- Presentation — NIJ Controlled Substances and Forensic Toxicology Research and Development Program (Frances Scott, Ph.D.)
- NIJ's Project Descriptions
- Presentation — NIDA's Current Drugged Driving Research (Marilyn Huestis, Ph.D.)
- NIDA's Project Descriptions

Presentation and Practice Expert Roundtable Highlights

Participants were invited to identify and discuss concerns of primary importance in their jurisdictions and professional fields. In other words, what information, tools and protocols would best support their service objectives — in addition to projects currently supported by NIJ and other federal agencies? A roundtable guide was developed in advance to indicate the wide range of presentation and discussion topics including, but not limited to, drugs of interest, laboratory and field tests, prosecution and defense, pretrial and post-disposition monitoring, and available resources.

Download the roundtable guide.

The following are highlights from presentations including discussions between presenters, practice experts and federal meeting participants.

- Reliable and timely drug intelligence and surveillance systems are needed across state, tribal and local jurisdictions to examine national and regional trends over time. Those could be enhanced by relevant incident details (e.g., packaging or paraphernalia). Basic testing and reporting, however, is not standard across jurisdictions. In their assessment of the Fatality Analysis Reporting System, which collects toxicology results from police-reported fatal crashes on public roadways, NHTSA found that inconsistencies limit inferences about drug-involved driving (e.g., impairment or crash causation). Aside from developing variables and definitions for standard reporting, issues include changes in drugs and analogs, and skilled manpower to collate and analyze the information collected. NIJ is funding a project to develop data mining tools that collect pharmaceutical mentions from poison control reports, and the Centers for Disease Control and Prevention (CDC) is funding a project to extract information on drug mentions from death certificates.

- NIDA is applying advanced technology and high-resolution mass spectrometry to determine human metabolism of NPS for which this is unknown, to identify the best markers for these drugs in urine samples. Due to the high potency and therefore low doses of these compounds, NPS are detectable in blood and oral fluid for a short time, making detection of metabolites in urine necessary. It is critical for these markers to be available rapidly for laboratories around the world to tie adverse effects occurring following ingestion of these compounds to the appropriate novel psychoactive compound to educate the public about the dangers of drug intake. In

addition, commercial reference manufacturers need to know which are the key standards to produce.

- NIDA investigators conducted controlled drug administration studies to determine the onset, peak and duration of drug effects and the time course of drugs and metabolites in oral fluid. The results are a scientific database for interpreting individual oral fluid drug concentrations, and development of policies around oral fluid testing. These policies determine what analyte should be tested and an appropriate cutoff concentration for both onsite screening and laboratory confirmation tests. Additionally, NIDA is evaluating the advantages and limitations of new biological matrices and the performance and efficacy of new field testing technology. For example, NIDA evaluated cannabinoid and cocaine onsite tests for detecting these drugs in breath and sweat.

- Scientists supported by NIJ are developing portable and inexpensive devices for rapid field detection of drug use from live individuals' oral fluids. NHTSA supports the training of drug recognition experts to administer a series of physiological and psychophysical tests to identify observable signs and symptoms related to impairment across a variety of drugs. Prosecution, however, is constrained by delays in laboratory confirmation and by drug legislation that lags behind innovations in illegal drug production. Jury expectations for unambiguous drug identification and impairment indicators, evidence analysis, and expert witness testimony have increased. This makes it harder for prosecutors, defense attorneys and judges to manage cases efficiently; and until cases are disposed (whether by dismissal or conviction), referrals to diversion, treatment services and other alternatives to incarceration cannot be made.

- Motor vehicle laws reference per se blood alcohol concentrations associated with impairment. NIDA research, however, found that drug detection and impairment are affected by time between ingestion and testing, and drug use frequency. Using simulators under controlled conditions, NIDA also found that cannabis impacts cognitive abilities necessary to respond to driving demands, and established concentrations of Δ9-tetrahydrocannabinoid (THC) during driving that produced similar impairment as 0.05 and 0.08 percent alcohol. Furthermore, they established that peak THC concentrations were higher when low dose alcohol was present, and that alcohol concentrations peaked later when THC was present. NHTSA is working toward understanding the scope of drugged driving in the U.S.; investigating aspects of drug-related impairment that impact driving; improving drugged-driving data collection; and enhancing the prevention, detection and prosecution of drugged driving.

Other research supported by federal agencies include the Office of National Drug Control Policy's (ONDCP) Community Drug Early Warning System that conducts secondary drug analysis using new tests on urine specimens previously obtained and tested for a limited panel of drugs. In one study, 72 of the 100 specimens that were negative for routinely-tested drugs were positive for synthetic cannabinoids. The Kansas Highway Patrol, among other state and local jurisdictions, is also conducting relevant studies that should yield additional information on drug recognition and impairment.

Other Resources

NIJ

- Preliminary Drug Identification: Field Investigation Drug Officer Program
- Find forensics research relating to drugs and crime

NHTSA

Read NHTSA's Traffic Safety Facts Research Notes on:

- Understanding the Limitations of Drug Test Information, Reporting, and Testing Practices in Fatal Crashes (pdf, 3 pages)
- Results of the 2013-2014 National Roadside Survey of Alcohol and Drug Use by Drivers (pdf, 5 pages)
- Drug and Alcohol Crash Risk (pdf, 11 pages)

NIDA

- Drugged Driving
- Drug Testing

ONDCP

- Community Drug Early Warning System: The CDEWS Pilot Project (pdf, 80 pages)

Government Accountability Office

- Drug-Impaired Driving: Additional Support Needed for Public Awareness Initiatives

NIST

- Organization of Scientific Area Committees: Seized Drugs Subcommittee

Other

- Scientific Working Group for the Analysis of Seized Drugs

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Participant List

Invited experts included state and local practitioners who routinely manage cases and supervise offenders associated with possession of controlled substances, driving under the influence, and other drug-related offenses in regions across the U.S.

Practitioners included: law enforcement (drug recognition experts, crime analysts); forensic laboratory scientists (forensic toxicologists, drug chemists); medical examiners; court practitioners (prosecutors, judges, defenders); and corrections officers (probation and parole). In addition to NHTSA, NIJ and NIDA, federal participants represented law enforcement, public health, and other agencies such as the Substance Abuse and Mental Health Services Administration, CDC, and ONDCP.

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National Highway Traffic Safety Administration

NHTSA
www.nhtsa.gov

Overview of NHTSA's Current Drugged Driving Research

Dereece D. Smither, Ph.D.
Office of Behavioral Safety Research

NHTSA Office of Behavioral Safety Research

- studies behaviors and attitudes in highway safety, focusing on drivers, passengers, pedestrians, and motorcyclists.
- identify and measure behaviors involved in crashes or associated with injuries
- develop and refine countermeasures to deter unsafe behaviors and promote safe alternatives

OBSR Research Solicitation Methods

- Open and limited competition contracts for research services
  - Full-and-Open Competitions
  - GSA
  - Indefinite delivery/Indefinite quantity (IDIQ)-Task Orders
  - Small Business & 8A
  - Small Business Innovative Research Program
  - Through NHTSA and other Agency's contract vehicles
- National Cooperative Research & Evaluation Program (NCREP)—NHTSA, GHSA, & Volpe
- To a limited extent—Unsolicited Contract Services

OBSR Research Approaches

- OBSR employs a variety of research and observational methods and designs al
  - Laboratory Studies (e.g., simulator studies)
  - Field Studies (e.g., roadside data collection)
  - Case Study
  - Focus groups
  - Naturalistic Observation (e.g., seatbelt observations, instrumented vehicles)
  - Physiological Observation (e.g., blood, oral fluid, breath)
  - Surveys (e.g., telephone-based, computer-based)
  - Evaluation Studies
  - Literature Reviews/Meta-analyses

NHTSA's Role

- Research Projects
- Demonstration Programs
- Support for Law Enforcement & Adjudication Efforts

Federal Partners

- NIDA
- NIAAA
- SAMHSA
- CDC
- ONDCP
- NTSB
- FDA
- DOJ

NHTSA
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A Little Background

- **A complex problem**
  - Effects of alcohol on driving performance fairly well-known
  - 30+ years of research and programmatic efforts on drugs

	Alcohol	Other Drugs
Size of Effort	One type of drug	Many (illegal, OTCs, prescription)
Research Efforts	Well-studied	Many, disparate
Metabolism	Processes understood	Variable; many possibilities
Effect on Driving behavior	Strong correlation to poor performance	Uncertain Correlation
Effect of High Doses	Greater decrements in performance	Unpredictable

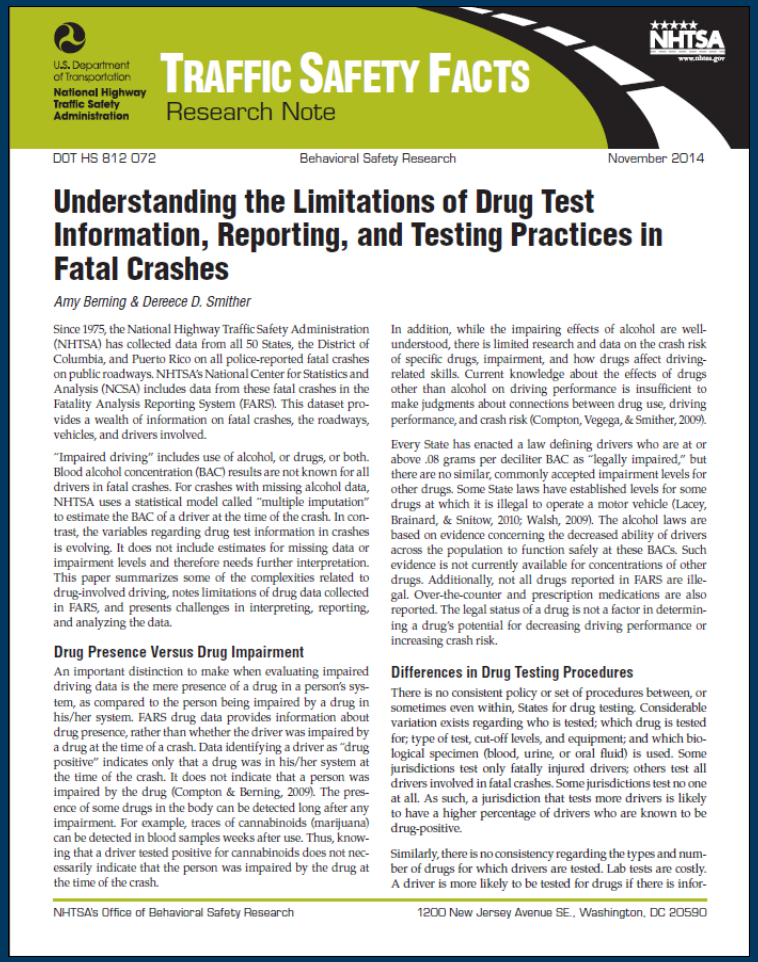
  - specific drug concentration levels **cannot** be reliably equated with effects on driver performance

National-Level Drug Data Sources—Examples

Data Source	Agency	Description
NSDUH (National Survey on Drug Use and Health)	SAMHSA	• Self-report • Adults • Use of alcohol, illicit drugs +driving
Youth Risk Behavioral Risk Factor Surveillance System (YRBSS)	CDC	• Self-report • 9-12th Grade Students • Drug use
MTF (Monitoring The Future)	University of Michigan (NIDA)	• Self-report • High School—Young Adults • Attitudes • Drug use+driving
Drug Recognition Expert (DRE) Database	NHTSA	• Law enforcement evaluation reports • DUID Suspects
National Roadside Survey	NHTSA	• Biological specimens (breath, oral, & fluid) • Nationally representative • Presence of drugs in drivers
FARS (Fatality Analysis Reporting System)	NHTSA	• Fatal injuries from MVCs • Alcohol-impaired driving data • Drugged driving Data

FARS Drug Data: A Cautionary Note

- Many people are seeking answers about drugged driving
- Many look to NHTSA's FARS data to help answer some of their questions
- However, NHTSA's FARS data has <u>many</u> limitations when it comes to drugged driving



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TRAFFIC SAFETY FACTS
Research Note

NHTSA

DOT HS 812 072 | Behavioral Safety Research | November 2014

Understanding the Limitations of Drug Test Information, Reporting, and Testing Practices in Fatal Crashes

Amy Berning & Dereece D. Smither

Since 1975, the National Highway Traffic Safety Administration (NHTSA) has collected data from all 50 States, the District of Columbia, and Puerto Rico on all police-reported fatal crashes on public roadways. NHTSA's National Center for Statistics and Analysis (NCSA) includes data from these fatal crashes in the Fatality Analysis Reporting System (FARS). This dataset provides a wealth of information on fatal crashes, the roadways, vehicles, and drivers involved.

"Impaired driving" includes use of alcohol, or drugs, or both. Blood alcohol concentration (BAC) results are not known for all drivers in fatal crashes. For crashes with missing alcohol data, NHTSA uses a statistical model called "multiple imputation" to estimate the BAC of a driver at the time of the crash. In contrast, the variables regarding drug test information in crashes is evolving. It does not include estimates for missing data or impairment levels and therefore needs further interpretation. This paper summarizes some of the complexities related to drug-involved driving, notes limitations of drug data collected in FARS, and presents challenges in interpreting, reporting, and analyzing the data.

Drug Presence Versus Drug Impairment

An important distinction to make when evaluating impaired driving data is the mere presence of a drug in a person's system, as compared to the person being impaired by a drug in his/her system. FARS drug data provides information about drug presence, rather than whether the driver was impaired by a drug at the time of a crash. Data identifying a driver as "drug positive" indicates only that a drug was in his/her system at the time of the crash. It does not indicate that a person was impaired by the drug (Compton & Berning, 2009). The presence of some drugs in the body can be detected long after any impairment. For example, traces of cannabinoids (marijuana) can be detected in blood samples weeks after use. Thus, knowing that a driver tested positive for cannabinoids does not necessarily indicate that the person was impaired by the drug at the time of the crash.

In addition, while the impairing effects of alcohol are well-understood, there is limited research and data on the crash risk of specific drugs, impairment, and how drugs affect driving-related skills. Current knowledge about the effects of drugs other than alcohol on driving performance is insufficient to make judgments about connections between drug use, driving performance, and crash risk (Compton, Vegega, & Smither, 2009).

Every State has enacted a law defining drivers who are at or above .08 grams per deciliter BAC as "legally impaired," but there are no similar, commonly accepted impairment levels for other drugs. Some State laws have established levels for some drugs at which it is illegal to operate a motor vehicle (Lacey, Brainard, & Snitow, 2010; Walsh, 2009). The alcohol laws are based on evidence concerning the decreased ability of drivers across the population to function safely at these BACs. Such evidence is not currently available for concentrations of other drugs. Additionally, not all drugs reported in FARS are illegal. Over-the-counter and prescription medications are also reported. The legal status of a drug is not a factor in determining a drug's potential for decreasing driving performance or increasing crash risk.

Differences in Drug Testing Procedures

There is no consistent policy or set of procedures between, or sometimes even within, States for drug testing. Considerable variation exists regarding who is tested; which drug is tested for; type of test, cut-off levels, and equipment; and which biological specimen (blood, urine, or oral fluid) is used. Some jurisdictions test only fatally injured drivers; others test all drivers involved in fatal crashes. Some jurisdictions test no one at all. As such, a jurisdiction that tests more drivers is likely to have a higher percentage of drivers who are known to be drug-positive.

Similarly, there is no consistency regarding the types and number of drugs for which drivers are tested. Lab tests are costly. A driver is more likely to be tested for drugs if there is infor-

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A Few of Many Questions

- How many drivers are alcohol and/or drug positive?
- Which drugs are related to increased crash risk?
- What is the effect of certain drugs on driving performance?
- What is the impact of training on an officer's ability to detect drugged driving?
- Can a field sobriety test be feasibly developed?
- How can law enforcement data be used to enhance detection of drugged drivers?
- How effective and accurate are portable drug testing devices?

How many drivers are alcohol and/or drug positive?

National Roadside Survey of Alcohol & Drugged Driving (2013-14)

- *Obtain data on this the prevalence of alcohol- and drug-positive drivers on the road.*
- *Drivers voluntarily provide breath, oral fluid, and blood samples and answer questions on alcohol & other drug use*
- *Research Note published on NHTSA website*

  http://www.nhtsa.gov/staticfiles/nti/pdf/812118-Roadside_Survey_2014.pdf

Questions? Contact Amy.berning@dot.gov

How many drivers are alcohol and/or drug positive?

National Roadside Survey General Results			
Alcohol Results	**Alcohol Positive**	**≥.08 g/dL**	**Drug Positive**
1973	36.0%	7.5%	--
2007	12.4%	2.2%	16.3%
2013-14	8.3%	1.5%	22.5%
Drug Results	**2007**	**2013-14**	
THC	8.6%	12.6%	
Any Illegal Drug	12.4%	15.1%	
Only Medications	3.9%	4.9%	

- **Of night-time drivers with BAC .01-.079 g/dL, 29.3% also tested positive for drugs (2007)**
- **Of night-time drivers with a BAC ≥.08 g/dL, 31.8% also tested positive for drugs (2007)**

How Many Drivers are Alcohol and/or Drug Positive?

