Final Report
of the inquiry commissioned by the
Ministry of Economics and Small Businesses,
Technology and Transport
for North Rhine-Westphalia
into the incidence of

# "Drugs in Road Traffic"

with special focus on

# Heroin

by

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Inquiry "Drugs in Road Traffic"

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**Summary**

The basis for the investigations comprises 912 blood samples taken by the police between 1994 and 1996 arising especially from the suspicion of people driving under the influence of drugs. All blood samples were analysed for cannabinoids (see also final report concerning "Cannabis in Road Traffic", August 1996), cocaine and its metabolites, amphetamines and derivatives (e.g. ecstasy), benzodiazepines and alcohol. In addition, if suspicion was high enough, the presence of LSD and various substances contained in medication was investigated. For the inquiry submitted which focuses on the incidence of heroin in road traffic, all 290 opiate-positive blood samples were subjected to extraction in an automated process employing deuteriated standards, and the extract analysed precisely both qualitatively and quantitatively by gas chromatography / mass spectrometry for morphine, monoacetylmorphine, codeine and dihydrocodeine.

The police were trained to be able to recognise the influence of drugs. A specially designed form (police report) was used for recording the main symptoms expected from drug use. Particular emphasis was placed on the appearance of the eyes and the reaction of the pupils to stimulation by a light source, in this case a flashlight. Pre-selection performed by the police can be deemed highly successful. In 83.9 % of the cases (765 in total), drugs or other intoxicating substances were found in the blood samples, and in 8.3 % of the cases (76 in total), only alcohol. Correspondingly, only 7.8 % of the 912 blood samples (71 in total) proved to be negative.

In a large number of the blood samples, more than 1 substance was detected. Of the 765 drug-positive blood samples, cannabinoids were found in 515 of the samples, opiates in 290, benzodiazepines in 214, cocaine in 203, amphetamines in 75, LSD in 3, other intoxicants in 8, and alcohol in 236.

A total of 281 accidents were registered. The opiate users caused 89 of these and thereby assume the top position among the drug consumption groups. The second position was occupied by the cannabis consumers with 78 accidents. 107 of the accidents fell into the category "serious" or "very serious".

Among the consumers of illegal drugs, the average age of the cannabis users was the lowest at 22.9 years, and the highest among the opiate users at 28.0 years.

42 of the opiate users were found to have taken only codeine or dihydrocodeine-containing painkillers or cough suppressants (antitussives). The remaining 248 were deemed heroin users for all further considerations. Over 90 % of the heroin users had consumed in addition to heroin at least one, and sometimes even three and more other intoxicants. The combinations opiates + cocaine + benzodiazepines and opiates + cannabis + benzodiazepines were the most frequent of the combinations containing three drugs. Thus, poly-drug use is usual among heroin users.

Due to pharmacokinetic and pharmacodynamic considerations, the unconjugated (free) morphine was chosen as the variable for ascertaining a possible concentration / effect correlation.

Monoacetylmorphine, the first derivative of heroin, was only detected sporadically in the blood samples. The following four concentration ranges (classes) were chosen:- Under 10 ng/mL morphine, 10–19.9 ng/mL morphine, 20–49.9 ng/mL morphine and 50 ng/mL morphine or more. According to the type of poly-drug use ascertained, these 4 classes were again subclassified:- No significant poly-drug use, additional influence by stimulants, additional influence by the combination of stimulants and central nervous system (CNS) depressants, and additional influence only by central nervous system depressants. This resulted therefore in 16 different classes within the group of heroin users. In all classes, the police and medical reports were examined for indications of the presence of negligible/no, small/moderate or strong deficiency symptoms. From this, the impairment ratio yes : no was derived. Additionally, the cumulative frequency of driving errors /conspicuous driving behaviour was determined for all classes. The threshold value of 26 % was applied as used in the study of cannabis. This value was calculated by evaluation of accumulated alcohol-typical accidents under the influence of alcohol. Statistically, 26 % of the drivers who caused an accident when their vehicle had left the road on either side had a blood alcohol concentration under 1.1 ‰. 74 % had a blood alcohol concentration above 1.1 ‰. After all data had been evaluated, it was shown that the heroin users displayed conspicuous behaviour in road traffic even with low levels of morphine in their blood, irrespective of the type of intoxicants simultaneously consumed. As résumé of the inquiry, it is suggested that if in future any driver of a motor vehicle is suspected of having used heroin, that a blood sample be analysed for morphine, and that, irrespective of the type and quantity of any additional intoxicants found, a blood concentration of free morphine of 10 ng/mL or above indicates that the driver is unfit to drive according to §§ 315 c and 316 StGB (German penal code).

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# 1 Introduction

In the report "Cannabis im Straßenverkehr"[1] ("Cannabis in Road Traffic"), the effect of the various cannabis products was explained in detail. Over 2 million German citizens are estimated[2] to have tried these, which are freely available for example in the Netherlands in special "Coffee Shops". In road traffic, the cannabis consumer is in absolute terms the most conspicuous of the drug users, which is not surprising considering the ubiquity of this drug. The number of opiate users was however only marginally lower. As the number of consumers of heroin and other opiates[3] has been estimated[4] to be 10 times lower than the number of cannabis consumers in Germany, and that it can be assumed that heroin users are—due to their poor financial situation—normally unable to afford a motor vehicle, then a single heroin user must pose a far higher safety threat in road traffic than a single cannabis consumer. This was the reason for focusing our attention on opiates (heroin) in road traffic after having dealt with cannabis.

## 1.1 History

It is interesting to note that even 150 years ago the differences between hashish and opium were known precisely. Ernst Freiherr von Bibra[5] wrote this in 1855:-

*"As a narcotic, hashish is closest to opium, although it differs in many respects, producing an effect similar to that of spirits. Obviously the consumption of hashish, or at least of all of the preparations known to us, is not so dangerous, and is not accompanied by the mass of lamentable after-effects caused by opium.*

*Taken in moderate doses, hashish stimulates the appetite. It does not cause the continuous constipation, the disgust, the general weakness of the limbs or the shivering which we have seen from opium. However, it causes the pupils to dilate which is not the case with opium, and from time to time, catalepsy. On the other hand its ability to act as pain-killer and tranquilliser is initially not as good as opium. Whereas the opium consumer seeks solitude and abandons himself to his dreams in silence, he who has taken hashish relishes company, laughs and is cheerful.*

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1 Daldrup, Th.: Abschlußbericht des im Auftrage des Ministeriums für Wirtschaft und Mittelstand, Technologie und Verkehr des Landes Nordrhein-Westfalen durchgeführten Untersuchungsvorhabens "Cannabis im Straßenverkehr" AZ. 732-21-03/2.1.1, Düsseldorf, August 1996

2 Bundeskriminalamt: Rauschgiftjahresbericht Bundesrepublik Deutschland 1996. Bundeskriminalamt, Wiesbaden, pp.71

3 In the study, the term *opiates* includes the substances heroin, morphine, codeine and dihydrocodeine.

4 Bundeskriminalamt: Rauschgiftjahresbericht Bundesrepublik Deutschland 1996. Bundeskriminalamt, Wiesbaden, pp.70

5 Freiherr von Bibra, E.: Die Narkotischen Genußmittel und der Mensch. Wilhelm Schmid, Nürnberg, 1855, pp. 289-290


lxxiiij Des Contrafayten

# Magſot.

DEr Magſot ſeind vilerley geſchlecht / wie ſolichs Dioſcoridis vnd Plinius nach der lenge anzöigen. So vil aber hye här gehört / findē wir zweyerley geſchlecht Magſots. als den Weiſſen vnd den Schwartzen. Der Weiſſz hat ein langelechten kopff / vnd würt ettwan ins brot gebachen. Der Wyld / iſt der ſchwartz Magſot / der artzney mer dann der ſpeiß dyenſtlich.

Diagram 1: Opium poppy (German: Magsot): Wood-carving by Hans Wedlitz from the book of herbs "Contrafayt Kreüterbuch" by Otto Brunelfz, 1537.

*In the light of opium being a narcotic and a drug which rids oneself of all worries, hashish has to be spoken out in favour of as being the lesser of the two evils, if one is forced to choose."*

References to the analgesic use of the poppy have been found in scripts written in the 7th Century BC. The Egyptian doctors were presumably the first to discover its anaesthetic properties and integrate it into medicinal practice[6].

One very early reference to the recovery of the poppy resin or opium[7] was found in Crete in the form of the so-called Goddess of the Poppy (diagram 2), whose head was adorned with the grooved seed capsules. The Goddess was found in the shrine of Gazi. She is possibly the personification of the goddess of sleep or death. The small statue originates from the post-palatial phase III (14th – 11th century BC) in the late Minoan era (Bronze Age), the end of the Minoan civilisation on the island of Crete[8].