Washington Roadside Survey of Alcohol & Drugs

Obtain data on this the prevalence of alcohol- and drug-positive drivers on the road. Emphasis on change in prevalence of THC-positive drivers before and after the change in WA's law allowing the sale and use of marijuana for recreational use.

Questions? Contact Amy.berning@dot.gov

Which Drugs Are Associated with Increased Crash Risk?

Alcohol & Drug Crash Risk: A Case-Control Study

Estimate the risk of crash involvement due to alcohol and drug use by collecting biological samples from crash- and noncrash-involved drivers

Research Note published on NHTSA website

http://www.nhtsa.gov/staticfiles/nti/pdf/812117-Drug_and_Alcohol_Crash_Risk.pdf

Questions? Contact Amy.berning@dot.gov

Which Drugs Are Associated with Increased Crash Risk?

Contribution of Alcohol and Drugs to Crash Risk

Drug and Alcohol Use	Adjusted Odds Ratio	95% CI*	P Value
No Alcohol / No Drug	1.00		
No Alcohol / Positive Drug	1.02	0.88 – 1.17	0.83
Positive Alcohol (< 0.05) / No Drug	0.84	0.55 – 1.29	0.43
Positive Alcohol (< 0.05) Positive Drug	1.03	0.55 – 1.94	0.93
Positive Alcohol (≥ 0.05) / No Drug	6.75	4.20 – 10.84	<0.0001
Positive Alcohol (≥ 0.05) / Positive Drug	5.34	2.75 – 10.37	<0.0001

Shading indicates statistical significance. Reference for all conditions was no drug and no alcohol. *CI = Confidence Interval

What Is the Effect of Certain Drugs on Driving Performance?

Examine the Effects of Inhaled Cannabis on Driving Performance

A study of the effects of low and high doses of inhaled cannabis, combined with low or placebo doses of alcohol, on driving performance in the National Advanced Driving Simulator (NADS)

Questions? Contact dereece.smither@dot.gov

Training For Law Enforcement Personnel

Course	Course Hours	Prerequisite
Standard Field Sobriety Test (SFST) Training (Drugs That Impair Driving unit)	24 Hours (8 hours)	none
Advanced Roadside Impaired Driving Enforcement (ARIDE) Program	16 hours	SFST
Drug Evaluation and Classification (DEC) Program Training	9 days	SFST; DRE Pre-School (1st 2 of 9 days); ARIDE (optional)

How Can Law Enforcement Data Be Used to Enhance Detection of Drugged Drivers?

Explore the Predictive Validity of Drug Evaluation and Classification (DEC) Program Tests

Collect large sample of DRE (Drug Recognition Expert) reports and perform statistical analyses to determine which combination(s) of elements in the data provide the most efficient and effective means to predict the toxicology-confirmed results

Questions? Contact dereece.smither@dot.gov

What Is the Impact of Training on an Officer's Ability to Detect Drugged Driving?

Evaluation of the Advanced Roadside Impaired Driving Evaluation (ARIDE) Curriculum

Assess Course Implementation and Learner Performance of participants in the In-Class and Online versions of the course

Questions? Contact dereece.smither@dot.gov

How effective and accurate are portable drug testing devices for widespread use?

Evaluation of Drug Testing Devices

Collect oral fluid data from arrestees using 2 commercially available rapid drug testing devices

Questions? Contact Amy.berning@dot.gov

Can a field sobriety test be feasibly developed?

Developing a Field Test for Detecting Drivers Impaired by Cannabis

Gather, evaluate, and interpret literature, on tests of impairment from marijuana or other drug use (e.g., test of cognitive ability, behavioral tests, driving skills tests) and provide suggestions for a promising test and/or combinations of tests that could be validated in a laboratory study and (later) in field studies

Questions? Contact dereece.smither@dot.gov

Where can you find our RFPs?

Solicitation method	Locate NHTSA's Requests for Proposals Here:
Full & Open Competition	www.fbo.gov
GSA Schedules	http://www.gsa.gov/portal/category/100611
IDIQ	Competition limited to firms selected
Small Business & 8A	Competition limited to registered firms
Cooperative Agreements & Grants	www.grants.gov
Small Business Innovation Research (SBIR) Program	www.sbir.gov/agencies/department-of-transportation
NCREP	Via Volpe's own solicitation methods (e.g., FBO, GSA, SBIR, IDIQ)

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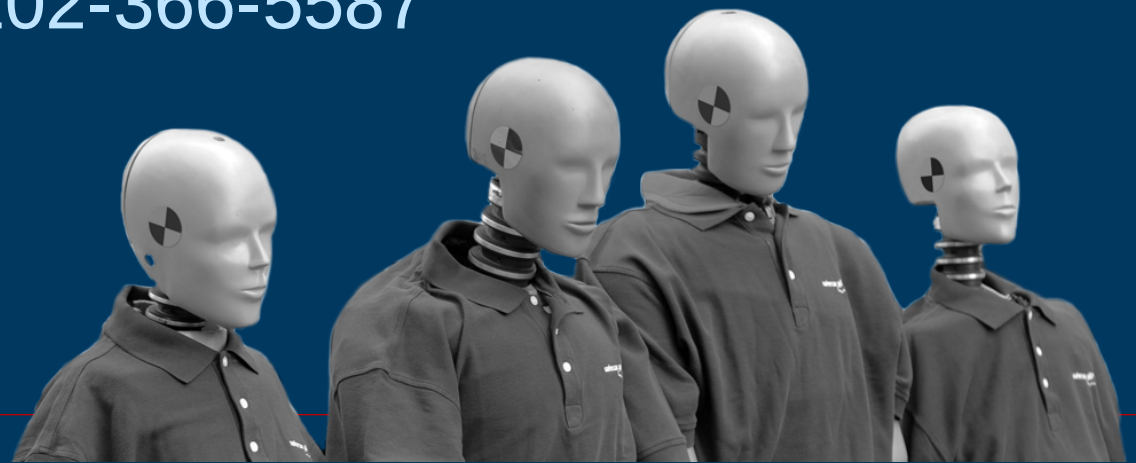


NHTSA OBSR Recent Drugged Driving Projects

Project Title	Project Objective	Project Manager	Project Status
Evaluation of the Advanced Roadside Impaired Driving Evaluation (ARIDE) Curriculum	*Assess Course Implementation and Learner Performance of participants in the In-Class and Online versions of the course*	Dereece Smither	Study Underway
Evaluation of Drug Testing Devices	*Collect oral fluid data from arrestees using 2 commercially available rapid drug testing devices*	Amy Berning	Study Underway
National Roadside Survey of Alcohol & Drugged Driving (2013 14)	*Collect large sample of DRE (Drug Recognition Expert) reports and perform statistical analyses to determine which combination(s) of elements in the data provide the most efficient and effective means to predict the toxicology-confirmed results*	Dereece Smither	Final Report Under Review
Examine the Effects of Inhaled Cannabis on Driving Performance	*A study of the effects of low and high doses of inhaled cannabis, combined with low or placebo doses of alcohol, on driving performance in the National Advanced Driving Simulator (NADS)*	Dereece Smither	Data Analysis Underway; Some results released by NIDA
Washington Roadside Survey of Alcohol & Drugs	*Obtain data on this the prevalence of alcohol- and drug-positive drivers on the road. Emphasis on change in prevalence of THC-positive drivers before and after the change in WA's law allowing the sale and use of marijuana for recreational use.*	Amy Berning	Research Note Published on NHTSA Website; Additional Reports Pending
Alcohol & Drug Crash Risk: A Case Control Study	*Estimate the risk of crash involvement due to alcohol and drug use by collecting biological samples from crash- and noncrash-involved drivers*	Amy Berning	Research Note Published on NHTSA Website; Additional Report Pending
Developing a Field Test for Detecting Drivers Impaired by Cannabis	*Gather, evaluate, and interpret literature, on tests of impairment from marijuana or other drug use (e.g., test of cognitive ability, behavioral tests, driving skills tests) and provide suggestions for a promising test and/or combinations of tests that could be validated in a laboratory study and (later) in field studies*	Dereece Smither	Study Underway

National Cooperative Research and Evaluation Program (NCREP)
Current Drugged Driving Projects

MAP-21, Subsection 402(c), states that the Secretary, acting through the NHTSA Administrator, shall establish a cooperative program to research and evaluate State highway safety countermeasures. This program is jointly managed by NHTSA and the Governors Highway Safety Association (GHSA). The projects are administered by NHTSA with the help of The Volpe National Transportation Systems Center

Project Title	Project Objectives	NHSTA Subject Matter Expert	Status
Collect Drug Use Data from Drivers Arrested for DUI or DUID	*Examine the characteristics of drug use among drivers arrested for DWI and or DUID. The study will collect information, including self-report data and biological samples, on over-the-counter, prescription, and illegal drug use on the day of arrest.*	Amy Berning	The Project Summary has been posted on Fedbizopps.com.
Examination of the Legalization and Decriminalization of Marijuana on the Driving While Impaired (DWI) System	*This project will examine how a state's DWI system evolves with the legalization and decriminalization of marijuana. It will "tell the story" of how states manage the enforcement, prosecution, adjudication and communication following enactment of recreational and/or medical marijuana laws. Law makers, State governments, GHSA, and NHTSA and other Federal agencies will be the primary audience.*	Dereece Smither	This project is underway. The formal Planning Meeting involving **GHSA, NHTSA,** and **Volpe** held for January 29, 2015. The Expert Panel Meeting is tentatively scheduled for July 14-15 2015.
Summarize Major Data Sources of Drug Driving Information	*Identify sources of data on drug use and drugged driving, and note their strengths and weaknesses. Synthesize the information and illustrate strategies for pulling together information across data sources to answer research and policy questions. Look across databases to develop profiles of the drugged driving issue.*	Dereece Smither	Project scoping is underway.

NIJ Controlled Substances and Forensic Toxicology Research and Development Program

Frances Scott
Physical Scientist
National Institute of Justice
Office of Investigative and Forensic Sciences

Active Projects – Controlled Substances

#	Grantee Name	Award Number	Project Title
1	Auburn University	2012-DN-BX-K026	Forensic Chemistry of Substituted 1-Alkyl-3-Acylindoles: Isomeric Synthetic Cannabinoids.
2	Auburn University	2013-DN-BX-K022	Bath Salt-type Aminoketone designer Drugs: Analytical and Synthetic Studies on Substituted Cathinones
3	The George Washington University	2014-R2-CX-K009	The Utility of Ultra High Performance Supercritical Fluid Chromatography for the Analysis of Seized Drugs: Application to Synthetic Cannabinoids and Bath Salts
4	Florida International University	2011-DN-BX-K531	Separation and Identification of Drugs of Abuse Using ESI-IMS-MS
5	The Florida International University	2012-DN-BX-K048	Paper microfluidic systems for rapid and inexpensive presumptive detection of drugs and explosives
6	University of Central Florida	2012-R2-CX-K005	Transition Metal Cluster Compounds for the Fluorescent Identification and Trace Detection of Substances of Abuse
7	McCrone Research Institute	2011-DN-BX-K528	Development of a Modern Compendium of Microcrystal Tests for Illicit Drugs and Diverted Pharmaceuticals
8	The Research Foundation for The SUNY, University at Albany	2013-DN-BX-K041	Statistical Analysis and Forensics Determination of Designer Drugs via Direct Analysis in Real Time Mass Spectrometry (DART-MS)
9	West Chester University of Pennsylvania	2014-R2-CX-K008	A Systematic Evaluation of the Analysis of Drug Microcrystals Using Infrared Microspectroscopy
10	Harris County, TX	2013-DN-BX-K020	Characterization of Performance-Enhancing Peptides via Inlet Ionization on DART-TOF/MS
11	Sam Houston State University	2014-R2-CX-K005	Development of Heated Headspace Solid Phase Microextraction-Gas Chromatography/Mass Spectrometry for Chemical Profiling of Marijuana

Active Projects – Forensic Toxicology

#	Grantee Name	Award Number	Project Title
1	Florida International University	2013-DN-BX-K032	Aptamer-Based, Exonuclease-Amplified, Paper Device for Point of Collection Screening of Cocaine and Methamphetamine in Oral Fluid
2	The Florida International University Board of Trustees	2014-R2-CX-K006	Forensic Toxicological Screening/Confirmation of 500+ Designer Drugs by LC-QTOF-MS and LC-QqQ-MS Analysis
3	Trustees of Indiana University	2014-R2-CX-K007	Paper Spray Mass Spectrometry for Rapid Drug and Drug Metabolite Screening Directly fromPostmortem Blood Samples
4	Research Triangle Institute	2012-R2-CX-K001	Characterization of Designer Drugs: Chemical Stability, Exposure, and Metabolite Identification
5	Research Triangle Institute	2013-DN-BX-K017	Dried Blood Spot Analysis as an Emerging Technology for Application in Forensic Toxicology
6	Research Triangle Institute	2013-DN-BX-K021	Analysis of Drugs of Abuse in Human Hair: Surface Contamination and Localization of Analytes
7	The Center for Forensic Science Research and Education	2013-DN-BX-K018	Identification and Prevalence Determination of Novel Recreational Drugs and Discovery of Their Metabolites in Blood, Urine and Oral Fluid
8	Sam Houston State University	2012-R2-CX-K003	Improved Detection of Synthetic Cathinones ("Bath Salts")in Forensic Toxicology Samples
9	Sam Houston State University	2013-R2-CX-K006	Long-Term Stability of Synthetic Cathinones in Forensic Toxicology Samples
10	University of Utah	2011-DN-BX-K532	Prediction of drug interactions with methadone, buprenorphine and oxycodone from in vitro inhibition of metabolism
11	University of Utah	2014-R2-CX-K012	Data mining PCC annual reports
12	Virginia Commonwealth University	2014-R2-CX-K010	Characterization and Abuse of Electronic Cigarettes: The Efficacy of a Personal Vaporizer as an Illicit Drug Delivery System
13	IsoForensics, Inc.	2013-DN-BX-K009	Isotope Analyses of Hair as a Trace Evidence Tool to Reconstruct Human Movements: Establishing the Effects of the "Human Ecosystem" On Strontium and Oxygen Isotope Ratios

TECHNOLOGY WORKING GROUP (TWG) – OPERATIONAL REQUIREMENTS

(Updated Fall 2014)

NIJ

TWG Operational Requirements - Controlled Substances and Toxicology

#	Operational Requirement
1	Better dissemination strategies for and/or improved access to current research and technology, especially SOPs, to avoid duplication of effort in method development/problem solving and in house validation/verification.
2	Standards/new reference materials for use in forensic labs, especially standards for comparison (to include parent drugs and metabolites).
3	Research into trends in structure that will lead to stability issues (i.e shelf life); including controlled substances and/or non-controlled substances unintentionally becoming controlled substances.
4	Guidelines for a communal determination of "structural similarity". Compilation of existing pharmacological activity data, as well as research to determine the pharmacological activity where it is not known.
5	More effective , faster, more efficient streamlined processes in sample detection, collection, handling and analysis/interpretation, including research to determine source of bottlenecks, as well as to address policy matters pertaining to case processing (e.g. scientific basis for two orthogonal tests).
6	Development and application of emerging or current instrumentation being applied to method development (e.g., microspectrophotometer, using the second derivative, thermal analysis coupled with FTIR or GC-MS, Fast-GC and 2D-GC).
7	Research into efficiency of case management policies/casework (e.g. what are the judicial consequences).

TWG Operational Requirements - Controlled Substances

#	Operational Requirement
1	Development of best practices for chemical identification among emerging technologies. (e.g. evaluation of different instrument platforms), including analysis of cost effectiveness or other benefit of emerging technology.
2	Evaluation of techniques for resolution/identification of forensically relevant isomers, including standardization of criteria to conclude spectra match and use of non-MS techniques (Raman, IR).
3	Standardized/available published methods for extraction and quantitation of THC from various substrates or materials.
4	Guidelines for: validation of methods, performance of SOPs, verification/validation of instruments.
5	Uniform understanding in the community of the terms validation, performance verification, and method.
6	Better scheduling/legislation regarding emerging drugs.

TWG Operational Requirements - Toxicology

#	Operational Requirement
1	Forensically-relevant approaches for statistical interpretation of evidence (e.g. postmortem toxicology levels). Data mining of existing data sets.
2	Research on correlation of blood and oral fluid values, especially in regards to DUID interpretation, including differences between point of contact devices and lab confirmation.
3	Research to examine drug (esp. prescription drugs) levels pre- and post-embalming.
4	Research correlating DRE findings and toxicology results.
5	Training of sufficient quantity of personnel on difficult/non-robust instrumentation. Guidelines for call for bids to include specifics of training.
6	More robust 'expert' interpretation system that can automatically review raw data from GC/MS and/or LC/MS/MS analysis of toxicology samples to rapidly screen and flag those samples that require more intensive review by analysts and that ideally would be able to automatically calculate quantitative values based upon standards included in the same data batch.

HIGHLIGHTED PROJECTS

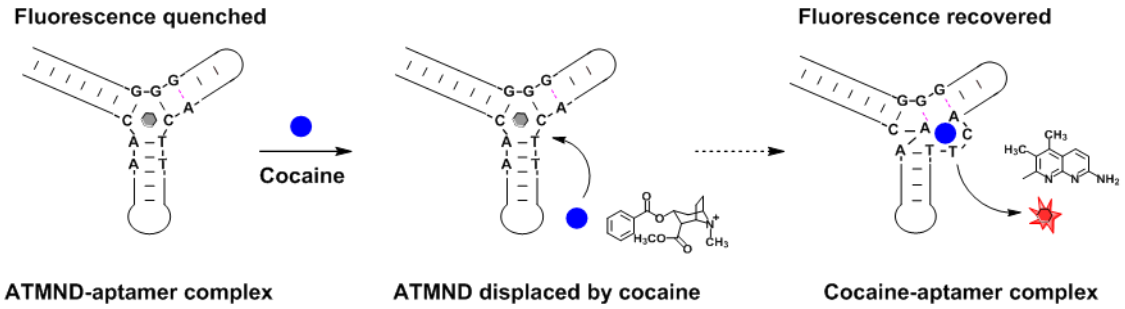
NIJ

Aptamer-Based, Exonuclease-Amplified, Paper Device for Point of Collection Screening of Cocaine and Methamphetamine in Oral Fluid

Florida International University - 2013-DN-BX-K032

Develop a colorimetric detection platform with a low cost, portable, paper-based microfluidic device to simultaneously detect trace amounts of cocaine and methamphetamine in oral fluid.

- Anticipated postage stamp sized paper.
- Detect cocaine and methamphetamines in oral fluid within 5 minutes.
- High specificity.

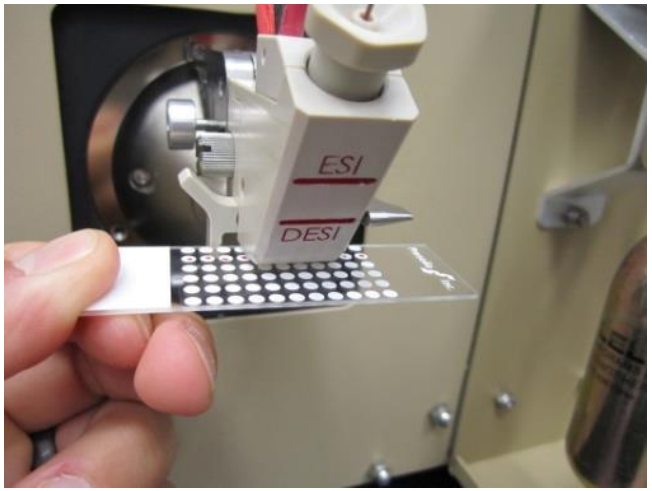


NIJ

Accessing the Probative Value of Physical Evidence at Crimes Scenes with Ambient Mass Spectrometry and Portable Instrumentation

Illinois State University - 2011-DN-BX-K552

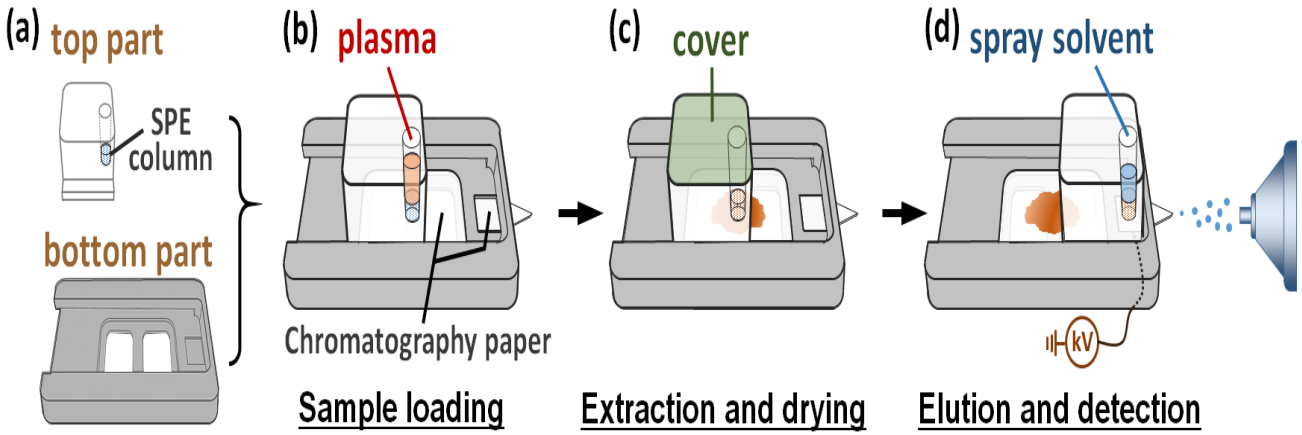
This project sought to develop a portable chemical detector based on a state-of-the-art mass spectrometer (MS) capable of sampling externally-generated ions. This capability allows direct screening of target compounds or “analytes” in their native environment and state without prior preparation.



Paper Spray Mass Spectrometry for Rapid Drug and Drug Metabolite Screening Directly from Postmortem Blood Samples

Trustees of Indiana University - 2014-R2-CX-K007

This project proposes to develop a paper spray mass spectrometer into an effective tool for drug screening of postmortem blood samples and other forensically relevant specimens. In this method, drug detection by mass spectrometry is carried out directly from a blood sample deposited on paper. It requires no sample preparation and can detect drugs and drug metabolites at forensically relevant levels directly from biofluid matrices.



Dried Blood Spot Analysis as an Emerging Technology for Application in Forensic Toxicology

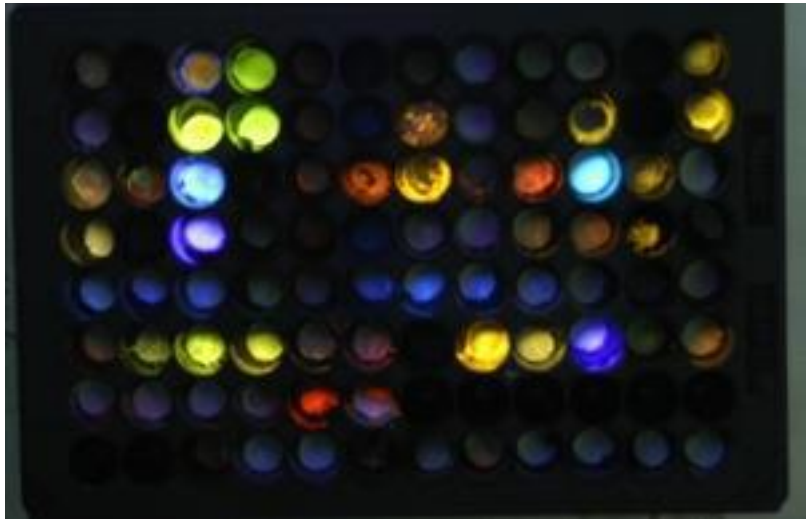
Research Triangle Institute - 2013-DN-BX-K017

The purpose of this study is to evaluate DBS analysis, using LDTD-MS/MS and LC-MS/MS, for the detection of drugs relevant to forensic toxicology, including drugs of abuse, emerging designer drugs, and drugs used in drug-facilitated crimes.

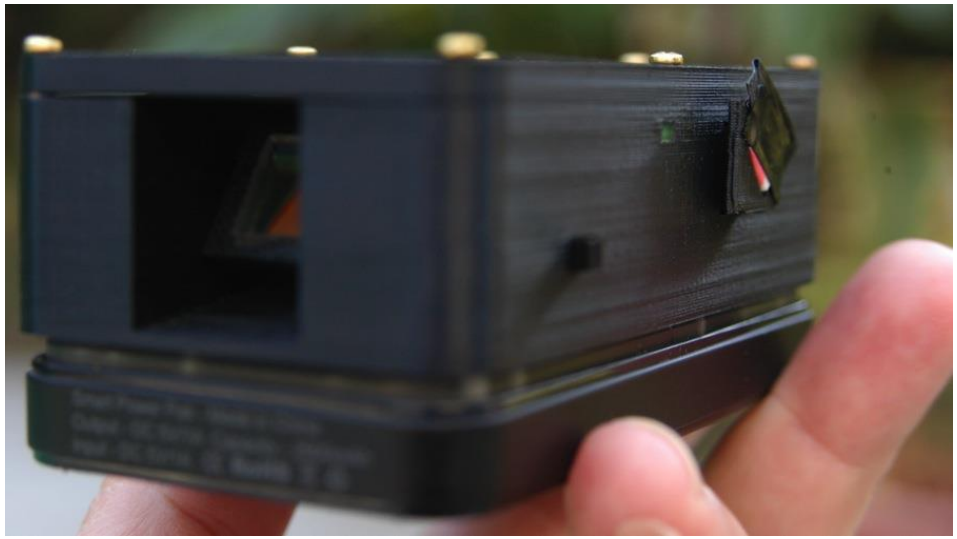
Transition Metal Cluster Compounds for the Fluorescent Identification and Trace Detection of Substances of Abuse

University of Central Florida - 2012-R2-CX-K005

This study will be to develop the application of new transition metal based indicators for the identification and trace detection of substances of abuse. These indicators will be used in conjunction with a 3D-printed fluorometer, a smartphone, and a cloud-based spectral database for rapid, inexpensive, field identification.



Example well plate under 254 nm illumination

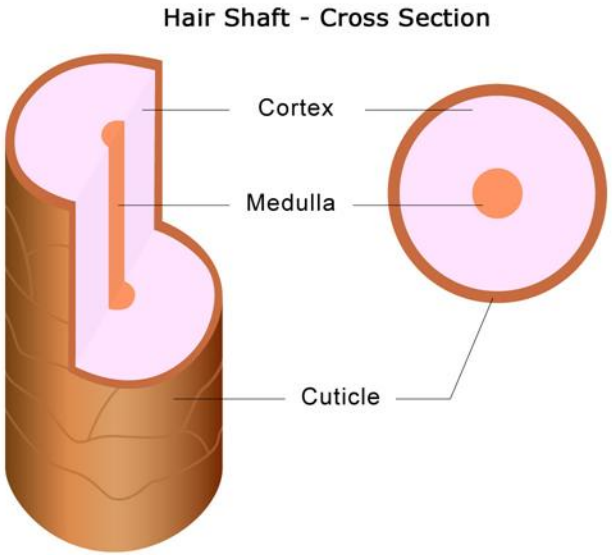


Analysis of Drugs of Abuse in Human Hair: Surface Contamination and Localization of Analytes

Research Triangle Institute - 2013-DN-BX-K021

This study examines the effects of environmental contamination of human hair leading to external deposition of amphetamine, methamphetamine, heroin, and oxycodone to identify drug use.

- Do drugs distribute in the hair differently due to consumption vs. contamination?
- Can distinct regions of a hair cross section be sampled?
- Are there differences in analyte distribution between externally contaminated samples and samples from known users?



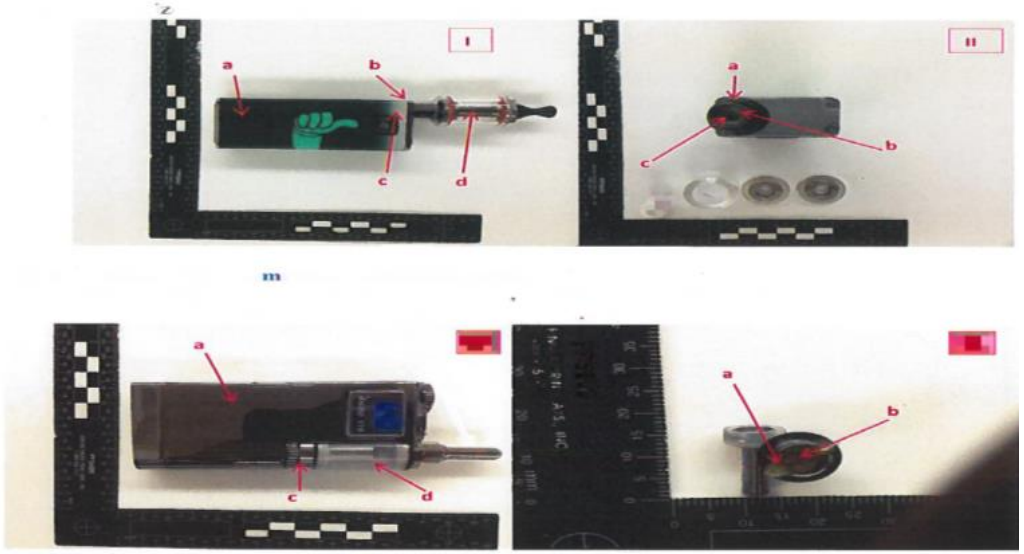
Characterization and Abuse of Electronic Cigarettes: The Efficacy of a Personal Vaporizer as an Illicit Drug Delivery System

Virginia Commonwealth University - 2014-R2-CX-K010

- Develop reliable, validated analytical methods by analyzing e-cigarette devices, device components, and aerosol for pharmaceuticals in adulterated, unadulterated, and self-prepared formulations.

- Characterize commercially available e-cigarettes.

- Characterize the liquid refill products for e-cigarettes, to include nicotine and adulterant pharmaceuticals.



Data mining PCC annual reports

University of Utah - 2014-R2-CX-K012

Proposing to mine the collected Tables 21 from the American Association of Poison Control Centers' annual report from 2000 to 2014 and collate the co-occurrence of pharmaceuticals (and alcohols) in the listed fatalities.

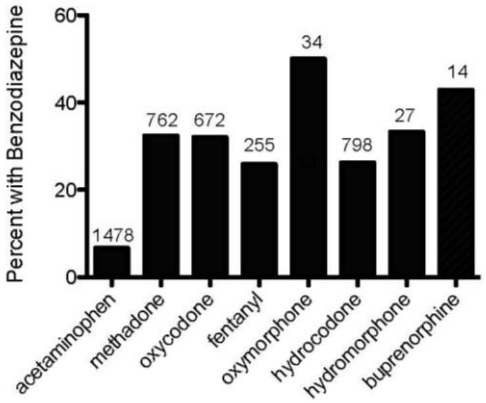


Table 21. Listing of fatal nonpharmaceutical and pharmaceutical exposures.

Annual Report ID	Age	Substances	Substance Rank	Cause Rank	Chronicity	Route	Reason	RCF	Analyte	Blood Concentration @ Time
		alprazolam	2	2					alprazolam	98 ng/mL In Whole Blood @ Autopsy
		diazepam	3	3						
343ai	20 y M				U	Ingst	Int-A	2		
		tramadol	1	1					tramadol	4.1 mcg/mL In Whole Blood @ Autopsy
		alprazolam	2	2					alprazolam	96 ng/mL In Whole Blood @ Autopsy
		carisoprodol	3	3						
344ai	20 y M				U	Ingst	Int-A	2		
		acetaminophen/ hydrocodone	1	1					hydrocodone	0.15 mcg/mL In Whole Blood @ Autopsy
		skeletal muscle relaxant	2	2					carisoprodol	5.1 mcg/mL In Whole Blood @ Autopsy
		skeletal muscle relaxant	2	2					meprobamate	9.3 mcg/mL In Whole Blood @ Autopsy
		alprazolam	3	3					alprazolam	109 ng/mL In Whole Blood @ Autopsy

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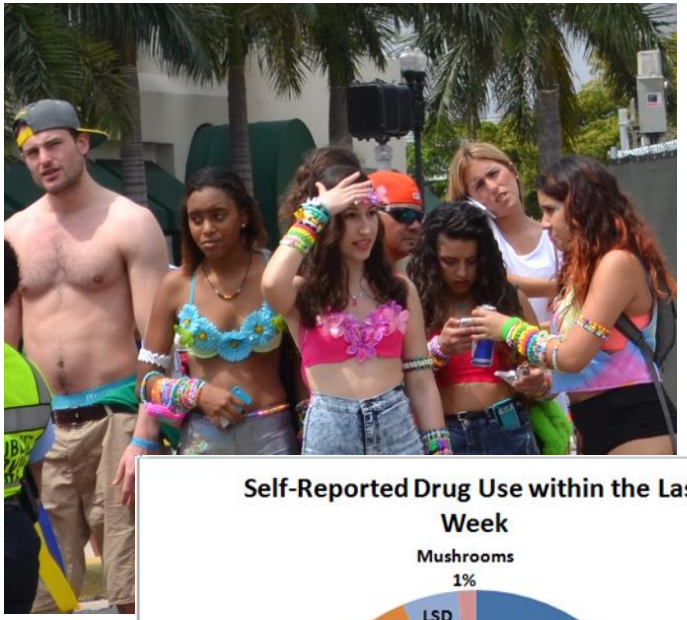
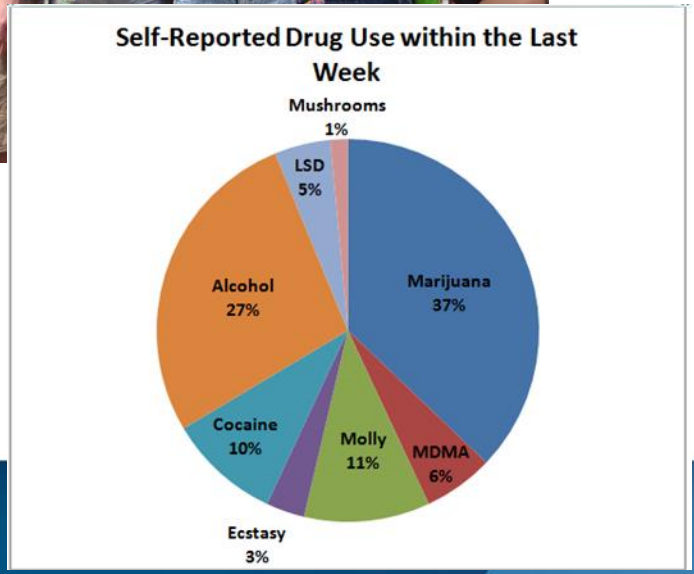
Identification and Prevalence Determination of Novel Recreational Drugs and Discovery of Their Metabolites in Blood, Urine and Oral Fluid

The Center for Forensic Science Research and Education - 2013-DN-BX-K018

This project is collecting and analyzing of paired blood, urine, and oral fluid samples from volunteer participants attending electronic dance music festivals (EDM), many of whom are likely to have ingested some of the newest designer drug products on the market.