Even in the last century, a sleep-inducing liquor for sucklings was prepared by the rural population in middle Europe by boiling the dried and pulverised seed-containing capsules in water. Whilst people had been warned about using the liquor for this purpose, it was recommended that the same liquor be sweetened with sugar or honey, and given to older children and adults for the

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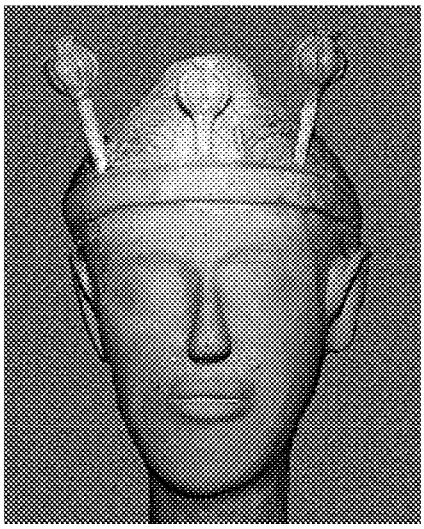
6 Wagner, H.: Rauschgift-Drogen, Springer, Berlin, Heidelberg, New York, 1970, pp. 12

7 Opium: derived in the 15th C from Latin „opium", which in turn goes back to the Greek „opion", the diminutive of „opos" (=vegetable milk)

8 Sakellarakis, J.A.: Heraklion, das archäologische Museum. Ekdotike Athenon S.A., Athen, 1993, pp. 89-91

Diagram 2: Mohngöttin. Statue aus den Heiligtümern von Gazi (Kreta), 14. bis 11. Jahrhundert v.Chr.



alleviation of whooping cough as well as chest and throat complaints[9]. The addictive effect of morphine was already known in the 18th and 19th century, especially through reports from the Asian region. J. F. Gmelin wrote the following in his history of plant-derived poisons[10]: *"A small dose of the poppy resin repeated daily numbs the senses, makes people become silly, forgetful, increasingly indifferent towards pain or delight, and destroys their perception and feeling of worthiness. Their manner is always frosty.*

*The poppy resin works through the nerves towards the soul. A small dose calms the nerves and places oneself in a happy mood. As long as the effect prevails, the happiness can displace the largest of worries."*

*..... "Even if they take a dose only as large as a pinhead at the outset, their demand always steadily increases to a pinch. Every time after indulging—perhaps four or five hours later, and at the latest 24 hours for beginners—the euphoria disappears leaving them sad, depressed, cold and without feeling, incapable of any sort of work. They are lacklustre and weak, anxious, restless and shivery, and languish for the happy moment when they can once more partake of the poppy resin, which breathes zest and vitality back into them for several hours. However, on returning, this depressed state of mind grows ever stronger, and if the dose is repeated to prolong the euphoria yet again, then they become—apart from the increasingly shorter happy time—so miserable, that they are constantly dull, weak, unable to perform any task, and even completely unable to obtain satisfaction from anything. Their soul is sapped of its vitality, their senses and feelings become lifeless and dulled. They age much more quickly, often dying before they turn fifty years of age."*

Based on reports on opium addiction in China, Ernst Freiherr von Bibra describes the effects of opium, and especially the withdrawal symptoms occurring in opium smokers even more precisely[11]: *"The same man says that, when he has consumed his portion, he has no desire to sleep until 12 or 2 o'clock in the morning, when he falls into a restless slumber which lasts until 8 or 9 o'clock the next morning. When he awakens, he is dizzy, and his head is muddled and afflicted with pain. His mouth is dry, and he is thirsty but he cannot drink otherwise he will vomit. His eyelids are as if they had been stuck together. Evil-smelling mucus exudes from his nose. He has no appetite, and is incapable of reading, writing or performing any task. All bones and muscles ache,*

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9 Most, G.F.: Encyklopädie der gesammten Volksmedicin. Brockhaus-Verlag, Leipzig, 1843, pp. 453

10 Gmelin, J.F.: Allgemeine Geschichte der Pflanzengifte. 2nd edition, Raspesche Buchhandlung, Nürnberg, 1803, pp. 748 and 758-760

11 Freiherr von Bibra, E.: Die Narkotischen Genußmittel und der Mensch. Wilhelm Schmid, Nürnberg, 1855, pp. 209-210

*and he gasps for breath and would like to have a bath, but cannot endure it. This condition lasts until he has his morning smoke from the pipe, after which he eats and drinks a little, has a bath and goes about his duties.*

*.... The opium smoker must soon increase the dose he started with, if the initial effect is to be maintained. The dose is doubled, increased tenfold, and it is not a rarity for an old opium smoker to take a daily dose one hundred times larger than that with which he started.*

It is remarkable that the Chinese doctors were well acquainted with methods for detoxifying and treating the opium addiction, which are still currently practised. Freiherr von Bibra[12] writes:- *"Almost every opium smoker succumbs to the described afflictions, and according to witnesses, hardly anyone has ever been able to break out from the vicious circle and free himself. The desire to relive the initial experience of euphoria, together with the urge to rid himself of the dire consequences just set in, ultimately tighten their vice-like grip, relentlessly compelling him to increase the dosage one step further towards his demise.*

*In addition it must be mentioned that sudden and total opium withdrawal very often worsens the condition and can even lead to death, which is well known to the Chinese. Seldom does an opium smoker manage to gradually break the habit. A few isolated cases have been known. If a doctor is consulted, which is a rare thing, the therapy is often successful. Here, at the beginning, doses of opium preparations similar in size to those the addict currently takes, must be prescribed. Then the size of the dose is decreased, and at the same time a bitter drug of some kind is administered in strong doses in order to assist the weakened digestion.*

*The patient must at the same time be cheered up, and take exercise as well as eat nutritious food. There is then hope that a cure can be effected in 6 to 8 weeks."*

The attempt to remove the addictive effect of morphine by creating derivatives led to the synthesis of heroin[13]. Heroin is produced by the acetylation of morphine. In 1899 it was added to the list of official medicines[14] and marketed world-wide by the former dye manufacturer F. Bayer & Co Elberfeld (now Bayer AG). In 1906, the following text appeared in an issue of the company's newsletter[15]: *"In spite of Harnack's rather unjustified warnings, heroin is today an integral part of our medicinal inventory. Among the available substitutes for morphine, it has become undoubtedly the favourite. When administered in the appropriate doses, it is at least no more dangerous than any other sedative belonging to the group of morphine derivatives. Since its availability, people have gradually learnt to use heroin with the caution it requires as a powerful drug; bad initial experiences arising through its unscrupulous use are now seldom, and the number of good experiences are continually increasing."*

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12 ibid. pp. 212

13 Wright, C.R.A.: J. Chem. Soc. (London) 27 (1874) 1035

14 Ullmann, F.: Enzyklopädie der technischen Chemie. Urban und Schwarzenberg, Berlin, Wien, 1919, vol. 6, pp.410

15 Pharmaceutische Producte der Farbenfabriken vorm. Friedr. Bayer & Co, Elberfeld. Ergänzungsband, 1906, pp.196-210

Heroin was administered several times daily in doses between 3 and 10 mg especially for the treatment of acute bronchitis, depression or for the local treatment of cancer. Heroin was also used by several doctors for "demorphinising" - i.e. it was administered in withdrawal programmes as a substitute for morphine.

21 years later, L. Lewin[16] realised that *"those who had been poorly taught, initially denied the possibility of addiction to heroin with awful consequences analogous to those from morphine addiction. The truth is, that it exists, and that this drug finds its way into other countries in large amounts to be used just like tea, coffee or alcohol. Withdrawal programmes for heroin addicts in their completely run-down physical state produce severe symptoms."*

In 1929, heroin was struck off the list of official medicines[17].

## 1.2 Heroin in Road Traffic

Even today, morphine extracted from opium is used as the source for heroin production. In illegal production, 100 % pure morphine is never used, thus it always contains a certain amount of other opium alkaloids–especially codeine, but also papaverine and noscapine (=narcotine) or their acetylated derivatives. Acetylation is generally performed with acetic anhydride. The heroin is then thinned down with various other substances, meaning that the active ingredient content of "street heroin" is generally unknown[18]. Often the active content is only around 5 %[19], so that when a heroin addict says that he consumes 1 gram of heroin per day, this equates to only 50 mg of pure heroin.

## 1.3 Heroin Addiction

Some of the currently discussed reasons for the use of heroin are that it seems to put the individual in a position to be able to either avoid confronting an unpleasant situation, get around it, or change it. The psychological heroin addiction develops very quickly indeed. The user demands it constantly, but believes—because he does not notice a physical dependence straight away—that he is not addicted and can give it up at any time. Due to this error of judgement, supported by the anxiety-subduing and euphoria-producing effect of this opiate, the frequency of dose repetition increases—in spite of the dangers widely known today—relatively quickly. This behaviour leads

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16 Lewin, L.: Phantastica - Die betäubenden und erregenden Genussmittel. Georg Stilke, Berlin, 2nd edition, 1927, pp.102

17 Ahrens, G.: Giftgesetz und Giftverkehr. J.A. Barth, Leipzig,1987, pp. 366

18 According to the annual report 1996, „Rauschgiftkriminalität in Nordrhein-Westfallen“ (Drug Criminality in North Rhine-Westphalia) released by the „LKA“ (Criminal Investigation Department) Düsseldorf, pp.27, the active substance content of the 681 heroin samples analysed in 1996 returned values between 0.2 and 88.3%, on average 18.2%.

19 According to the „Rauschgiftjahresbericht“ (Annual Drug Report), released by the „BKA“ (Federal Criminal Investigation Agency), Wiesbaden, pp.41, 31% of the total 5854 heroin samples analysed in 1996 were found to have an active substance content less than 10%.

inevitably to the well known physical addiction, expressing itself in the form of the considerable withdrawal symptoms[20].

## 1.4 Heroin Consumption

Heroin is normally taken by bypassing the intestinal tract by smoking, by "spotting" (inhalation of the vapours produced by heating heroin on aluminium foil) or by intravenous injection of street heroin which has been mixed with acids (normally citric or ascorbic) and water, and finally filtered through a cigarette paper. This last method makes more effective use of the active ingredient than smoking or spotting, meaning that in proportion a smaller amount is necessary for intoxication. One further difference is that the higher concentration of heroin and its metabolites and their faster uptake on the corresponding receptors in the central nervous system enhances the effect. In the majority of cases the heroin consumer does not start by injecting intravenously, but quickly changes over to it as soon as an advanced stage of addiction has been reached.