Drug Recognition & Impairment Research
August 24, 2015

NIDA's Current Drugged Driving Research

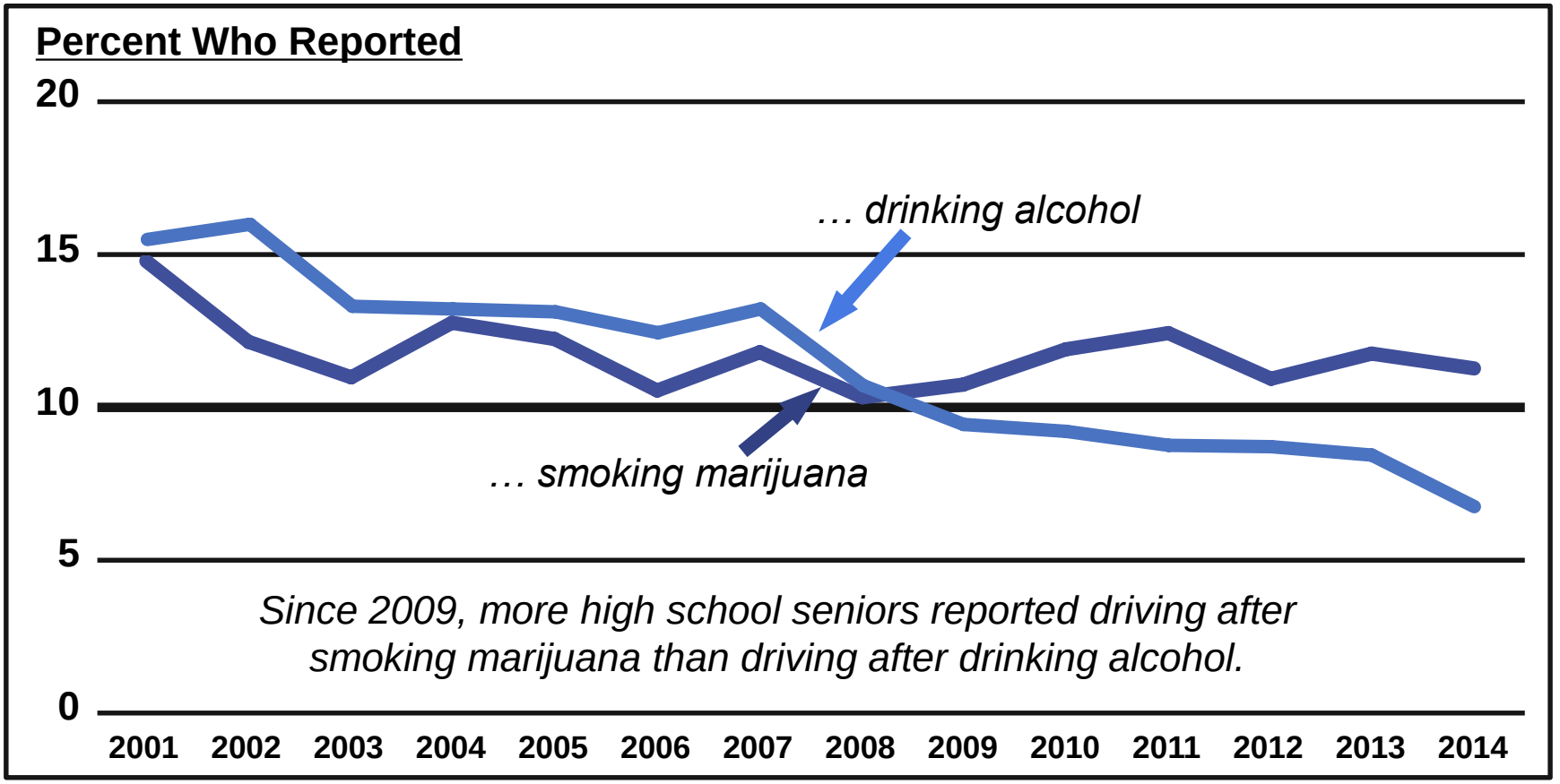
Professor Dr. Dr. (h.c.) Marilyn A. Huestis
Chief, Chemistry & Drug Metabolism, IRP
National Institute on Drug Abuse, NIH

NIDA's Mission & Current Extramural Grants on Drug Recognition & Impairment Research

- To lead the Nation in bringing the power of science to bear on drug abuse & addiction
- Monitoring the Future Study
  - Annual survey of nationally representative samples of high school 8th, 10th & 12th graders since 1975
  - Questions related to licit & illicit drug use
  - Driving under the influence & riding with someone who's under the influence
  - Demographic & lifestyle questions

12th Graders Who Drove After Smoking Marijuana or Drinking Alcohol, 2001-2014

During the LAST TWO WEEKS, have you driven a car, truck, or motorcycle after ...



Source: University of Michigan, 2014 Monitoring the Future study. Unpublished special tabulations (December 2014)

NIDA's Current Extramural Grants on Drug Recognition & Impairment Research

- Medical marijuana implementation & impact on health
  - Accidents, drug driving, laws, improved policies
- In vivo driving impairment research method: A new methodology for examining drug & alcohol impaired driving
- Drugged driving resources website for prevention of drugged driving
- NIDA International Program support of ICADTS Illegal Drugs & Driving Workgroup

NIDA's Current Extramural Grants on Drug Recognition & Impairment Research

- Effects of drug treatment courts on outcomes of adults & their children
  - Driving While Intoxicated; drug driving; laws
- Drinking, driving & drugs: trajectories of DWI recidivism & how to intervene
  - Merge Texas driving record & treatment data to identify & evaluate risk & protective factors for DWI/DUI recidivism among individuals who received alcohol &/or drug treatment & successful interventions

NIDA's Current Extramural Grants on Drug Recognition & Impairment Research

- Drinking & driving among recent Latino immigrants
  - Latinos consistently overinvolved in alcohol-related motor-vehicle fatal crashes but do not drink more than Whites
  - Evaluate level of understanding by recent immigrants about alcohol-related traffic laws & policies, & their level of compliance & an estimation of prevalence of problem crucial to assessing need for designing efficient countermeasures

Chemistry & Drug Metabolism NIDA Intramural Research Program

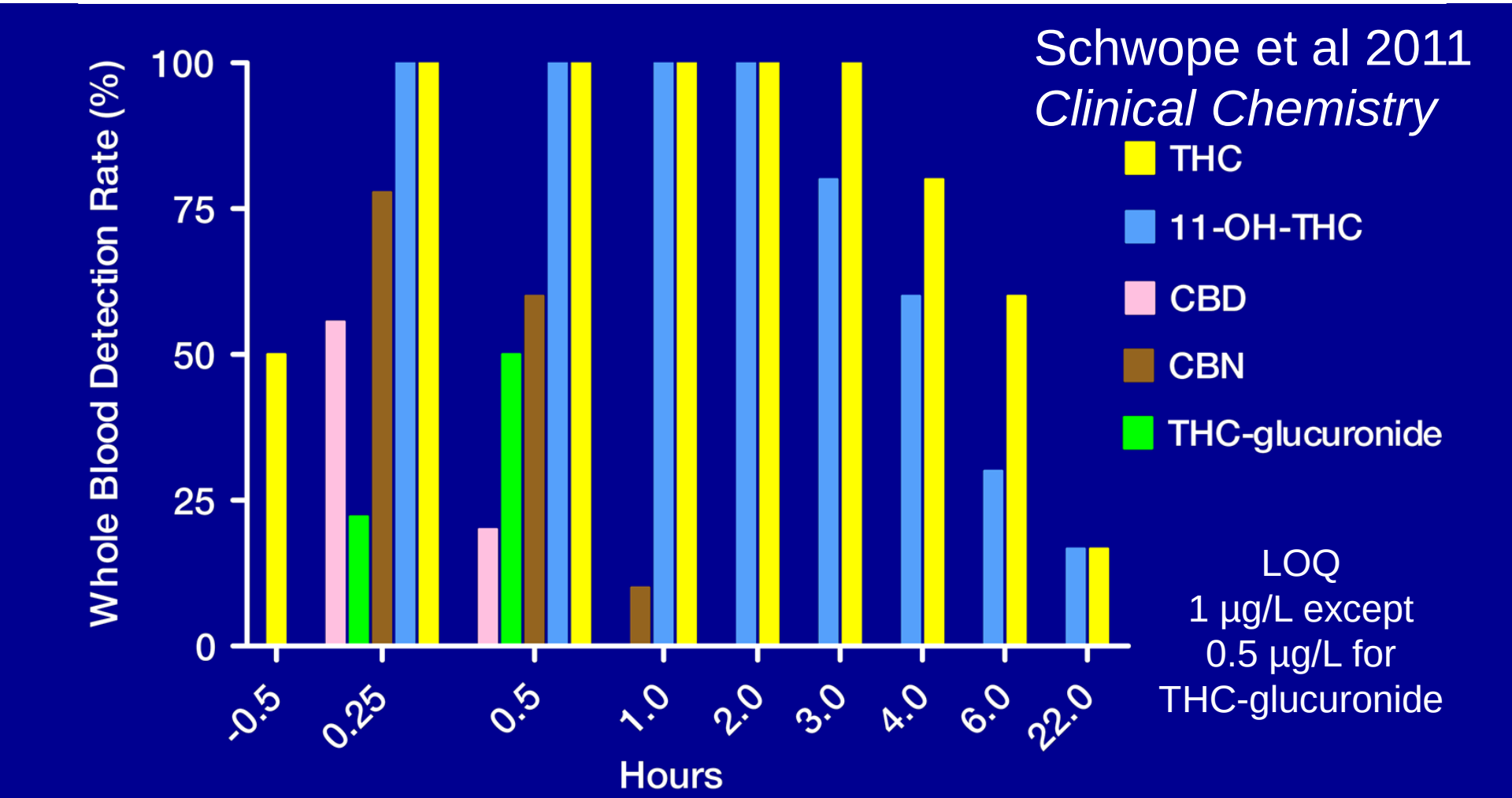
- Conduct controlled drug administration studies on pharmacodynamic & pharmacokinetic effects of drugs
  - Opioids, cocaine, methamphetamine, cannabis, MDMA, tobacco & alcohol
  - Onset, peak & duration of cognitive, psychomotor, subjective, hormone & physiological effects
  - Initial, peak & duration of drug concentrations in blood, plasma, oral fluid, urine, hair & sweat

Chemistry & Drug Metabolism NIDA Intramural Research Program

- Effects of cannabis with & without low dose alcohol on driving
  - National Advanced Driving Simulator- U of Iowa
- Novel psychoactive substances (NPS)
  - Screening &confirmation of synthetic cannabinoids, synthetic cathinones, piperazines
  - Identification of best urinary NPS targets by incubation with human hepatocytes & high resolution mass spectrometry HRMS
  - Non-targeted HRMS to identify urinary NPS, LC-MS/MS for targeted qualitative & quantitative NPS analysis

Are There Markers of Recent Cannabis Intake in Blood?

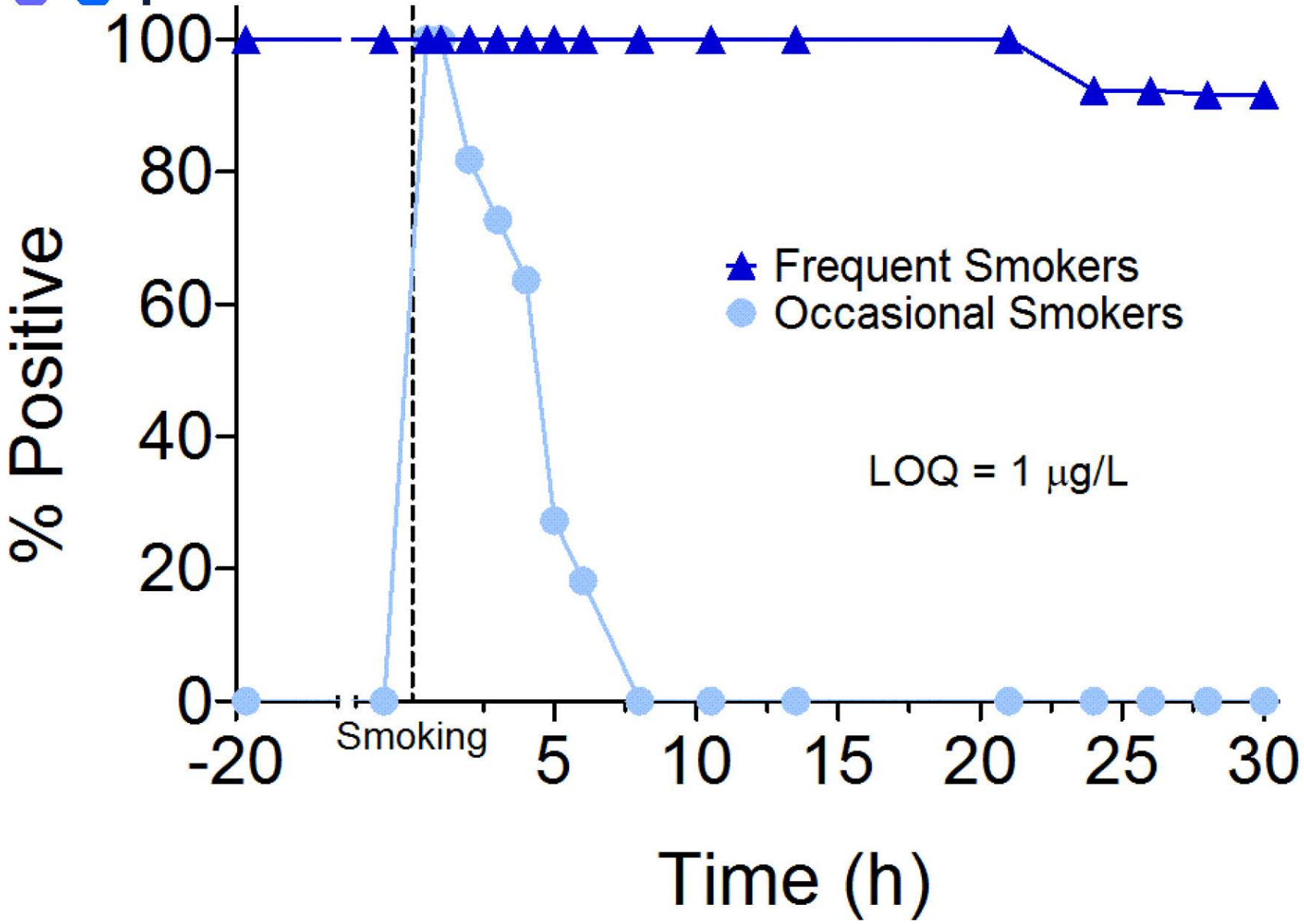
THCCOOH & THCCOOH-glucuronide present in all samples