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[20] Platt, J.J. und Labate, Ch.: Heroinsucht. Theorie, Forschung, Behandlung. Steinkopff, Darmstadt, 1982, pp. 126

## 2 Pharmacology

With the opiates, we are dealing with centrally acting substances which produce a sedative-hypnotic effect. These substances stifle physical and psychological functions, and lead to changes of mood (generally euphoria). Besides these rather general (complex) effects, all substances produce analgesic effects to a lesser or greater extent, as well as hindering the breathing[21], cough and emetic control centres, body temperature regulation[22], and the secretion and peristalsis in the gastro-intestinal tract[23]. Furthermore, many opiates lead to constriction of the pupils (myosis)[24] through stimulation of the parasympathetic nervous system.

Of the opiates considered in the inquiry, those which are currently used therapeutically are morphine as an analgesic, and codeine and dihydrocodeine as cough suppressants. Heroin is seldom used due to its highest propensity of all opiates to cause addiction. Commercial products (injection solutions) are available solely in Canada and Great Britain under the name Diamorphin[25]. These are used for the treatment of agonising pain in the final stage of an illness[26].

### 2.1 Metabolism and Kinetics

In the body, heroin is broken down in the blood by esterases (besides others) via monoacetylmorphine (6-MAM) to morphine, with a half-life of several minutes. In table 1, half-life[27] values are quoted which have been determined or supplied by various authors.

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21 Despite the suppression of the emetic control centre, nausea and vomiting are still possible through stimulation of chemoreceptors.

22 Danger of hypothermia at low ambient temperatures.

23 A typical consequence is spastic constipation (among others).

24 Stumpf, Ch.: Neuropharmakologie. Springer, Wien-New York, 1981, pp.138-139

25 ABDATA Pharma-Daten-Service: Pharmazeutische Stoffliste, 10th edition, Werbe- und Vertriebsgesellschaft Deutscher Apotheker mbH, Eschborn/Taunus, 1996, pp.161

26 Martindale. The Extra Pharmacopoeia, 29th edition, The Pharmaceutical Press, London, 1989, pp.1302-1303

27 The half-life of a substance is the time interval necessary for its concentration in blood serum or plasma to decrease by 50%.

Table 1: Half-life values of heroin, monoacetyl morphine (6-MAM) and morphine after intranasal or intravenous administration of heroin[28].

| Substance | Half-life | Reference |
|---|---|---|
| Heroin | 3,6 - 6 min | Skopp et al. (1997) |
| Heroin | 2,8 - 4,9 min | Jenkins et al. (1994) |
| Heroin | 2 - 9 min | Iten (1994) |
| Heroin 6 mg | 5,4 ± 3 min | Cone et al. (1993) |
| Heroin 12 mg | 4,2 ± 1,2 min | Cone et al. (1993) |
| 6-MAM | 16,8 - 28,2 min | Skopp et al. (1997) |
| 6-MAM | 5,3 - 5,9 min | Jenkins et al. (1994) |
| 6-MAM | 38 min | Iten (1994) |
| 6-MAM | 10,8 - 13,2 min | Cone et al. (1993) |
| Morphine | 1,7 - 3,1 hours | Skopp et al. (1997) |
| Morphine | 1,1 - 2,9 hours | Jenkins et al.(1994) |
| Morphine | 1,9 - 3,1 hours | Iten (1994) |
| Morphine | 1,5 - 2,8 hours | Cone et al. (1993) |

Heroin and 6-MAM are significantly more soluble in lipids than morphine, and therefore able to penetrate the blood-brain barrier faster and more effectively (of particular interest with intravenous injections). This is the underlying reason for the higher potency of heroin compared to pure morphine. In the brain (and other organs), heroin is broken down to 6-MAM and then to morphine, which bind to the corresponding receptors and thus represent the actual active substances of heroin. The hydrophilic character of morphine explains its longer residence time in the brain and thus its longer time of activity[29]. According to recent studies it can be assumed that, in the brain, the heroin / 6-MAM receptor is different to the morphine receptor[30].

Approximately one quarter of the intravenous morphine is bound to plasma protein. Free morphine is quickly distributed into the parenchymal tissue[31]. Less than 5% of the morphine is

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[28] Skopp, G. et al.: Plasma concentrations of heroin and morphine-related metabolites after intranasal and intramuscular administration. J. Anal. Toxicol. 21 (1997) 105-111; Jenkins, A.J. et al.: Pharmacokinetics and pharmacodynamics of smoked heroin. J. Anal. Toxicol. 18 (1994) 317-330; Cone, E.J. et al.: Pharmacokinetics and pharmacodynamics of intranasal "snorted" heroin. J. Anal. Toxicol. 17 (1993) 327-337; Iten, P.X.: Fahren unter Drogen- oder Medikamenteneinfluss. Forensische Interpretation und Begutachtung. Institut für Rechtsmedizin, Universität Zürich-Irchel, 1994 pp.186-207

[29] Physician's Desk Reference, 50th edition, Medical Economics Company, Montvale, 1996, pp.535

[30] Rossi, G.C. et al.: Novel receptor mechanisms for heroin and morphine-6ß-glucuronide analgesia. Neurosci. Letter 216 (1996) 1-4

[31] Physician's Desk Reference, 50th edition, Medical Economics Company, Montvale, 1996, pp.535

demethylated, so that it can simply be assumed that all of the morphine is metabolised to the gluconurides. Of these, morphine-3 glucuronide returned the highest concentration in plasma. The gluconuridising system exhibits considerable capacity, and is hardly saturated even during illness[32]. 90 % of the morphine administered intravenously is excreted via the urine within 24 hours[33].

After intravenous injection of 10 mg heroin per 70 kg body weight, the following metabolites were detected in the urine (see diagram 3):- Morphine-3-glucuronide (50 %), morphine (7 %), 6-MAM, 6-MAM-glucuronide, normorphine and normorphine-glucuronide[34]. A smaller proportion of the morphine is broken down to morphine-6-glucuronide. The latter shows the effect of an opiate as opposed to morphine-3-glucuronide. Through high heroin or morphine uptake after regular and strong dosing, blood morphine-6-glucuronide concentration slowly increases and becomes active on the peripheral opiate receptors. The question whether significant amounts of this metabolite penetrate the blood-brain barrier and thus constitute part of the activity of morphine in the central nervous system cannot be answered at present due to lack of knowledge in this area[35].

Only 40 % of orally administered morphine reaches the CNS. The remainder is metabolised in the gut and liver[36].

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32 ibid., pp. 1997

33 ibid., pp. 535

34 Yeh, S.Y. et al.: Identification of diacetylmorphine metabolites in humans. J. Pharm. Sci. 66 (1977) 201-204

35 Käferstein, H. und Sticht, G.: Opiatnachweis im Harn. Deutsche Forschungsgemeinschaft. Mitteilung XXI der Senatskommission für Klinisch-Toxikologische Analytik. VCH Verlagsgesellschaft mbH, Weinheim, 1993, pp.102-103

36 Physician's Desk Reference, 50th edition, Medical Economics Company, Montvale, 1996, pp. 1997

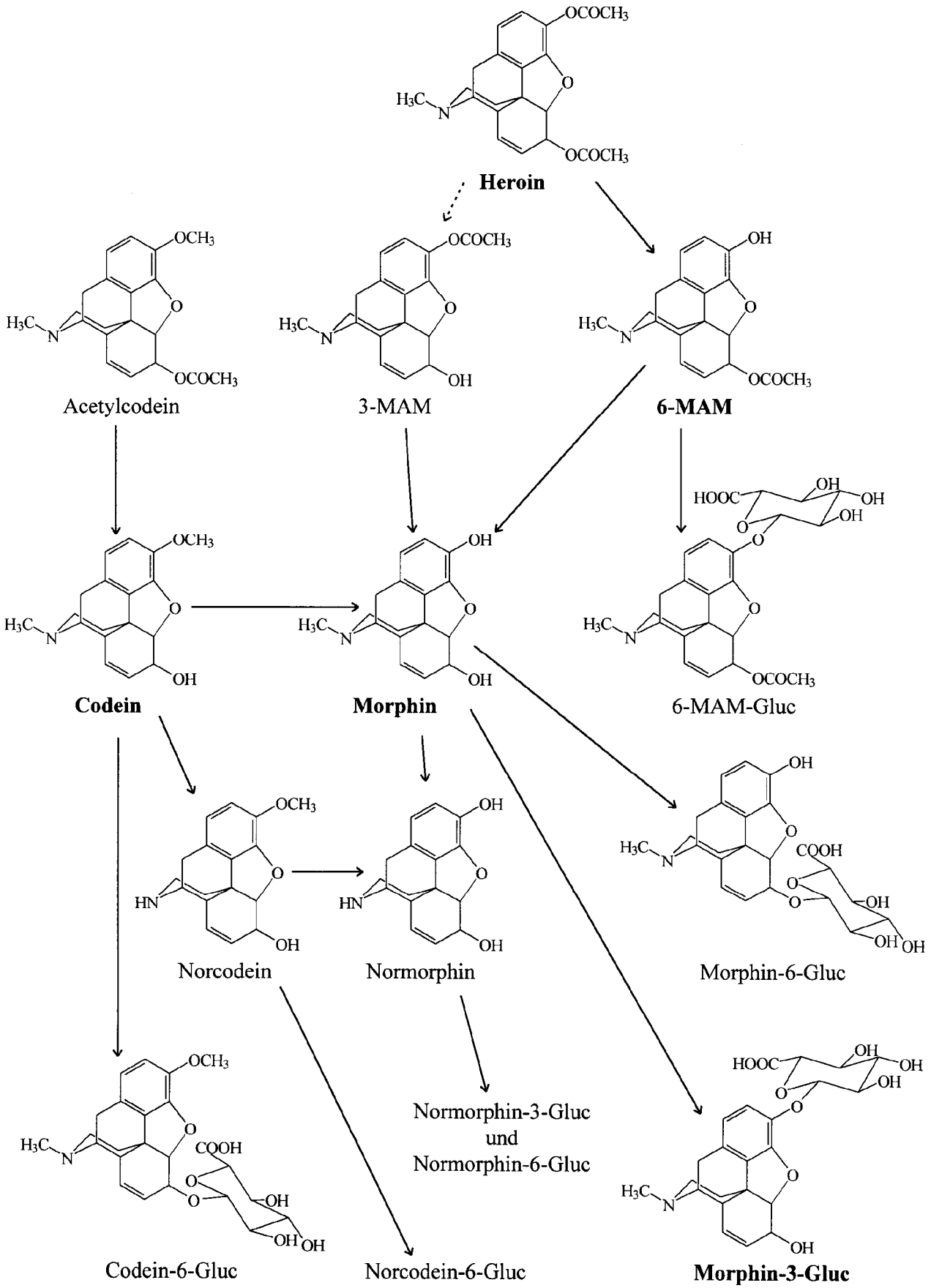
Table 2: Relation between the heroin dosage and the blood serum and plasma concentration of 6-MAM and free morphine[37] (abbreviations: i.n. = intranasal, i.v. = intravenous).

| Dose (mg) | Method of consumption / Number of test subjects | Time after consumption (h) | 6-MAM (ng/mL) | Morphine (ng/mL) | Reference |
|---|---|---|---|---|---|
| 6 | i.n. / 6+3 | 0,5 | 0 - 5,2 | 0 - 10,0 | Cone et al.; Skopp et al. |
| 6 | i.n. / 6+3 | 2 | 0 | 0 - 3,5 | idem |
| 6 | i.n. / 6+3 | 4 | 0 | 0 - 1 | idem |
| 12 | i.n. / 6+3 | 0,5 | 1,2 - 7,8 | 4,1 - 17,3 | idem |
| 12 | i.n. / 6+3 | 2 | 0 | 0 - 8,2 | idem |
| 12 | i.n. / 6+3 | 4 | 0 | 0 - 5,4 | idem |
| 10,5 | Smoking / 2 | 0,5 | 1.7 / 7.6 | 0 / 19,4 | Jenkins et al. (1994) |
| 10,5 | Smoking / 2 | 2 | 0 / 0 | 0 / 9,5 | idem |
| 10,5 | Smoking / 2 | 4 | 0 / 0 | 0 / 0 | idem |
| 10 / 12 | i.v. / 2 | 0,5 | 7,1 / 4.0 | 10,8 / 15,0 | Jenkins et al. (1995) |
| 10 / 12 | i.v. / 2 | 2 | 0 / 0 | 7,8 / 6,0 | idem |
| 10 / 12 | i.v. / 2 | 4 | 0 / 0 | 4,3 / - | idem |
| 20 | i.v. / 1 | 0,5 | 18,1 | 26,1 | idem |
| 20 | i.v. / 1 | 2 | 1,3 | 13,4 | idem |
| 20 | i.v. / 1 | 4 | 0 | 7,6 | idem |

Pharmacokinetic studies (see table 2) showed that the blood concentration of the heroin metabolite 6-MAM reaches significant levels only just after consumption. Morphine can be detected for a considerably longer time afterwards, and thus its level is used as the criterion for the toxicological judgement of heroin consumption (see further in table 3).

[37] Skopp, G. et al.: Plasma concentrations of heroin and morphine-related metabolites after intranasal and intramuscular administration. J. Anal. Toxicol. 21 (1997) 105-111; Jenkins, A.J. et al.: Comparison of heroin and cocaine concentrations in saliva with concentrations in blood and plasma. J. Anal. Toxicol. 19 (1995) 359-374; Jenkins, A.J. et al.: Pharmacokinetics and pharmacodynamics of smoked heroin. J. Anal. Toxicol. 18 (1994) 317-330; Cone, E.J. et al.: Pharmacokinetics and pharmacodynamics of intranasal "snorted" heroin. J. Anal. Toxicol. 17 (1993) 327-337

Diagram 3: Bio-transformation of diacetyl morphine (heroin), acetylcodeine, codeine and morphine. Abbreviations: MAM = monoacetyl morphine , gluc = glucuronide.



Based on the data concerning the pharmacokinetics of heroin, 6-MAM and morphine, the expected concentration of free morphine after the administration of heroin can be estimated with the help of mathematical models. The following diagram is exemplary of the expected serum morphine concentration for a heroin user who has administered heroin twice in the last 28 hours (2 50 mg pure heroin, or 2 0.5 g street heroin with an effective heroin concentration of 10 %). It shows that, within 12 hours, the morphine concentration can decrease to very low values. At this low concentration, withdrawal symptoms can appear in the case of physical addiction.

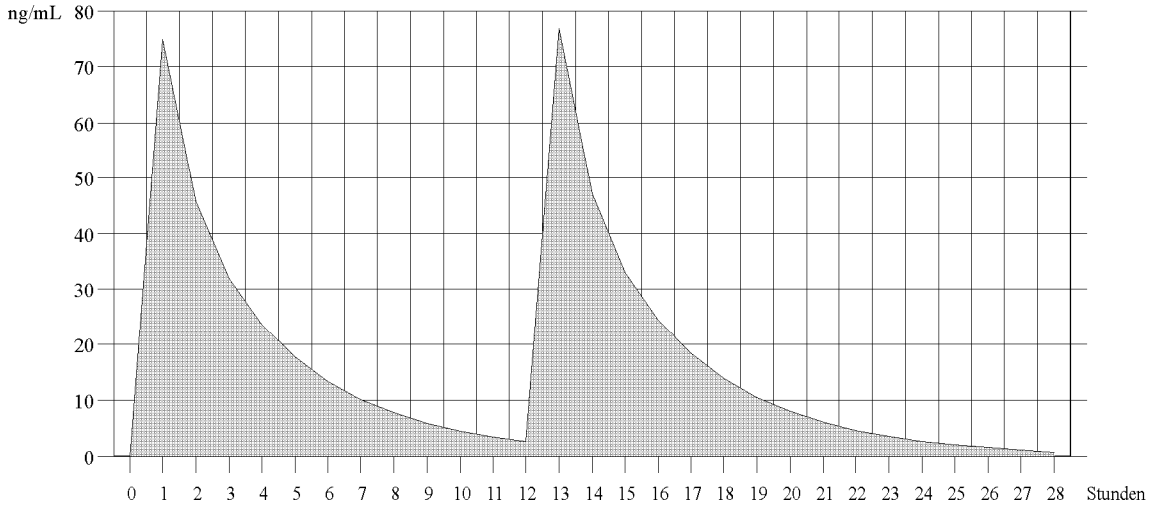



Diagram 4: Theoretical time dependent morphine concentration in serum after twofold heroin consumption within 12 hours. Morphine concentration was calculated in one-hour intervals.

## 2.2 Relation between Morphine / Heroin Dosage and Effect

Although there is no predictable relation between the blood morphine concentration and the analgesic response, it can be said that effective pain relief for an individual patient can not be achieved if it is lower than a certain level. The minimum effective blood concentration differs from patient to patient, and heavily depends on whether treatment with μ-receptor agonists has already been performed[38].

According to Jenkins et al.[39], a dosage-dependent response seems to exist concerning heroin-induced myosis (table 3). The pupil diameter changes quickly after administering the drug, followed by a plateau which lasts at least 4 hours. This result agrees with the findings of Martin and Fraser[40], who reported myosis lasting for at least 6 hours. Also, the entries "subjective effect" and "degree of pleasure" showed a direct relation to the amount consumed. From 10 mg upwards

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38 Physician's Desk Reference, 50th edition, Medical Economics Company, Montvale, 1996, pp.1997; Goodman and Gilman's the pharmacological basis of therpeutics. 8th edition McGraw-Hill, Inc., New York, 1990, pp.486-489

39 Jenkins, A.J. et al.: Pharmacokinetics and pharmacodynamics of smoked heroin. J. Anal. Toxicol. 18 (1994) 317-330

40 Martin, W.R. and Fraser, H.F.: A comparative study of physiological and subjective effects of heroin and morphine administrated intravenously in postaddicts. J. Pharmacol. Exp. Ther. 133 (1961) 388-389

of i.v. heroin, according to jenkins et al., a very positive effect was described by the test subjects immediately after the injection.

Table 3: Relation between myosis, heroin dosage and morphine concentration (according to Jenkins et al. 1994).

| Heroin | Max. pupil diameter | | Min. pupil diameter | | Morphine concentration (ng/mL) | |
|---|---|---|---|---|---|---|
| | Time (min.) | Diameter (mm) | Timespan (min) | Diameter (mm) | from | to |
| 0 mg | 2 | 6,2 | 15 - 30 | 5,0 | 0 | 0 |
| 10 mg | 0 | 5,8 | 10 - 30 | 3,4 - 3,6 | 10,8 | 12,5 |
| 20 mg | 0 | 5,8 | 2 - 240 | 2,8 - 3,0 | 7,6 | 57 |

## 2.3 Codeine and Dihydrocodeine

### *2.3.1 Codeine*

The biotransformation of codeine leads through glucuronidisation and demethylation to codeine-6-glucuronide, norcodeine and morphine. Norcodeine and morphine are broken down further or converted to the corresponding glucuronides (diagram 3). After codeine has been taken orally, on average 4 % is excreted via urine as morphine[41]. After codeine has been taken orally, it is reabsorbed rapidly. The absolute bioavailability is on average 70 %, and the relative bioavailability ca. 54 % due to a pronounced first-pass reduction in the liver. After oral consumption of 60 mg of codeine base by 11 young male test subjects, a maximum plasma concentration of on average 93 ng/mL was reached. The amount of bound protein was under 10 %. For healthy adults, the codeine elimination half-life is between 3 and 5 hours., and between 9 and 18 hours for people with kidney insufficiency. The elimination time also increases with age. The analgesic and antitussive effects of codeine are dependent on the dosage. The effects are brought about partly by the metabolites of morphine[42].