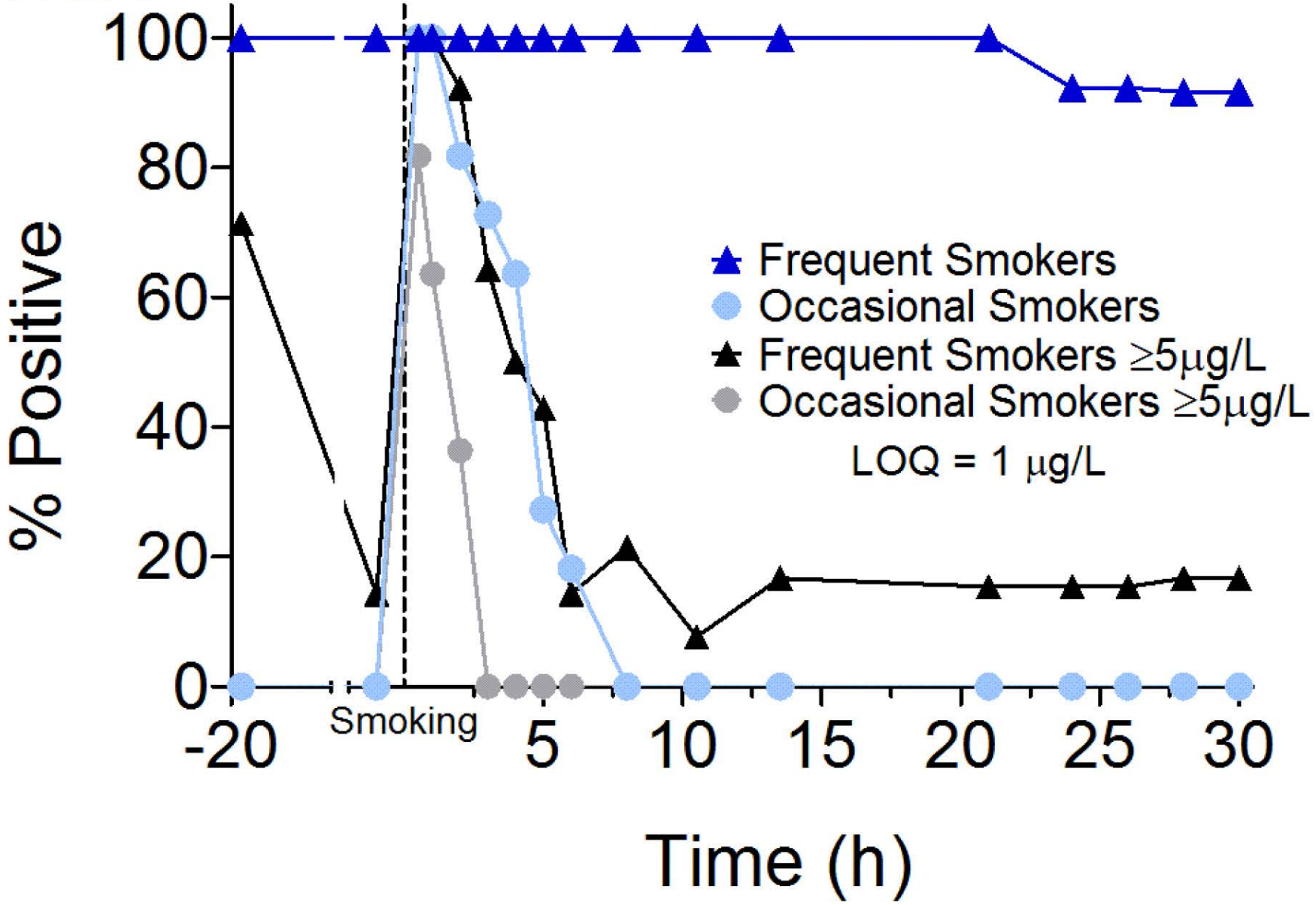
What Is Best THC Blood Concentration To Indicate Driving Impairment? 1, 2 or 5 µg/L?

Desrosiers et al 2014 *Clinical Chemistry*

Blood THC After Smoking 6.8% THC



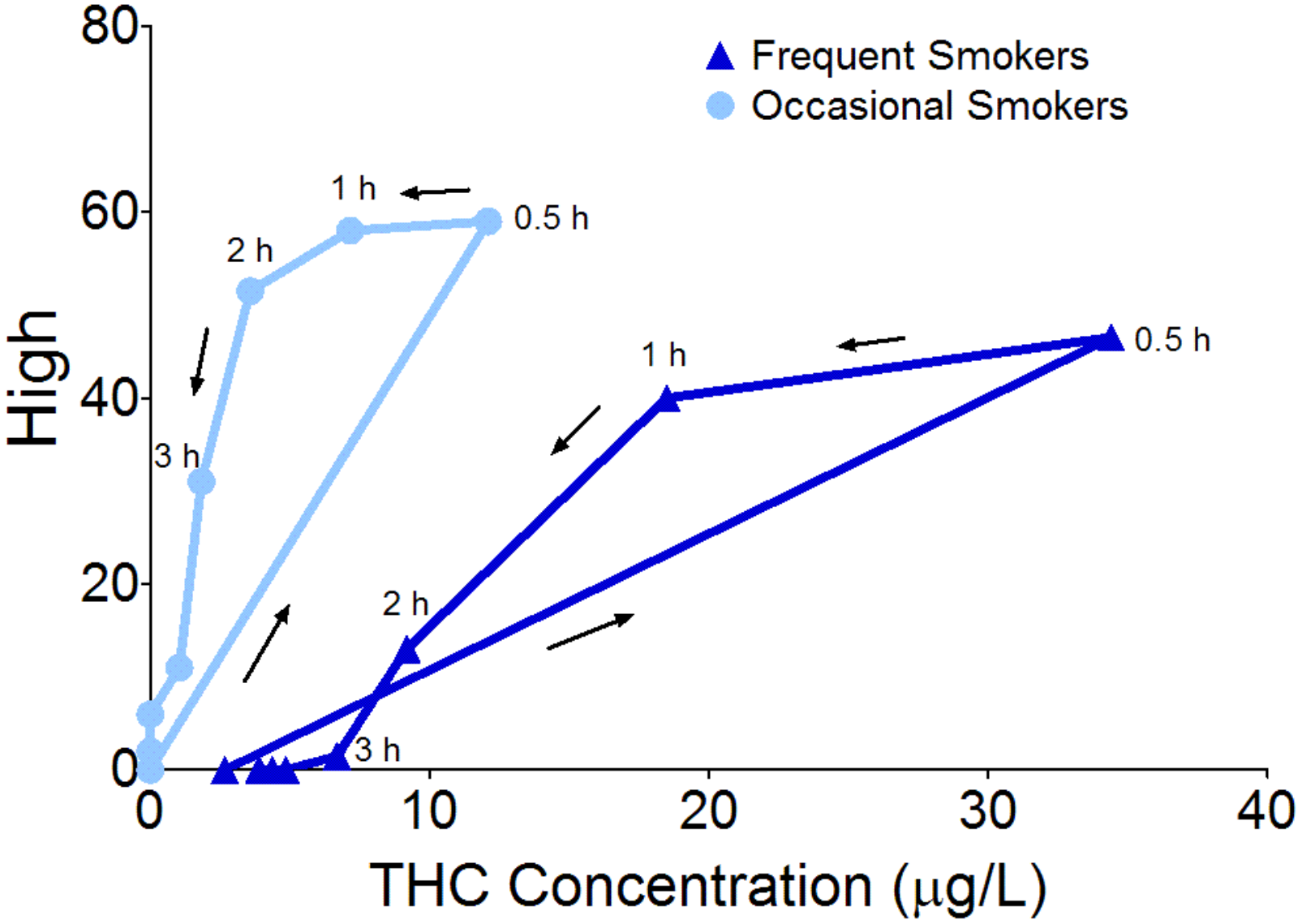
Blood THC After Smoking 6.8% THC



Legal Limits for Blood THC Concentrations & Driving

- In our research, occasional use = less than daily smoking & frequent smoking as daily cannabis smoking (varies by author)
- CO & WA state use ≥ 5 µg/L THC cutoffs
- Only 81.2% occasional smokers ≥ 5 µg/L at 30 min; all < 5 µg/L by 2 h
- <20% frequent smokers ≥ 5 µg/L by 5 h; 16.7% still ≥ 5 µg/L after 30 h

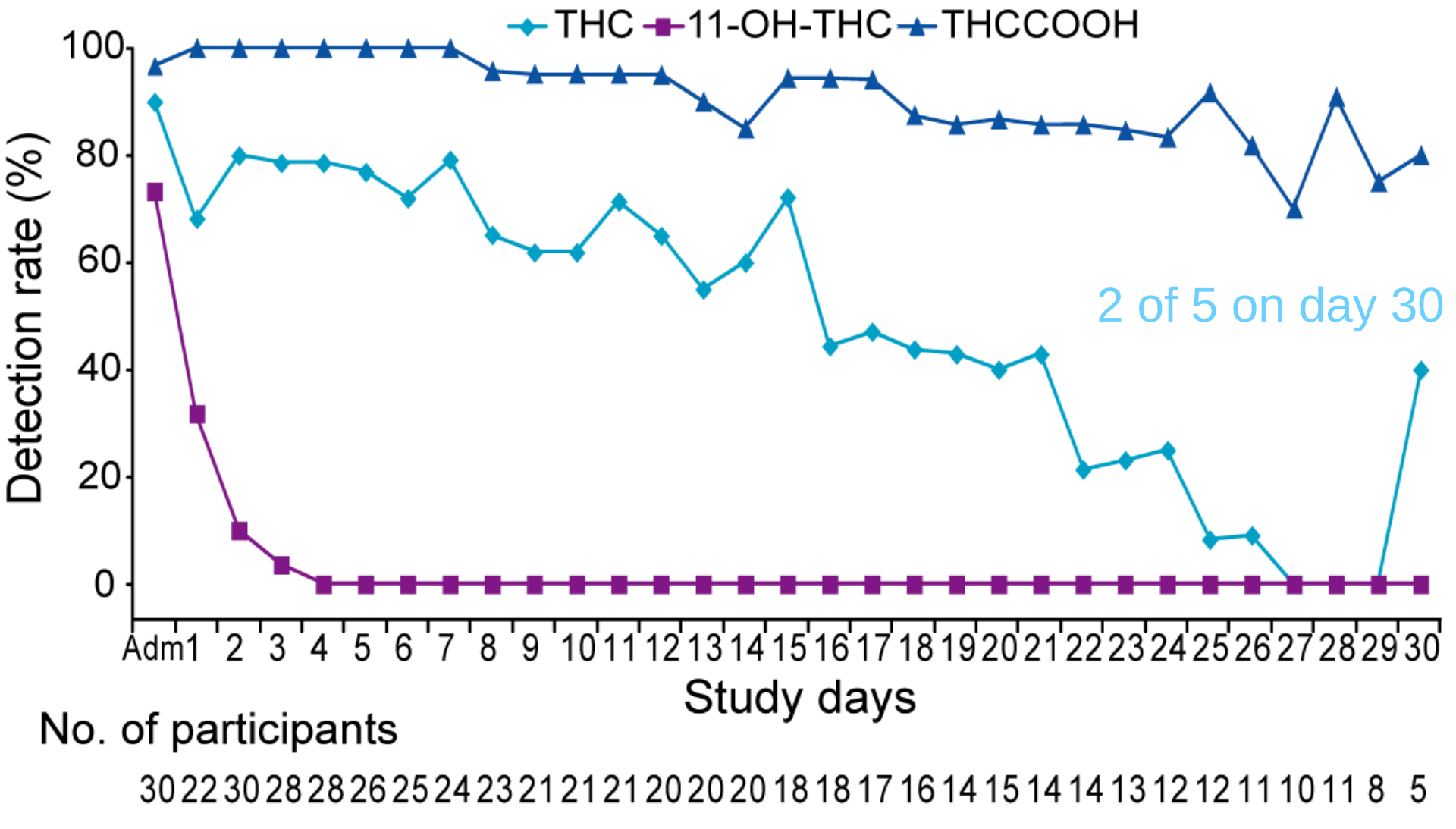
Hysteresis in Subjective “High”



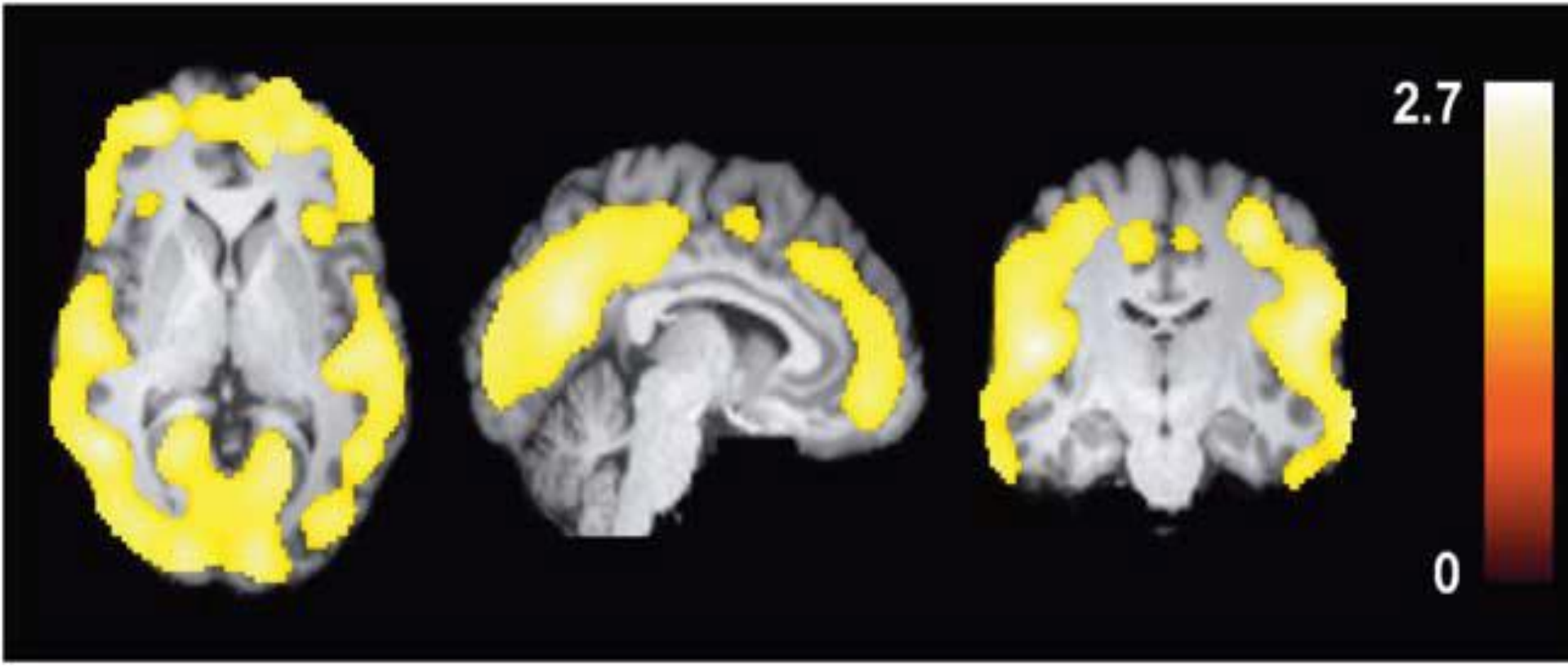
Residual Blood Cannabinoids Excretion in Chronic Frequent Cannabis Smokers Over 30 Days Sustained Abstinence

Bergamaschi et al *Clinical Chemistry* 2013

Median Cannabinoid Excretion in Chronic Frequent Cannabis Smokers Blood over 30 Days Sustained Abstinence (0.25 µg/L)