### *2.3.2 Dihydrocodeine*

As well as the use of dihydrocodeine as cough suppressant, it plays an important role in the treatment of heroin addiction. It is taken orally in the form of tablets, or as a syrup. It is almost completely reabsorbed, but its bioavailability is only 20 % due to high first-pass metabolism in the liver. Its efficiency as an analgesic in comparison to morphine was shown to be between 0.08 and

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41 Käferstein, H. und Sticht, G.: Opiatnachweis im Harn. Deutsche Forschungsgemeinschaft. Mitteilung XXI der Senatskommission für Klinisch-Toxikologische Analytik. VCH Verlagsgesellschaft mbH, Weinheim, 1993, pp.102-103

42 Technical information concerning codeine drops / fluid supplied by ct-Arzneimittel Berlin, October 1997.

0.16. After administering 30 mg dihydrocodeine to each of 24 healthy test subjects, the maximum plasma concentration after 0.75 to 2 hours (average 1.25 hours) was observed to be 204 ± 45 ng/mL. The elimination half-life was 4.8 ± 3.5 hours[43].

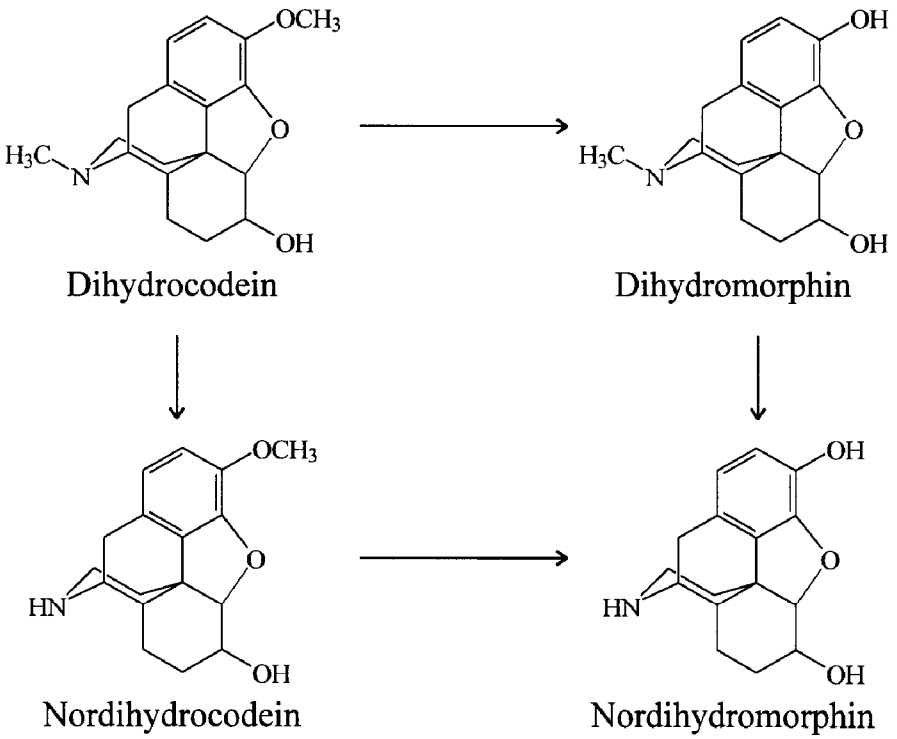


Diagram 5: Biotransformation of dihydrocodeine.

[43] Technical information supplied by DHC Mundipharma, March 1997.

## 3 Target of the Inquiry

In the final report of the inquiry commissioned by the Ministry of Economics and Small Businesses, Technology and Transport for North Rhine-Westphalia into the incidence of "Cannabis in Road Traffic", August 1996[44], the main objectives for this inquiry were also outlined, whereby the focus now is on the drug heroin and no longer on cannabis. This time, the possibility of establishing a relation between the blood analysis of heroin-related substances and the fitness of the individual to drive was to be explored. The basic procedure as implemented in the study "Cannabis in Road Traffic" was adhered to without changes. The survey forms underwent only minor changes (see appendices 1-3). Assessment forms were also used (see appendix 4). All opiate-positive samples were evaluated in this study, including those which had been submitted in the previous one. These underwent screening tests for the presence of opiates. Thus, a total of 912 samples submitted for both studies including documentation were available for the heroin inquiry. Police involved in the study were trained (see appendix 7 amongst others), and the doctors taking the blood samples were informed via anonymous blood test reports.

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[44] Daldrup, Th.: Abschlußbericht des im Auftrage des Ministeriums für Wirtschaft und Mittelstand, Technologie und Verkehr des Landes Nordrhein-Westfalen durchgeführten Untersuchungsvorhabens "Cannabis im Straßenverkehr" AZ. 732-21-03/2.1.1, Düsseldorf, August 1996

## 4 Heroin in Road Traffic

In recent years, many studies have been submitted concerning "Drug Abuse in Road Traffic". It is remarkable though, that findings concerning opiates / heroin were so rarely reported.

In the final report of the Road Safety Committee of the Parliament of Victoria, Australia, 1995[45], the influence of cannabis on driving fitness and the road safety implications of benzodiazepines and methadone were described in depth. However, the relevance of the opiates in the same arena was not mentioned.

Of the 1332 drivers fatally injured in accidents between 1990 and 1995, 52 % showed no trace of alcohol or other drugs, 25 % were tested positive for (only) alcohol, in 11.6 % cannabis was detected, in 6.3 % various medication, in 3.7 % amphetamine and other stimulants, in 3.3 % benzodiazepines and in only 2.6 % (= 35 cases) opiates, whereby the individual opiates were not differentiated[46].

Blood analysis of drivers who committed diverse traffic offences revealed the use of opiates in 17 % of the cases (alcohol 40 %, cannabinoids 27 %, benzodiazepines 12 %, stimulants 6 %)[47].

Of 513 drivers who had had an accident in Western Australia, whose deficiency symptoms could not be explained in terms of alcohol consumption alone, 19 % had consumed opiates, 78 % cannabis, 38 % alcohol, 25 % amphetamines and 21 % benzodiazepines[48].

Drummer[49] evaluated 1332 files of accidents with fatalities, and tried to quantify the relative risk (risk ratio) for each individual drug in the cases where intoxicants were deemed to have caused the accident. Here, the risk for the drivers who were found not to have consumed intoxicants, was set at 1.00. The drivers who had consumed cannabis was the only group under 1.00, with a risk ratio of 0.7. The ratio for the opiates / opioids (codeine, morphine, methadone or pethidine) was 2.4 although the number of cases was small (14). In contrast, the risk ratio for consumption of alcohol only (n = 333) was clearly higher at 5.7. For the other groups, the following risk ratios were as follows:- Amphetamines / stimulants (n = 25) 1.9, benzodiazepines (n = 13) 1.8 and alcohol plus drug (n = 123) 8.6. If the 1045 driver fatalities from the previously mentioned study are also included and more precisely evaluated, then it becomes evident that the group of opiate consumers was in every case to blame for the accidents where several vehicles

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45 Road Safety Committee, Parliament of Victoria (ed.) Inquiry into the Effects of Drugs (Other than Alcohol) on Road Safety. In Victoria. Final Report, vol. 1, 1996, pp.45-80

46 ibid. pp. 83

47 ibid. pp. 92

48 ibid. pp. 93-94, Road Safety Committee, Parliament of Victoria (ed.) The Effects of Drugs (Other than Alcohol) on Road Safety. First Report, L.V. North, Government Printer, Melbourne, 1995, pp.11-15

49 ibid. pp. 101ff

were involved, which means that the relative risk for the opiates with 14 still clearly exceeded that of alcohol with 3.4[50].

For the EU, de Gier[51] compiled the incidence of drugs in road traffic. Here, the percentage of cases where opiate consumers had been involved in accidents was determined:- In Denmark 1993 only 2 cases were cited, in Spain 1992, 1.7 % (n = 289), in Great Britain 1994 0.1 % (No. of cases unknown), and in Italy 1994, 7.0 % (n = 200). In the Netherlands in 1994, of 309 drivers suspected of driving under the influence of drugs, 250 tested positive: 57 had consumed opiates, 83 cocaine, 28 cannabis, 25 amphetamines and 28 methadone.

In Switzerland, for the period 1989 – 1991, a total of 243 traffic offences underwent further examination concerning the drivers' impairment being due to drugs or medication[52]. In 160 cases (65.8 %), the toxicological tests gave a positive result. For 137 of these 160, a breakdown of the results was available. This group was examined more closely. In 58 cases, opiates were found in the blood, in 16 cases without an accompanying intoxicant, and in a further 12 cases insignificant amounts of cannabinoids or cocaine metabolites were found. These 28 cases were deemed by the authors as being purely opiate cases[53]. In this group, 60.7 % had reddened conjunctiva, 50 % constricted pupils, and 35.7 % displayed an unsteady gait or tiredness symptoms. 9 had a blood concentration of free morphine between 10 and 25 ng/mL, 6 a concentration between 30 and 55 ng/mL, 6 a concentration between 60 and 100 ng/mL, and 7 a concentration of 100 or greater. High active substance concentrations were found in the blood of especially those drivers who had hardly displayed any deficiency symptoms at all in the medical examination.