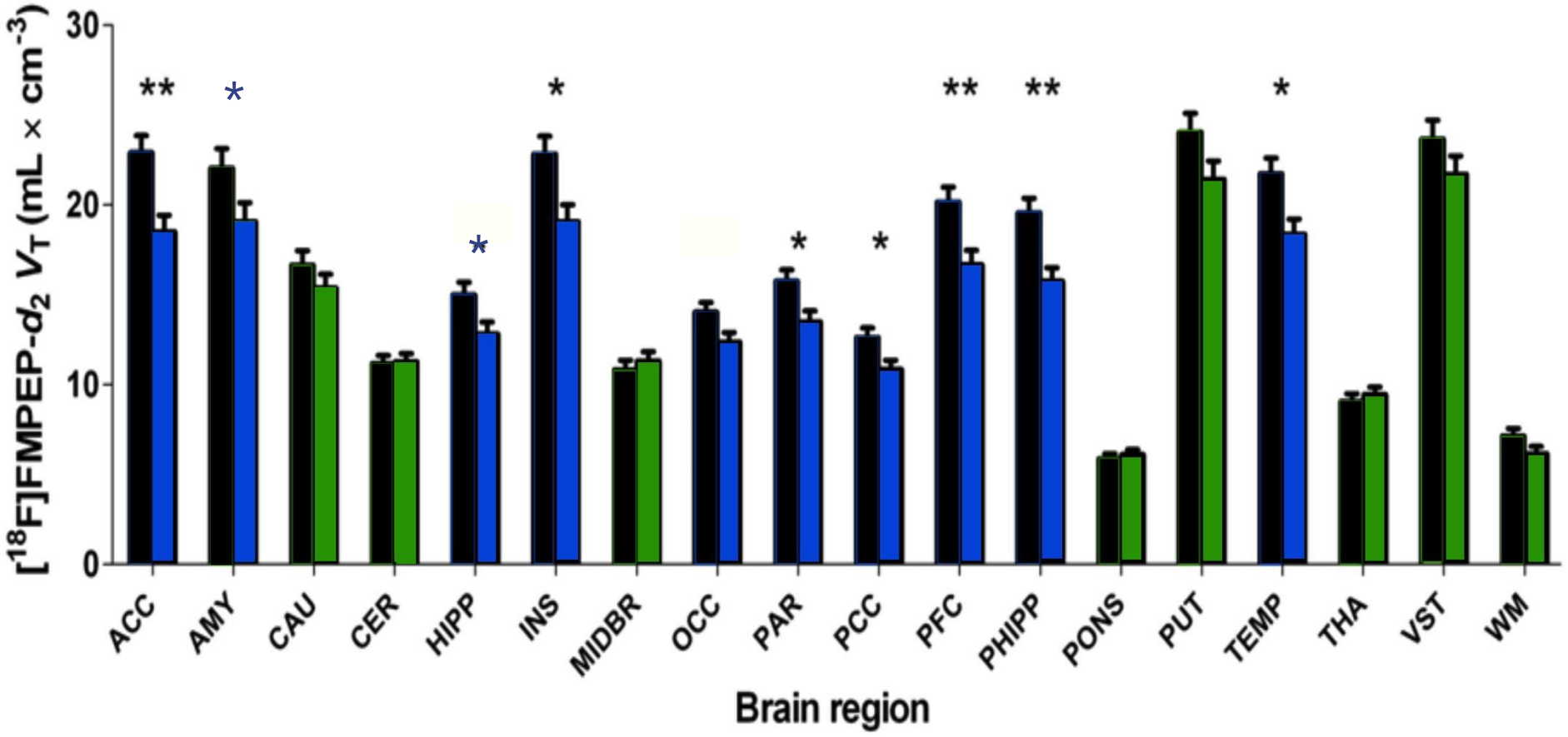


[^{18}F]FMPEP-d_2 Labels CB1 Cannabinoid Receptors in Brain of Chronic Daily Cannabis Smokers

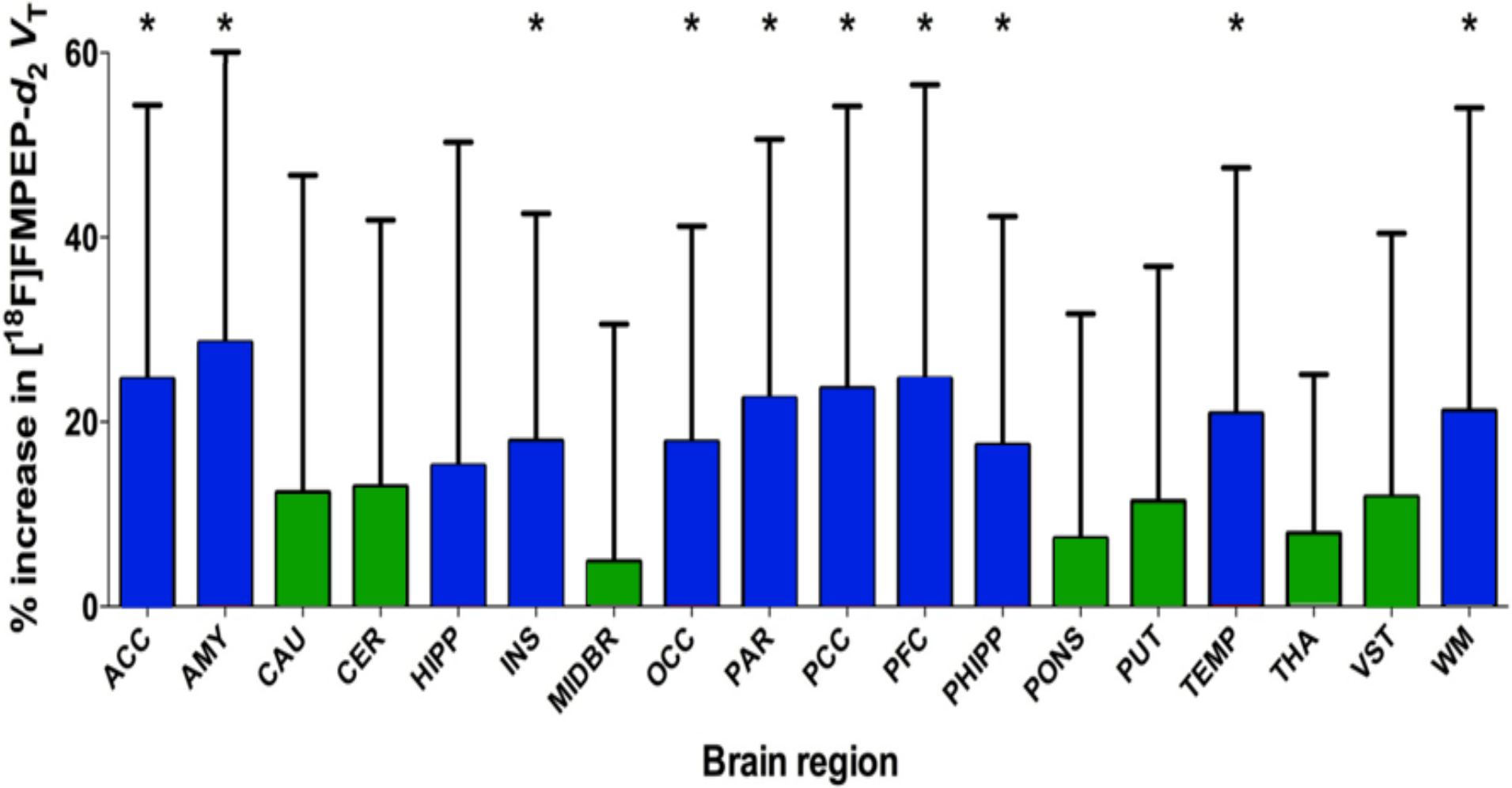


Hirvonen & Innis et al. *Molecular Psychiatry* 2012

CB_1-Cannabinoid Receptors Specifically Downregulated in Cortical Regions of Chronic Daily Cannabis Smokers (N=30) as Compared to Controls (N=28)



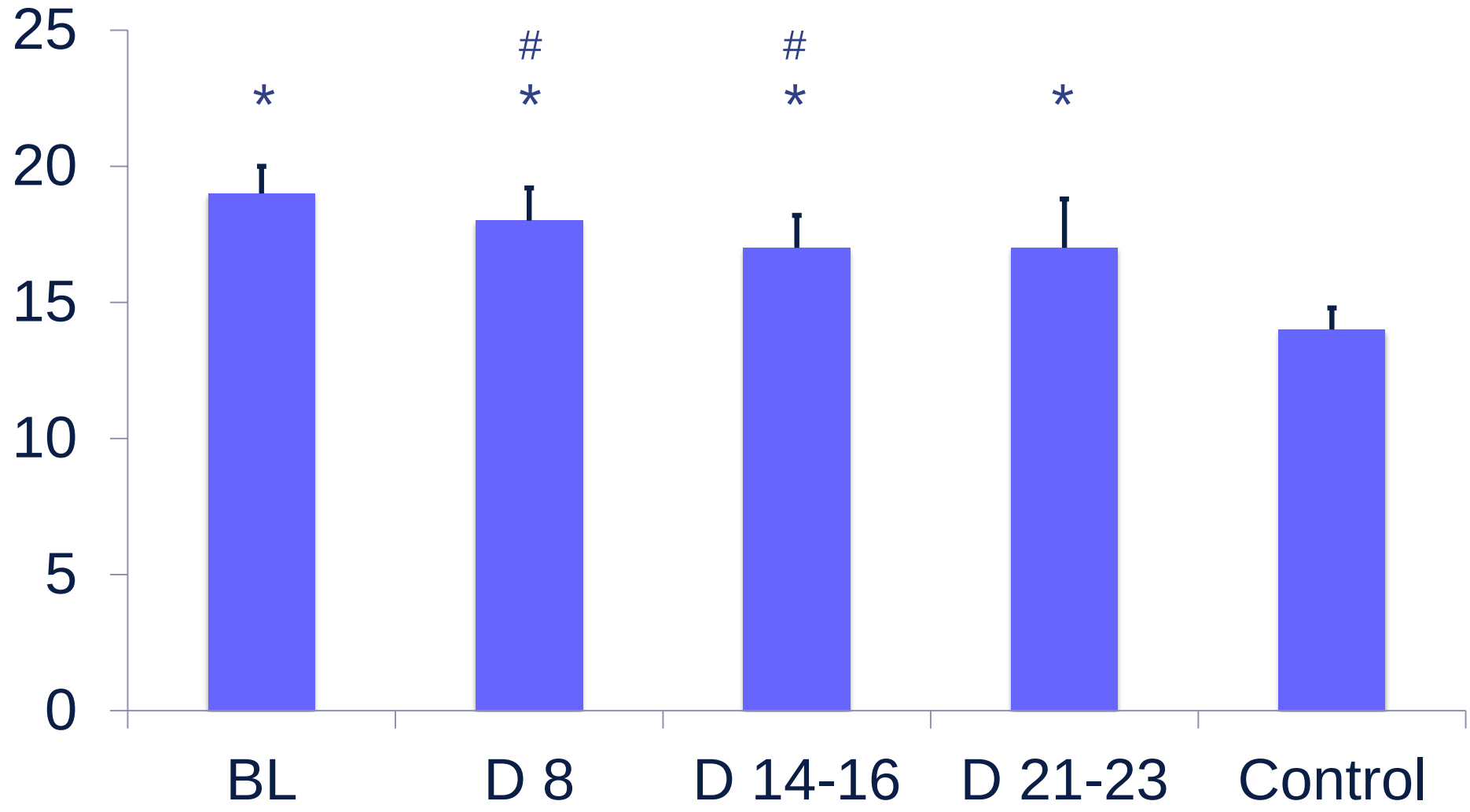
CB_1 Cannabinoid Receptors Significantly Increased after Sustained Cannabis Abstinence (N=14)



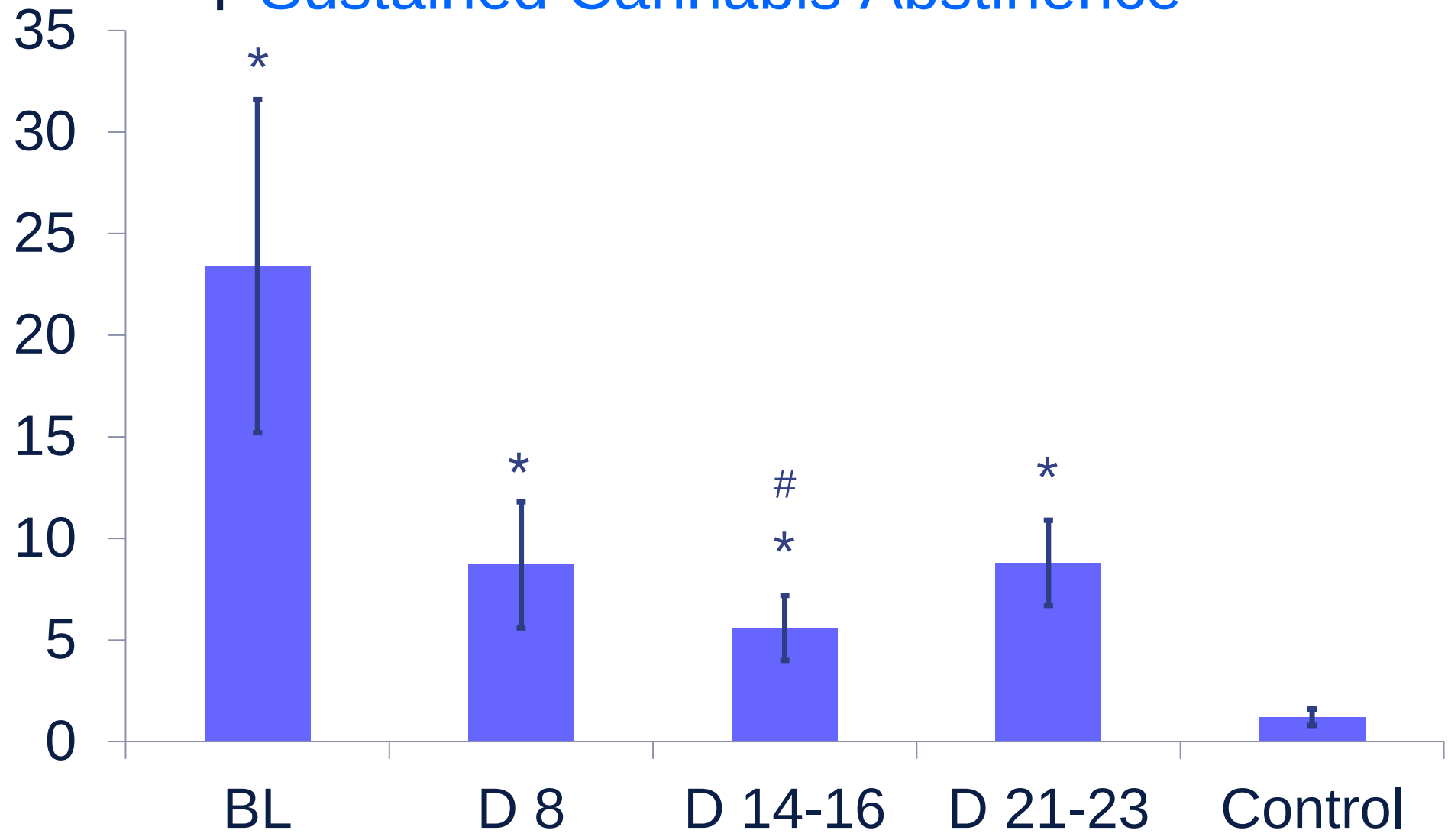
Psychomotor Impairment & Chronic Frequent Cannabis Smoking

Bosker et al *PLoS One* 2012

Mean±SE Tracking Error (mm) in Chronic Daily Cannabis Smokers During Sustained Cannabis Abstinence

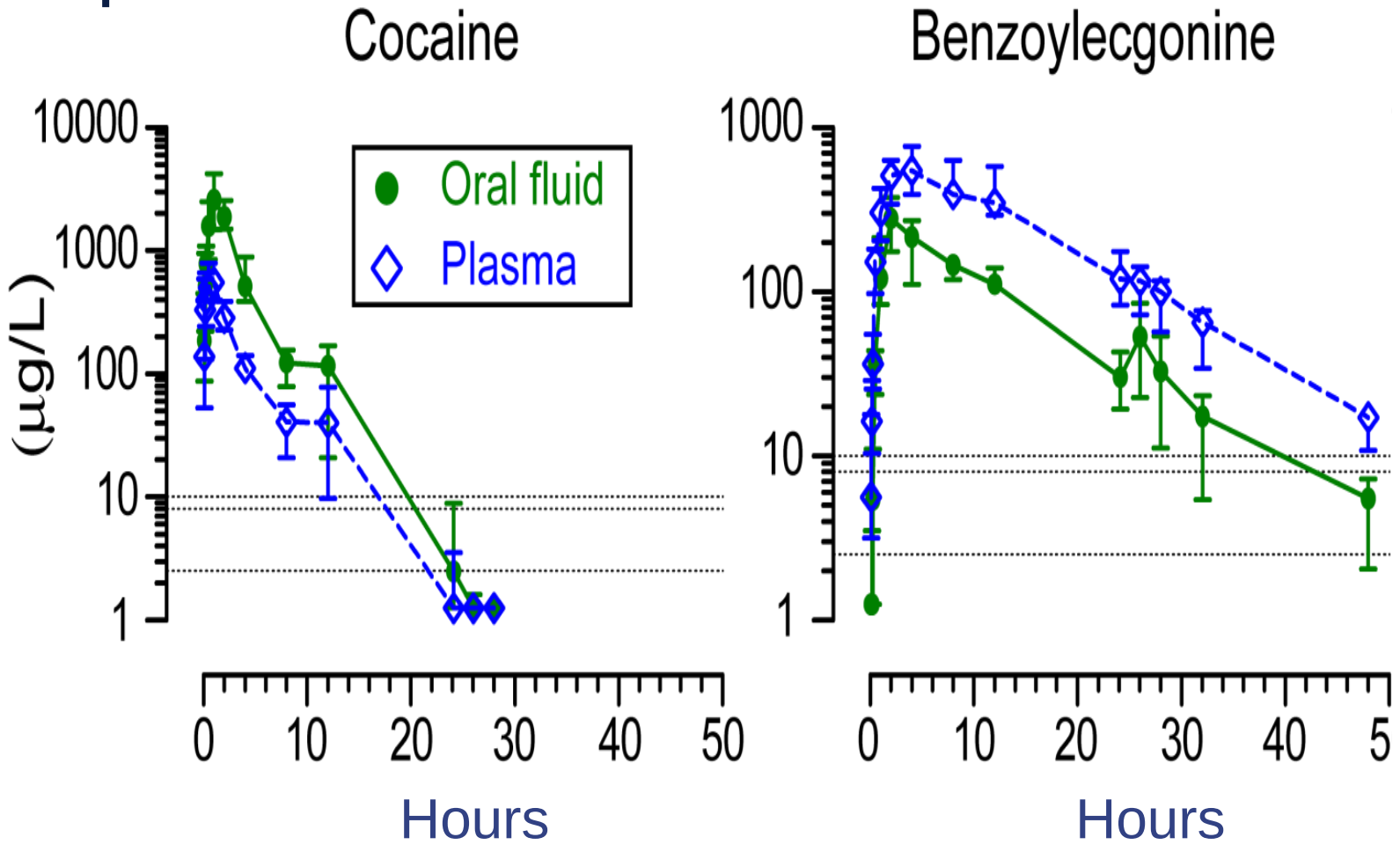


Mean±SE DAT Control Losses in Chronic Cannabis Smokers During Sustained Cannabis Abstinence