Also, the evaluation performed by Iten of the cases from the year 1992[54] to complement his work does not change his conclusion that "the inference of the impairment of driving fitness, which is based solely on the interpretation of blood morphine concentration, is questionable".

In Germany, two studies from the Hanover and Saarland regions have been submitted.

In a two-year study, in which 501 blood samples of drivers injured in accidents were tested, opiates were found in 10 of these (= 2 %). The exact analysis revealed that in the majority of

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50 Drummer, O.H.: Drugs in Drivers Killed in Australien Road Traffic Accidents. Report No. 0594, Victorian Institute of Forensic Pathology, Department of Forensic Medicine, Monash University, March 1994, pp.28, 37, 45,46

51 De Gier, J.J. (1995) Drugs other than Alcohol and Driving in the European union. Report IHP-54, April 1995, pp.25-26 (quoted from ibid., vol. 2, pp.66-67).

52 Koch, A.F., Iten, P.X.: Die Verminderung der Fahrfähigkeit durch Drogen oder Medikamente. Eine retrospektive Studie anhand von 243 Strassenverkehrsfällen aus den Jahren 1989 -1991, Institut für Rechtsmedizin, Universität Zürich, 1994, pp.14, 28

53 ibid. pp.34-40

54 Iten, P.X.:Die integrale Begutachtung von Fahrzeuglenkern unter Drogen- oder Medikamenteneinfluss. In: Daldrup, Th. und Mußhoff, F.: GTFCh - Symposium: Drogen und Arzneimittel im Straßenverkehr. Chemische Spuren bei Verkehrsunfällen. D. Helm, Heppenheim, 1995, pp.60-73

cases, codeine had been taken; only one case tested positive for morphine accompanied by codeine and dihydrocodeine[55].

In a further study from Saarland, blood samples designated by the police for alcohol determination were analysed additionally for other intoxicants. For the one-year period from October 1989 to September 1990, 660 from a total of 5406 samples were randomly selected. Of these 660, 570 contained only alcohol, 65 contained alcohol plus at least one other medicinal drug or active substance, and 22 contained only other drugs except alcohol. 3 samples tested negative. In 12 cases opiates were found, half in combination with alcohol. In 11 of the 12 cases, it can be assumed that heroin consumption had occurred (= 12.6 % of the positive drug / medication cases)[56].

In epidemiological studies in the USA, opiates are seldom found in drivers' blood. In 1986, 359 truck drivers selected randomly were shown to have no opiates in their urine, and the evaluation of rail transport accidents with serious damage and high personal injury as consequence revealed that opiates play a negligible role. Of the 594 blood samples taken from drivers involved in fatal accidents in the Los Angeles region in 1985/86 or 1987/88, none proved opiate-positive[57].

A more recent study encompasses a total of 1882 fatal accidents which occurred in a 14 month period in 1990/91 in 7 states of the USA. The blood samples were analysed for medicinal and other drugs in all cases, if death had occurred at the latest 4 hours after the accident. Morphine or codeine was found in only 9 of the cases (= 0.48 %), and heroin was not found at all[58]. In 4 cases, the morphine concentration was so low that it can be classified as a trace, in one case the concentration was high, and the levels in the remainder were classified as toxic.

However, even in the USA, there are evidently a number of drivers on the road too large to ignore, which belong to the group of opiate consumers. This was shown by evaluation of the results obtained by police who had undergone special training to become Drug Recognition Experts (DREs), and who had particular aptitude in being able to sense whether drivers were under the influence of drugs. For a period of 3 months in 1985 in Los Angeles, drivers who were not involved in accidents, but whose driving behaviour was suspected of being due to the influence of drugs were intensively interviewed by DREs. In 219 cases, the suspicion was confirmed. In 173 cases, a blood sample was able to be taken, and 35 of these (= 20.2 %) tested positive for opiates.

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55 Hausmann, E., Möller, M.R., Otte, D.: Medikamente, Drogen und Alkohol bei verkehrsunfallverletzten Fahrern. Bericht zum Forschungsprojekt 8004. Bundesanstalt für Straßenwesen (Hrsg.), Bergisch Gladbach, 1988, pp.62

56 Möller, M.R.: Drogen- und Medikamentennachweis bei verkehrsauffälligen Kraftfahrern. Bericht zum Forschungsprojekt 8946. Bundesanstalt für Straßenwesen (Hrsg.) Mensch und Sicherheit Heft M 29, Wirtschaftsverlag NW, Bremerhaven, 1994, pp.16

57 ibid. pp.7-8

58 Terhune, K.W., Ippolito, C.A., Hendricks, D.L. et al.: The incidence and role of drugs in fatally injured drivers. Final report., DOT HS 808 065, U.S. Department of Transportation, National Highway Traffic Safety Administration, October 1992, pp. 47 and appendix I, pp. 3

The DREs sensed opiate presence correctly 85 % of the time[59]. The main criteria indicating opiates were pulse irregularities, eye symptoms (sideways flickering, redness of the conjunctiva, pupil size and reaction to light), and voice characteristics. In addition, fresh injection points were a further, major sign of opiate use[60].

In Norway, all blood samples taken from drivers exhibiting conspicuous behaviour are subjected to official testing in a laboratory. In 1992 the number taken was 9355, of which 6637 indicated the presence of only alcohol, and the remaining 2718 suggesting the presence of an additional drug (medicinal or other). Of the latter, 336 had a blood alcohol concentration of over 1,5 ‰, and did not undergo further toxicological testing. The remaining samples were screened for drugs and active substances contained in medication. 1415 (59.4 %) were positive; primarily, tetrahydrocannabinol (842 times), benzodiazepines (802 times) and amphetamines (391 times) were found. Based on the total group, morphine was detected in the blood sample in 4.5 % of the cases (= 7.5 % of the positive samples) and codeine / ethylcodeine was detected in 3.6 % of the cases (= 6 % of the positive samples)[61].

In order to gather reliable data in Germany concerning the incidence of alcohol, medicinal and other drugs in road traffic, saliva samples supplied voluntarily by a total of 2053 drivers at various points in time in the period November 1992 until July 1994 were analysed for opiates (besides other drugs) using immunochemical methods. 9 saliva samples were positive. As the differentiation between codeine, dihydrocodeine and morphine was not possible at the time, the author decided to fall back on experience, and assumed that ¼ of the positive opiate results were due to heroin / morphine consumption. Thus it was assumed that about 0.11 % of drivers (calculated from the number of 2 or 9 drivers whose saliva returned a positive result) are on the road after taking heroin or morphine[62].

In 7 surveys carried out between 1973 and 1993, in which 14 to 25-year-olds were asked about their drug consumption, an average of 15 to 24 % over the time period admitted trying one drug (95 % of the time cannabis). Of these, 3 % in 1990 and 6 % in 1993 admitted to have taken heroin. Of the people surveyed, heroin consumption was admitted by 0 % in 1990 and 2 % in 1993; based only on the group which at the time of the survey (1993) was taking narcotics, the following picture was constructed:- heroin 4.5 %, cannabis 95.4 %, stimulants 9.1 %, LSD 4.5 % and various sniffed substances ("inhalants") 0 %. Based on further surveys of adults in which (alongside other

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59 Burns, M.: History of drug recognition training in the United States. In: Utzelmann, Berghaus, Kroj (ed.) Alcohol, Drugs and Traffic Safety - T92. TÜV Rheinland GmbH, Köln, 1993, pp.1539-1546

60 Voas, R.B., Tippetts, A.S., Hemmans, R.A.: Discriminant analysis of signs of drug impairment. In: Utzelmann, Berghaus, Kroj (ed.) Alcohol, Drugs and Traffic Safety - T92. TÜV Rheinland GmbH, Köln, 1993, pp.1553-1558

61 Christophersen, A.S., Mørland, J.: Driving under the influence of drugs other than alcohol: Is Norway a special case? In: Spiehler, V. (ed.) Proceedings of the 1994 Joint TIAFT/SOFT International Meeting. Bridging the World of Forensic Toxicology, Tampa, Florida, 1994, pp. 496-502

62 Krüger, H.-P.: Medikamente im Strassenverkehr. Epidemiologische Ergebnisse zu Auftreten und Risiken. In: Krüger, H.-P-, Kohnen, R. und Schöch, H. (Hrsg.) Medikamente im Straßenverkehr. Gustav Fischer, Stuttgart, Jena, New York, 1995, pp. 3-33

information) drug consumption details were obtained, calculations showed that in Germany some 240 000 people consume cannabis on a daily basis, accompanied by 100 000 "heavy" heroin users[63].

Until now, reports of road accidents after heroin consumption have only sporadically appeared. From two fatal car accidents, Sticht et al.[64] found respectively 330 and 32 ng/mL of free morphine in the drivers' blood samples. Simultaneous consumption of other intoxicants was not found. The Higher Regional Court (German: OLG) in Frankfurt[65] clarified the matter in a different case, that no scientifically determined threshold level exists which deems a driver unfit to be in charge of a motor vehicle.