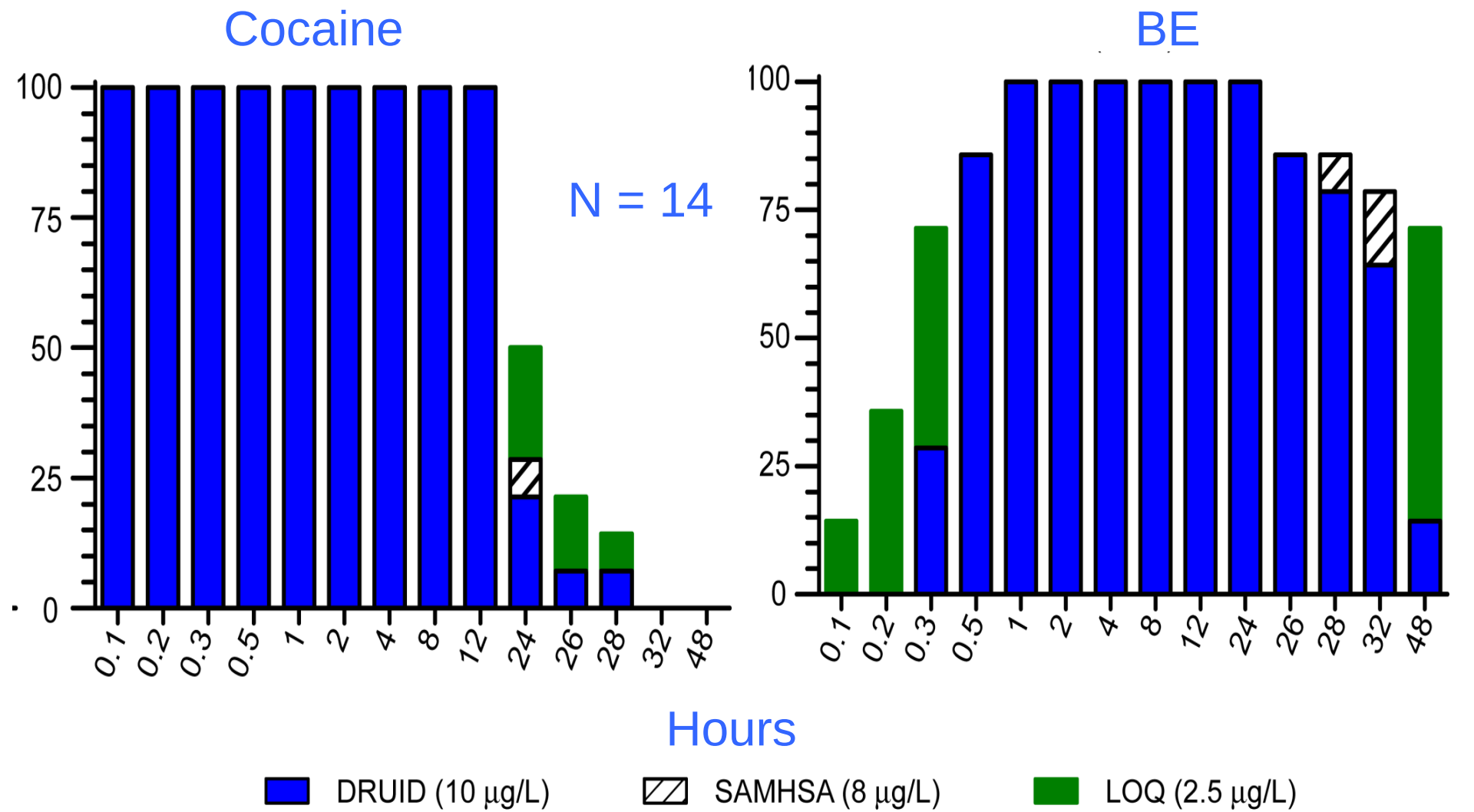
Is There A Better Biological Matrix for Monitoring for Driving Impairment?

Cocaine, BE & EME in Oral Fluid
150 mg/70 kg sc cocaine



(N=14 oral fluid) (N=13 plasma)

% Positive Expectorated OF Samples After 150 mg/70 kg Cocaine

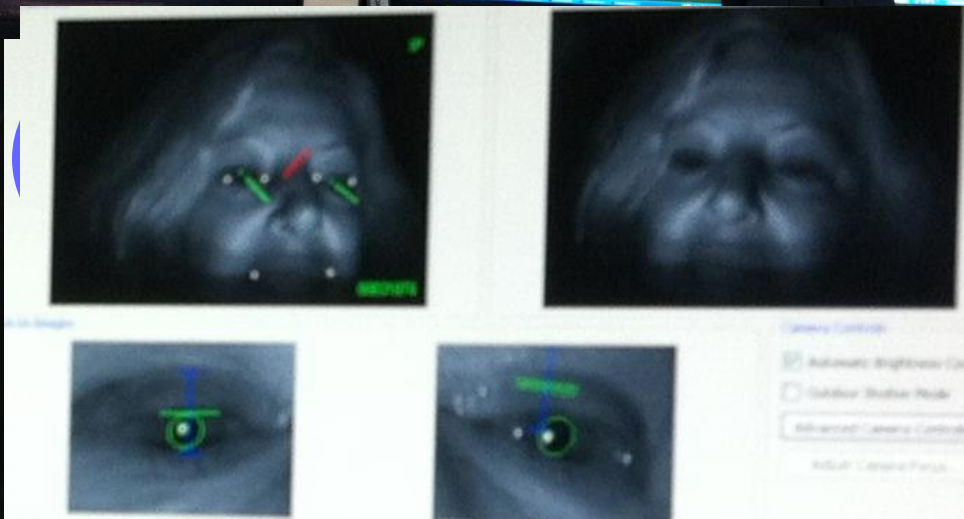


Breath Cannabinoid Concentrations After Acute Cannabis Smoking in Occasional & Chronic Frequent Smokers

THC-Positive Breath Specimens

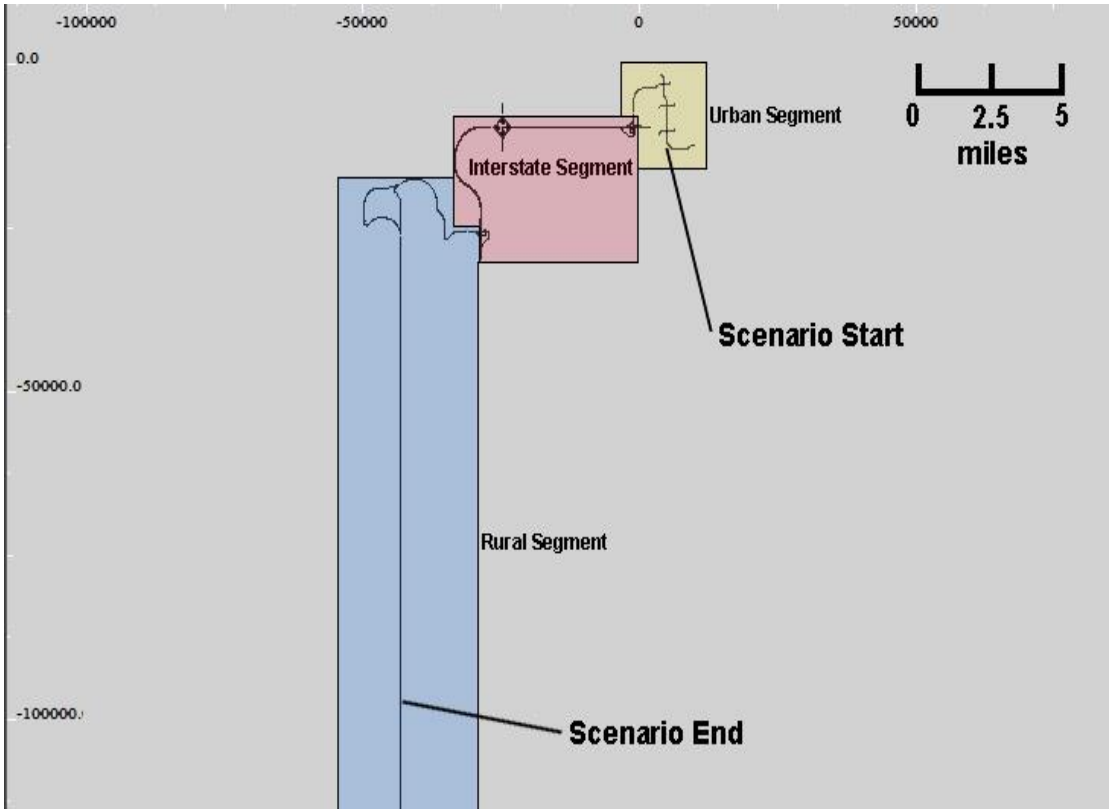
Time after smoking (h)	Chronic Users N=13	Occasional Users N=11
Admission	15.4%	0
-1.0	0	0
0.5	100%	90.9%
1.0	76.9%	63.6%
2.0	53.8%	0
3.0	0	0
4.0	7.7%	0

National Advanced Driving Simulator
University of Iowa



Iowa Study Simulations

- Nighttime driving
- 3 segments:
  - Urban
  - Interstate
  - Rural
- Each segment contains subtasks
- Drive time ~45 min



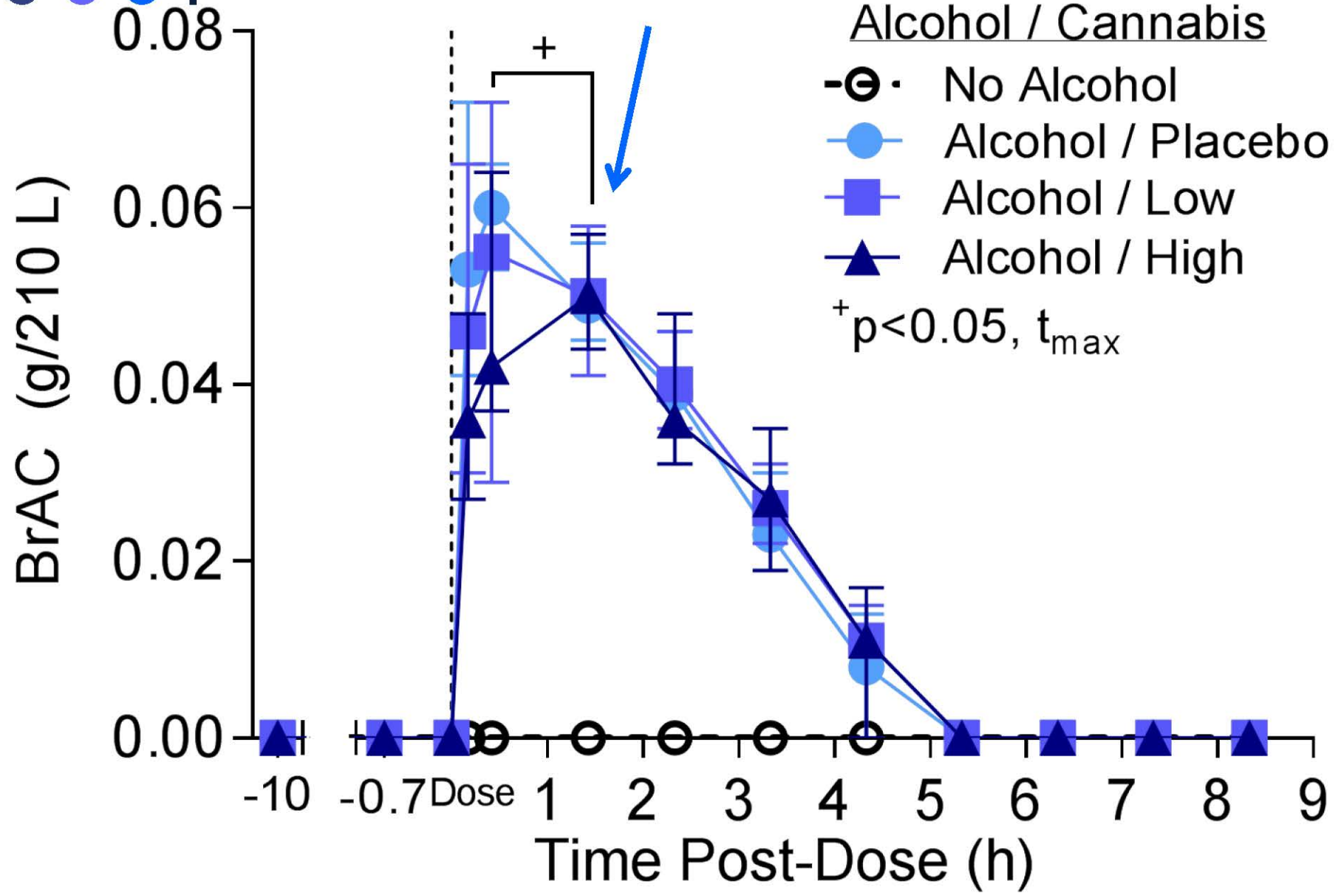
Cannabis Effects on Driving

- Decision-making
- Divided attention
- Visual search
- Focus, concentration
- Process changes
- Reaction Time
- Road tracking, vehicle control

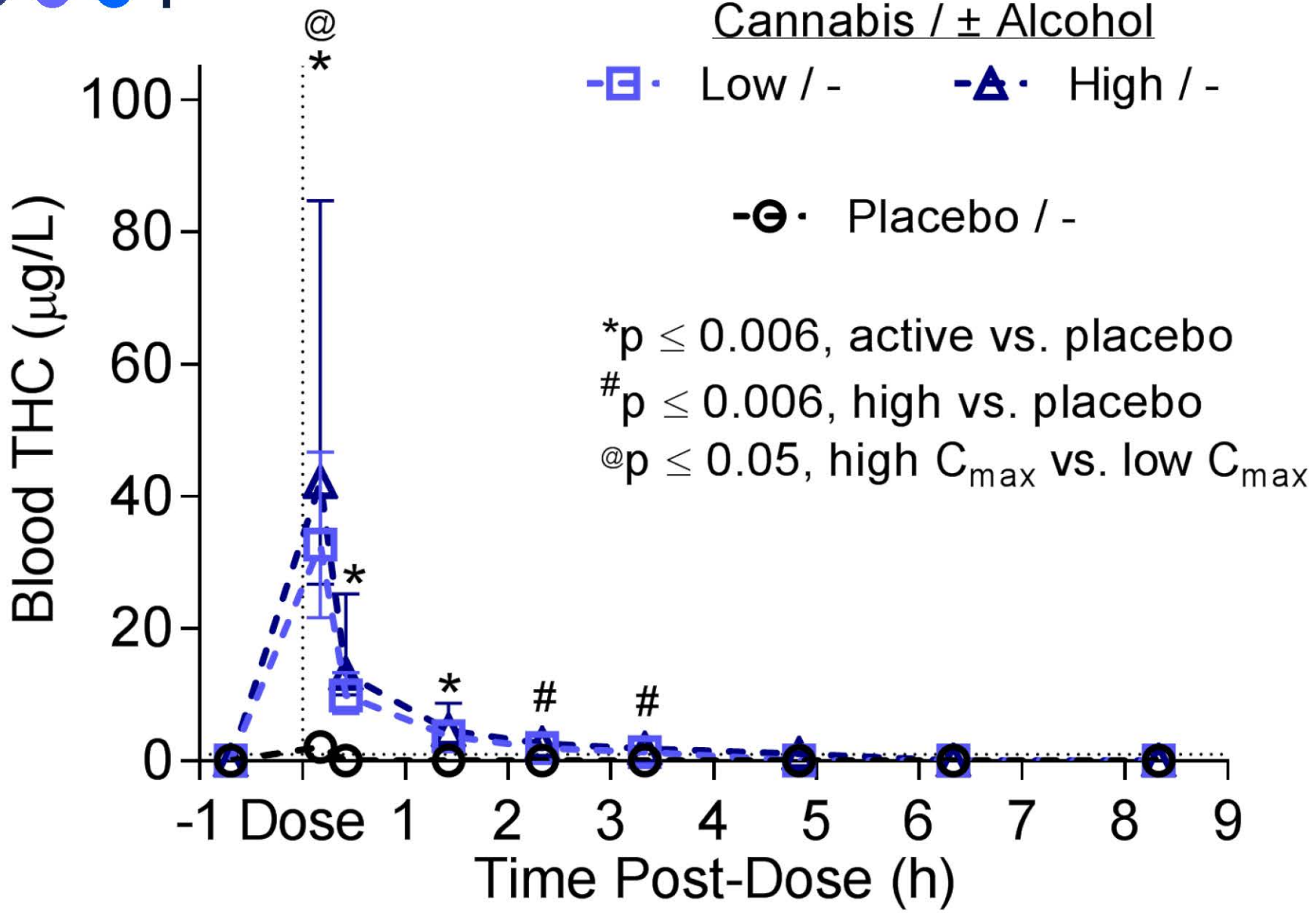
Drug Administration

- Placebo or low-dose alcohol
  - Calculated to produce ~0.065% peak BrAC (≥ 0.05% during driving)
- 0.5 g cannabis
  - Placebo, Low (2.9% THC), High (6.7% THC)
- Volcano® Medic vaporizer, inhale over 10 min