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63 Bundeszentrale für gesundheitliche Aufklärung: Die Drogenaffinität Jugendlicher in der Bunderrepublik Deutschland. Wiederholungsbefragung -1993/1994-, Referat 25, Köln, Dezember 1994, pp. 51-52; Herbst, K., Kraus, L. und Scherer, K.: Repräsentativerhebung zum Gebrauch psychoaktiver Substanzen bei Erwachsenen in Deutschland. Institut für Therapieforschung, München, 1996, pp. 42

64 Sticht, G., Käferstein, H. und Schmidt, P.: Zwei Verkehrsunfälle nach Heroin-Konsum mit tödlichem Ausgang. Blutalkohol 31 (1994) 233-237

65 OLG Frankfurt/M, Beschluß vom 4.3.1992 - 2 Ss 4/92: Blutalkohol 30 (1993) 207-208

# 5 Analysis of the Blood Samples for Opiates

## 5.1 Screening Tests

### *5.1.1 Screening for Cannabinoids, opiates, amphetamines, cocaine metabolites and benzodiazepines*

The blood samples are centrifuged at once. A portion of the serum is kept aside for the case that a non-fluoride-containing blood sampling tube has been employed, and this is mixed with NaF at a rate of 10 mg per millilitre serum. This sample is stored in a glass vial at –18 °C for later tests. Subsequently, 300 µL serum and aqueous calibration standards I to III (see table 4) are mixed with 300 µL acetone respectively, and homogenised on a Vortex mixer. A blank is prepared by mixing 300 µL water with 300 µL acetone. The precipitate from the serum-containing mixtures is removed by centrifuging once again (>10 000 rpm). 200 µL of the supernatant / calibration solution I to III / blank are then mixed with 20 µL saturated NaCl solution and analysed by FPIA[66] (ADx system from Abbott) for the substances listed in the table, as for analysis of urine according to the manufacturer's instructions. The values returned for the calibration standards are graphically portrayed after subtraction of the respective blank.

Table 4: Immunochemical analysis of Cannabinoids, opiates, amphetamines, cocaine metabolites and benzodiazepines in serum.

| Active substance group | Standard | I ng/mL | II ng/mL | III ng/mL | Value of the quantitative results |
|---|---|---|---|---|---|
| Cannabinoids (SCC) | THC-COOH | 20 | 50 | 100 | meaningful |
| Opiates | Morphine | 50 | 200 | 400 | only for orientation purposes |
| Amphetamines | d,l Amphetamine | 100 | 200 | 500 | only for orientation purposes |
| Cocainemetabolites | Benzoylecgonine | 500 | 1 000 | 1 500 | meaningful |
| Benzodiazepines | Flunitrazepam | 20 | 50 | 100 | only for orientation purposes |

The calibration curves obtained in this manner enable quantitative evaluation of the serum supernatant analysis. If the values obtained from the serum exceed the calibration standards, then dilution of the supernatant must be performed (e.g. 1+4) using the blank, and re-measured via immunoassay.

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[66] FPIA = Flourescence-Polarisation Immuno Assay

## 5.2 Testing for Alcohol

A headspace sample vial is filled with 50 µL serum and 500 µL aqueous internal standard (t-butanol) and analysed for ethanol employing the gas chromatographic method approved for forensic blood alcohol determination.

## 5.3 Determination of monoacetylmorphine, morphine, codeine and dihydrocodeine

### *5.3.1 Sample material required for testing*

2 mL serum. For the case that a non-fluoride-containing sample tube was used for taking the blood sample, the serum is mixed with NaF at a rate of 10 mg per millilitre serum, and stored in a glass vial at –18 °C. Alternatively, blood, urine or tissue (e.g. brain) can be used.

### *5.3.2 Equipment*

Gas Chromatograph: Hewlett Packard 5890 series II with split-splitless injector, glass liner with glass wool HP 5062-3587, Merlin Microseal septum HP 5181-8833, fused silica capillary column HP 5MS (30 m, 0.25 mm i.d.., df = 0.25 µm). Sample Changer: Hewlett Packard 7673 GC/SFC injector and controller. Mass Spectrometer: Hewlett Packard 5972 series mass selective detector. Computer: Hewlett Packard Vectra 486/33N with HP MS DOS 5.00-E.00.01 (Engl.), MS WINDOWS 3.1 (Engl.), HP CHEMSTATION B.02.02, Samson-Top G1034C version C.01.05 and MS EXCEL 4.0 (Engl.), Extraction Unit: HP PrepStation. Miscellaneous equipment: circular vibration mixer ("Vortex"); Microman M50 capillary pipette, ABIMED.

### *5.3.3 Expendable materials*

Sample Changer bottles: 2 mL rimmed bottle, clear glass, with crimp cap PTFE/silicon/PTFE film, WGA Pfungstadt; vials (2 mL); HP-DAU columns 300 mg for HP PrepStation

### *5.3.4 Chemicals required (analytical grade)*

Acetonitrile, ammonia, dichloromethane, disodiumdihydrogenphosphate, isooctane, isopropanol, methanol, N-methyl-N-trimethylsilyl-trifluoroacetamide (MSTFA), pyridine, HCl (0.1 M), Water

### *5.3.5 Reagents and solutions*

*5.3.5.1 Stock solutions*

Codeine stock solution 0.01 mg/mL, codeine-$d_3$ stock solution 0.01 mg/mL, dihydrocodeine stock solution 0.01 mg/mL, morphine stock solution 0.01 mg/mL, morphine-$d_3$ stock solution 0.01

mg/mL, 6-monoacetylmorphine stock solution 0.01 mg/mL, 6-monoacetylmorphine-$d_3$ stock solution 0.005 mg/mL

*5.3.5.2 D3 blend*

The stock solutions are blended as follows:- 0.4 mL codeine-$d_3$ stock solution + 0.4 mL morphine-$d_3$ stock solution + 0.4 mL 6-monoacetylmorphine-$d_3$ stock solution diluted to 4 mL with methanol.

50 µL of this blend contains 50 ng codeine-$d_3$, 50 ng morphine-$d_3$ and 25 ng , 6-monoacetylmorphine-$d_3$. It can be stored for several weeks at –18 °C.

*5.3.5.3 Reference standard*

The stock solutions are blended as follows:- 0.05 mL codeine stock solution + 0.3 mL dihydrocodeine stock solution + 0.05 mL morphine stock solution + 0.025 mL 6-monoacetylmorphine stock solution filled up to 1 mL with methanol.

50 µL of this blend contains 25 ng codeine, 150 ng dihydrocodeine, 25 ng morphine and 12.5 ng 6-monoacetylmorphine. It can be stored for several weeks at –18 °C.

*5.3.5.4 Control samples*

Each 19 mL portion of drug-free human serum is mixed with 200 mg sodium fluoride and 1 mL reference standard. The serum is stirred mechanically for 30 min. and then homogenised for 1 minute on the Vortex mixer. 1 mL of this is placed in each sample changer bottle and stored at –18 °C until the analysis is performed. The control samples can be stored for about one year.

### *5.3.6 Sample Preparation*

1.0 mL of acetonitrile is introduced to a 2 mL Eppendorf reactor vessel together with 50 µL D3 blend. Slowly, 0.7 mL serum, blood, urine or the control sample (or 0.2 – 1 g homogenised tissue) and 0.1 mL saturated aqueous disodiumhydrogenphosphate solution are added; these are mixed well on the Vortex mixer and then centrifuged at ca. 14 000 g for 5 minutes. 1.5 mL of the supernatant are transferred to a sample changer bottle, mixed with 0.1 mL 1M HCl and sent to the extraction step. 50 µL of the reference standard are mixed with 50 µL of the D3 blend.

### *5.3.7 Extraction with the PrepStation*[67]

The HP DAU columns are conditioned by washing with 2 mL methanol followed by 2 mL water and 2 mL 0.25 M hydrochloric acid. The supernatants contained in the sample changer

[67] A special thanks to the *Bund gegen Alkohol im Straßenverkehr* (Association against alcohol in Road Traffic) for financial support for the purchase of the PrepStation.

bottle are applied to the column at a flow rate of 1.0 mL/min. The columns are washed in turn with 3 mL water, 3 mL 0.1 M hydrochloric acid, 3 mL methanol and 1 mL of a mixture consisting of dichloromethane, isopropanol and ammonia (80 : 20 : 2 (V/V/V)). The opiates are then eluted with 1.6 mL of the same mixture. The program listing for the PrepStation can be found in appendix 5.

### *5.3.8 Derivatisation*

The eluate (and the reference standards) are evaporated at 50 °C in an atmosphere of nitrogen. The silyl derivatives are obtained by dissolving the residue in 200 µL isooctane, adding 10 µL pyridine and 10 µL MSTFA before incubating in a heating block at 90 °C for 30 minutes. An aliquot of this solution is then subjected to GC/MS analysis.

### *5.3.9 GC/MS Analysis*

The carousel is loaded with the sample bottles as follows: Position 95: Reference standard, position 100: Isooctane (blank), positions 1-n: Samples and control samples. The sample changer is programmed to inject a blank (isooctane) after every sample. This conveniently prevents substances from slurring into consecutive samples. At the beginning and after every 6$^{th}$ sample, the reference standard is injected. 5.3.3

*Injected volume:* 2 µL; *temperature program:* Start temp.: 150 °C, start time: 1.00 min; step 1: 60 °C /min to 245 °C for 7.50 min; step 2: 60 °C/min to 300 °C for 4.00 min. Duration of analysis: 15.00 min; *carrier gas:* Helium; *SIM parameters:* Solvent delay: 5.20 min. Group 1: (Dihydrocodeine) dwell per ion (DPI) = 60 msec; low resolution; start time: 7.16 min; ions in group: 236.1; 282.2; 315.2; 373.3. Group 2: (Codeine (-$d_3$)) dwell per ion (DPI) = 40 msec; low resolution; start time: 8.25 min; ions in group: 343.2; 346.2; 371.2; 372.2; 374.2; 375.2. Group 3: (Morphine (-$d_3$)) dwell per ion (DPI) = 45 msec; low resolution; start time: 9.10 min; ions in group: 196.2; 199.2; 401.3; 404.3; 429.3; 432.3. Group 4: (6-monoacetyl-morphine (-$d_3$)) dwell per ion (DPI) = 65 msec; low resolution; start time: 10.01 min; ions in group: 287.2; 340.3; 343.3; 399.3; 402.3.