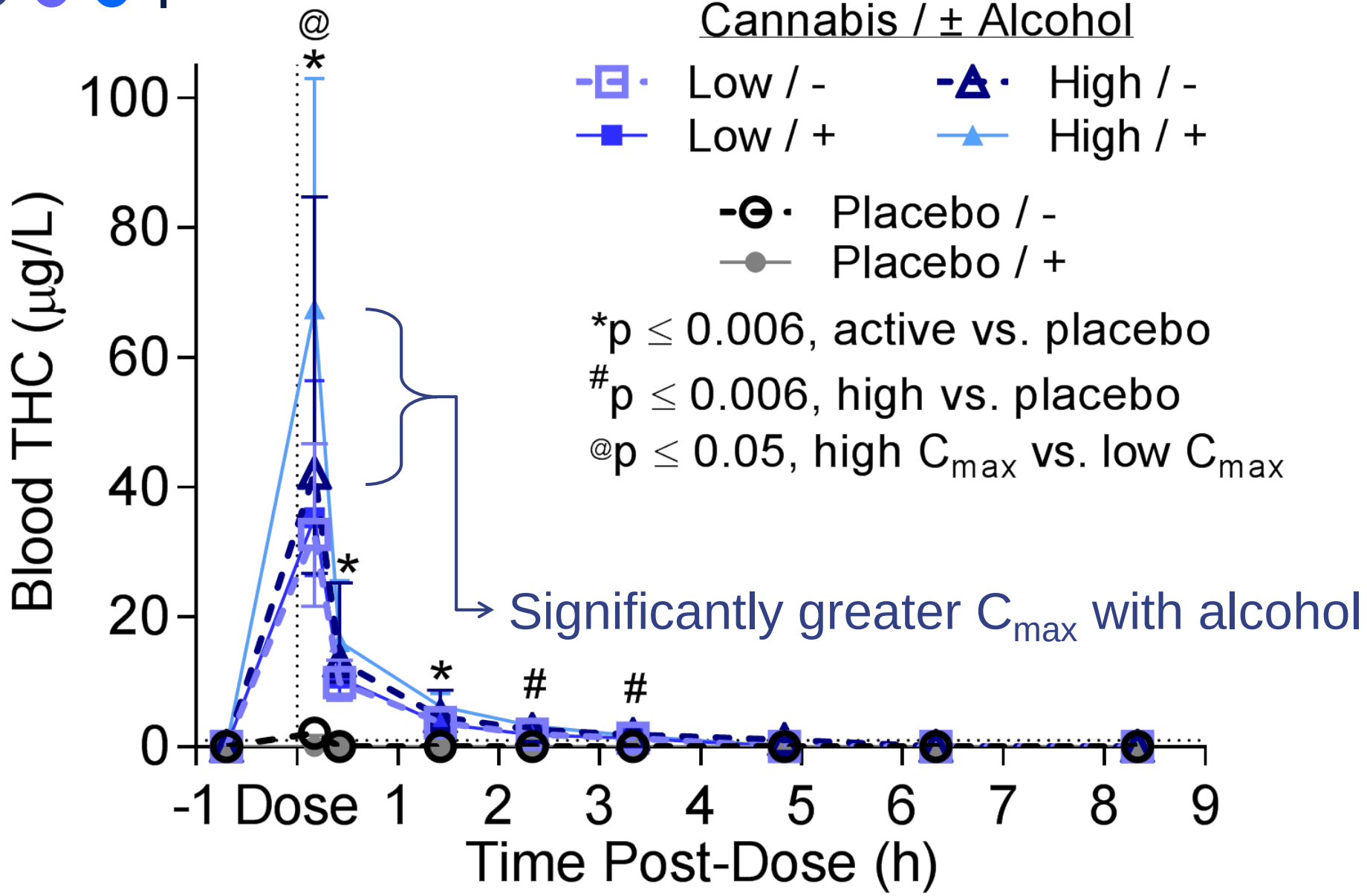
Median [Interquartile Range] Alcohol



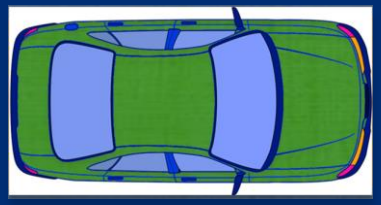
Median [Interquartile Range] Blood THC



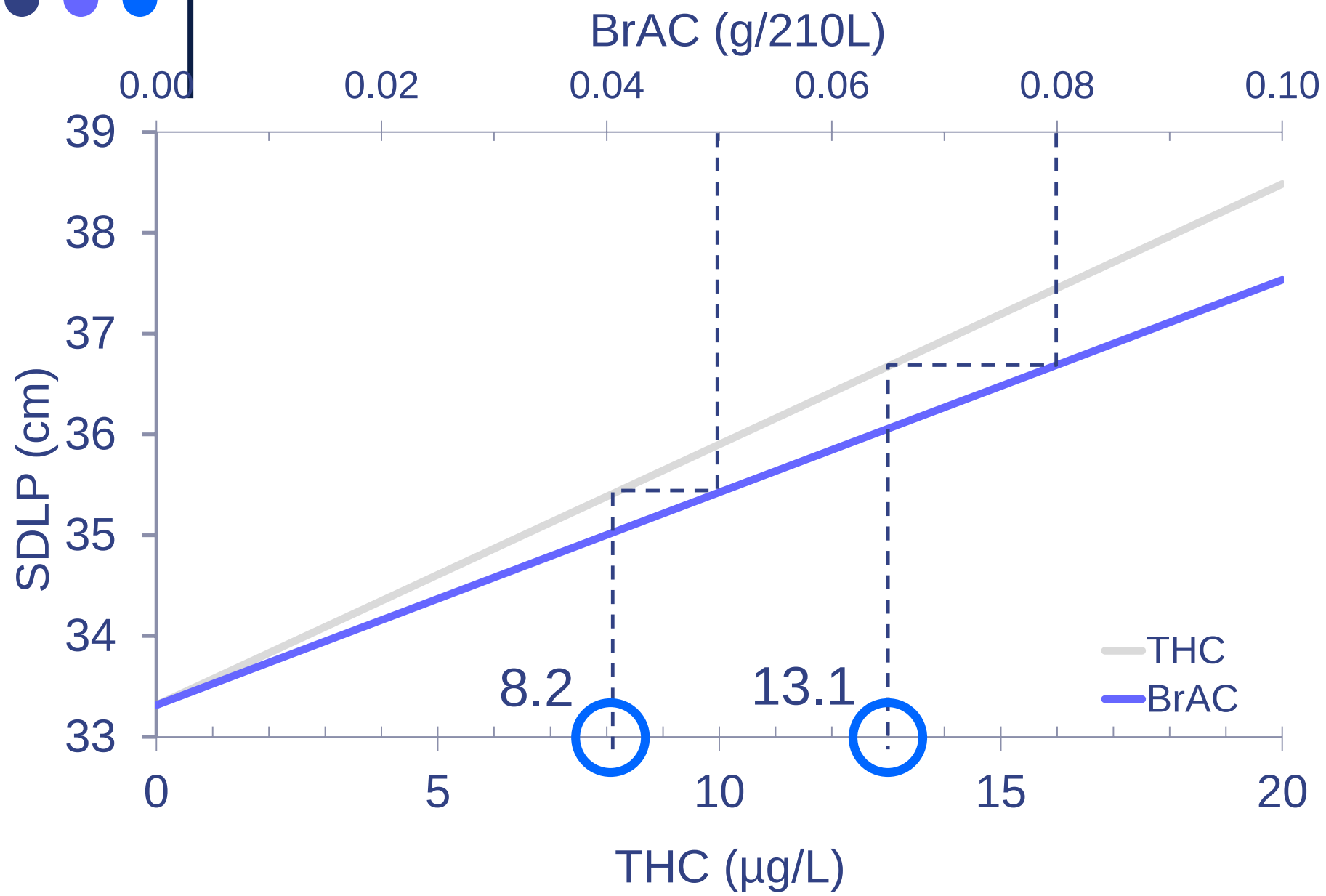
Median [Interquartile Range] Blood THC



Cannabis & Alcohol Effects: Driving Lateral Control



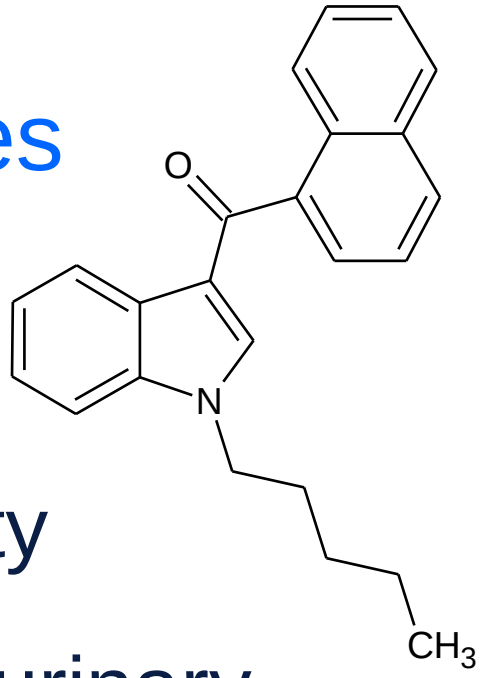
SDLP vs. THC & SDLP vs. BrAC



Driving Lateral Control

- Cannabis & alcohol affected SDLP, concentration dependent
  - ~8.2 & ~13.1 µg/L THC during driving produced impairment ~ [illegal] 0.05 & 0.08 g/210L
  - Due to blood draw delays, measured concentrations in authentic cases will be lower
- Additive effect with alcohol (not synergistic)
- No cannabis effect on other lateral control measures

NPS Analytical Challenges



- Vast array of target analytes
- Changing target analyte availability
- Lack of information about human urinary metabolites of new cannabimimetics
- Highly potent compounds produce lower metabolite concentrations
- Common metabolites for different targets

Challenges for Monitoring Synthetic Cannabinoid Intake

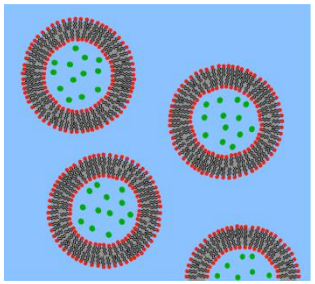
- Compounds closely related chemically, making chromatographic separation difficult
- Constantly need to add new compounds & metabolites

NPS: New Face of Drug Abuse

- Essential to identify NPS markers in biological samples
  - Short detection windows for parent NPS in blood & oral fluid
  - Urine markers provide longer detection times
  - Essential to document SC intake to link adverse outcomes with specific NPS & to educate public about potential SC toxicity

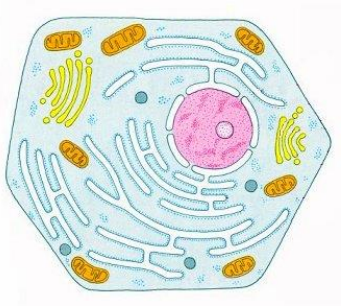
Identifying Human Metabolites with Human Liver Microsomes & Hepatic Cell Cultures & High-Resolution Mass Spectrometry

HLM Preparation $T_{1/2}$ determination



1

Incubation with human hepatocytes

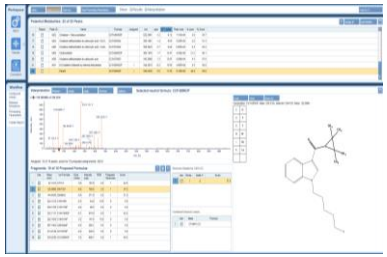


2

Analysis by LC-HRMS

3

Software-assisted data analysis



Compounds Evaluated to Date

- AKB48
- STS-135
- RCS-8
- RCS-4
- PB-22 & 5F-PB-22
- AB-PINACA & 5F-AB-PINACA
- AB-FUBINACA
- THJ-018 & THJ-2201
- AMB & 5F-AMB
- MDMB-FUBINACA
- FUBIMINA
- 5F-SDB-005-INDOLE
- FDU-PB-22
- FUB-PB-22
- AH-7921
- PV8
- Alpha-PVT
- 4MeO-alpha-PVP

Thank You!

NIH grants relating to drug recognition and impairment

Outside of the Huestis lab, there are seven active NIH grants that support work related to drugged driving:

Project	PI Name(s) All	Title
DA032693-04	PACULA, ROSALIE	Implementation of Medical Marijuana and its Impact on Health
DA034616-02	JOHNSON, MARK B	IVDIRM: A New Methodology for Examining Drug- and Alcohol-Impaired Driving
DA038410-03	STELTER, REBECCA LYNN	The Drugged Driving Resources Website for the prevention of drugged driving
DA032548-03	SLOAN, FRANK A.	Effects of drug treatment courts on outcomes of adults and their children
AA021829-02	MAXWELL, JANE C	Drinking, Driving and Drugs: Trajectories of DWI Recidivism and How to Intervene
AA022202-02	ROMANO, EDUARDO O (contact); DE LA ROSA, MARIO R.	Drinking and Driving Among Recent Latino Immigrants
AA007464-39	HOFFMAN, PAULA	Behavioral Pharmacogenetics of Drug and Alcohol Abuse

Drug Recognition and Impairment Research Meeting
Criminal Justice Practice Experts Roundtable Guide

April 24, 2015

Instructions: The purpose of the expert roundtable is to identify and discuss the concerns of primary importance to practitioners in your jurisdiction and professional field, as well as the kinds of information, tools and protocols that would best support your service objectives. Please review the following discussion items and prepare to present informally to the group opinions based on your training, work experience and other information exchanges. Some may not apply to you, and other items or variations of these are open to discussion.

1. Drugs of Interest
   - Opioids – heroin, prescription drugs
   - Marijuana – cannabis, concentrates, edibles
   - Amphetamines – methamphetamine, other
   - Novel psychoactive substances - synthetic cannabinoids, cathinones, opioids
   - Pharmaceuticals - methadone, buprenorphine, benzodiazepines
   - Hypnotics - zolpidem, other
   - Alcohol and other drug combinations
2. Lab
   - Signature programs – authentics/standards, variations
   - Analogs – definition, scope of compound
   - Certified standards - shifting landscape of substances used
   - General unknown screening applications - LC-HRMS, other
   - Interpretation of findings
3. Field
   - Screening– presumptive (reasonable suspicion)- potential new methods
   - Investing in field confirmation testing
   - Onsite data collection, measures and documentation
   - Drug testing and alternative matrices
   - Impairment – cognitive, physiological and biochemical
   - Impairment – fatigue, distraction and other combinations
   - Seizures and other evidence – small clandestine labs
4. Prosecution and Defense
   - Laboratory turn-around time
   - Laboratory testimony (*U.S. v. Melendez-Diaz*)
   - Legislation – structural and pharmacological similarity, variation in application across jurisdictions
   - Levels of testing – regulatory and lab cutoffs for detection
   - Per se laws
5. Pretrial and Post-Disposition Monitoring
   - Harm reduction vs abstinence – differentiating new from residual use, environmental contamination
   - Medication-assisted treatment
   - Home visits
6. Resources
   - Identifying and measuring advances toward goals

- Determining and prioritizing needs – equipment, staffing and re/training
- Leveraging Federal and other agency resources