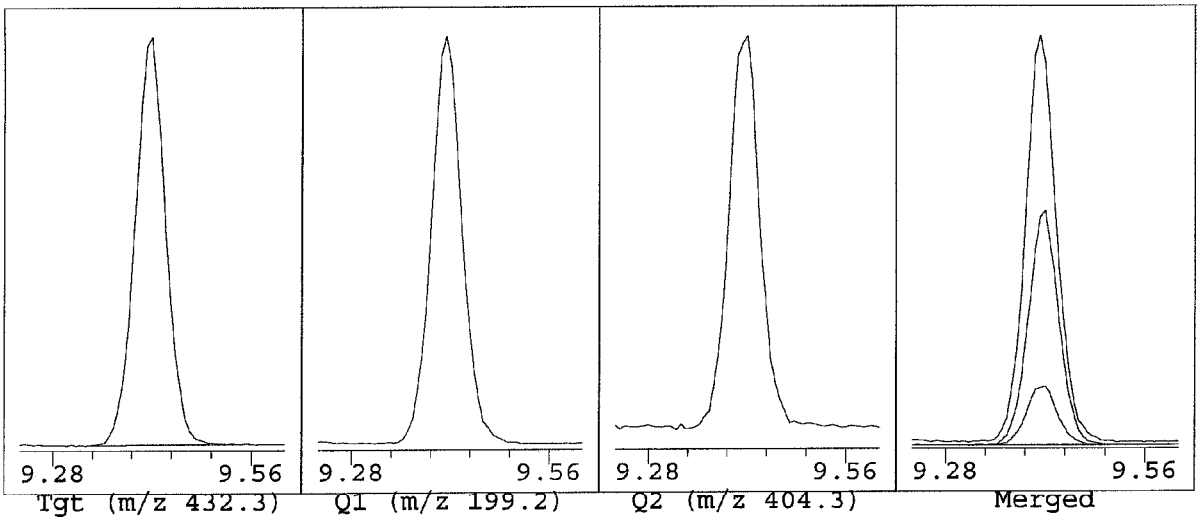
### *5.3.10 Calibration*

For calibration of the GC/MS, the following solution is required: *Calibration solution:* 35 µL codeine stock solution + 70 µL dihydrocodeine stock solution + 35 µL Morphine stock solution + 35 µL 6-monoacetyl-morphine stock solution filled up to 525 µL with methanol. *Level I:* 15 µL of the calibration solution are pipetted into a vial together with 50 µL D3 blend and subsequently treated as a reference standard. *Level II:* 75 µL of the calibration solution are pipetted into a vial together with 50 µL D3 blend and subsequently treated as a reference standard. *Level III:* 150 µL of the calibration solution are pipetted into a vial together with 50 µL D3 blend and subsequently treated as a reference standard.

To construct the calibration lines, the following values are entered in the calibration table: *Level I:* 10 ng/mL codeine, 20 ng/mL dihydrocodeine, 10 ng/mL morphine, 5 ng/mL 6-monoacetylmorphine. *Level II:* 50 ng/mL codeine, 100 ng/mL dihydrocodeine, 50 ng/mL morphine, 25 ng/mL 6-monoacetylmorphine. *Level III:* 100 ng/mL codeine, 200 ng/mL dihydrocodeine, 100 ng/mL morphine, 50 ng/mL 6-monoacetylmorphine. The deuteriated standards are quoted as having the following concentrations: 50 ng/mL codeine-$d_3$, 50 ng/mL morphine-$d_3$, 25 ng/mL 6-monoacetylmorphine-$d_3$. The calibration is performed according to the manufacturer's guidelines.

Diagram 6: Ion chromatogram of morphine and morphine-$d_3$

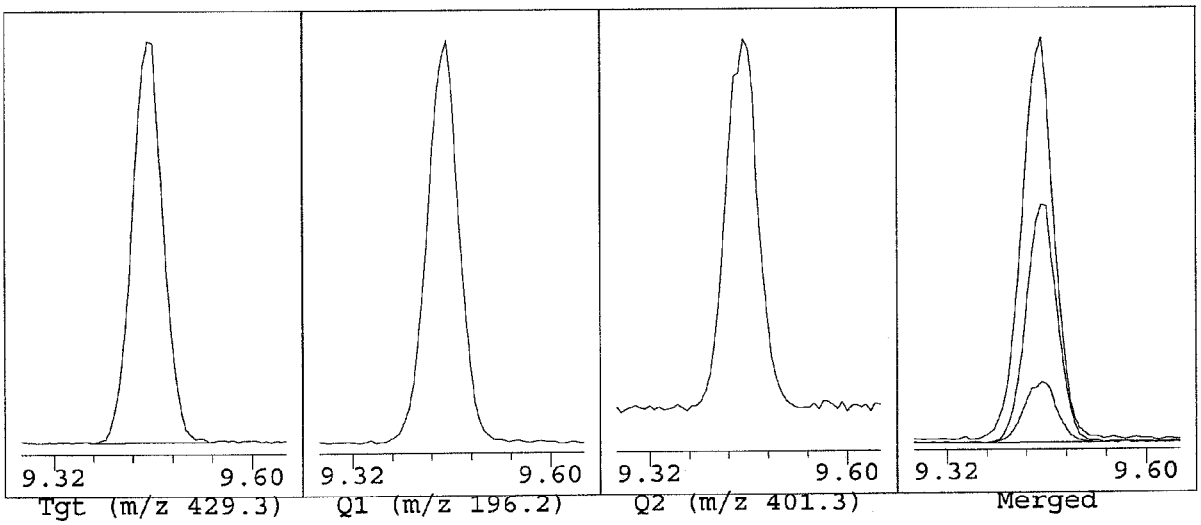
Compound: d3-Morphin
Ret Time: 9.42
Pk # and Type: 5 *ISTD3
Concentration: 50.00 ng/ml




| | Signal | Ratios | Limits | RT | Limits | Resp | Integ Type |
|---|---|---|---|---|---|---|---|
| Tgt | 432.30 | 100.0% | | 9.42 | 8.95 | 8791 | events |
| Q1 | 199.20 | 162.4 | 138.2- 186.9 | 9.42 | to | 14279 | events |
| Q2 | 404.30 | 26.0 | 22.2- 30.0 | 9.42 | 9.89 | 2283 | events |
| Q3 | 0.00 | 0.0 | 0.0- 0.0 | 9.42 | | 0 | auto |

f(x) = 0 X² + 1 X + 0 Coefficient is 0

Compound: Morphin
Ret Time: 9.46
Pk # and Type: 6
Concentration: 23.50 ng/ml

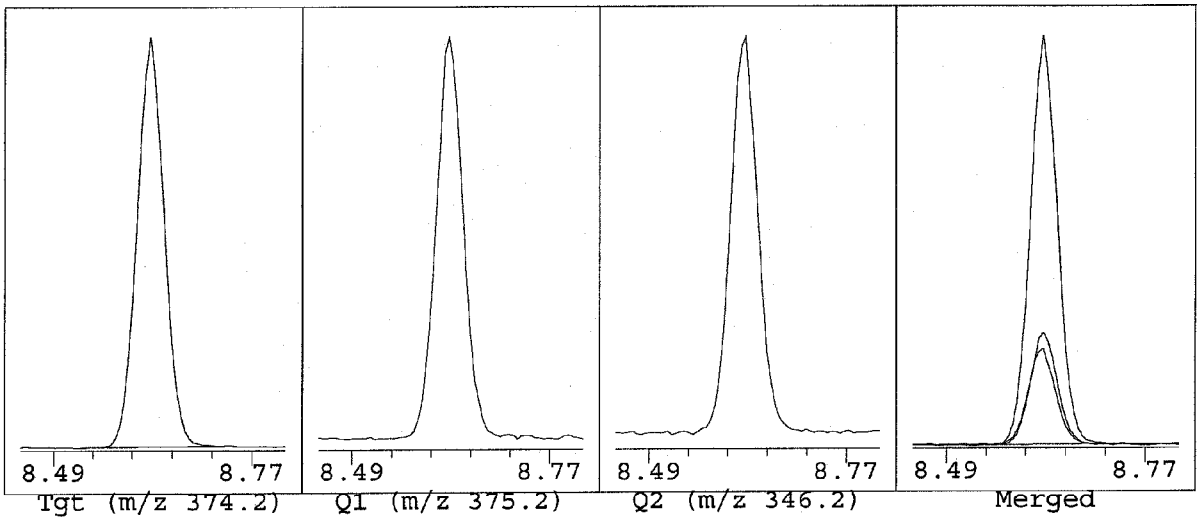



| | Signal | Ratios | Limits | RT | Limits | Resp | Integ Type |
|---|---|---|---|---|---|---|---|
| Tgt | 429.30 | 100.0% | | 9.46 | 9.22 | 4497 | events |
| Q1 | 196.20 | 148.6 | 126.3- 170.8 | 9.46 | to | 6683 | events |
| Q2 | 401.30 | 26.9 | 23.0- 31.1 | 9.46 | 9.70 | 1209 | events |
| Q3 | 0.00 | 0.0 | 0.0- 0.0 | 9.46 | | 0 | auto |

f(x) = 0 X² + 1.08843 X + 0 Coefficient is 0.999928

Diagram 7: Ion chromatogram of codeine and codeine-$d_3$

Compound: d3-Codein
Ret Time: 8.63 Concentration: 50.00 ng/ml
Pk # and Type: 1 *ISTD1

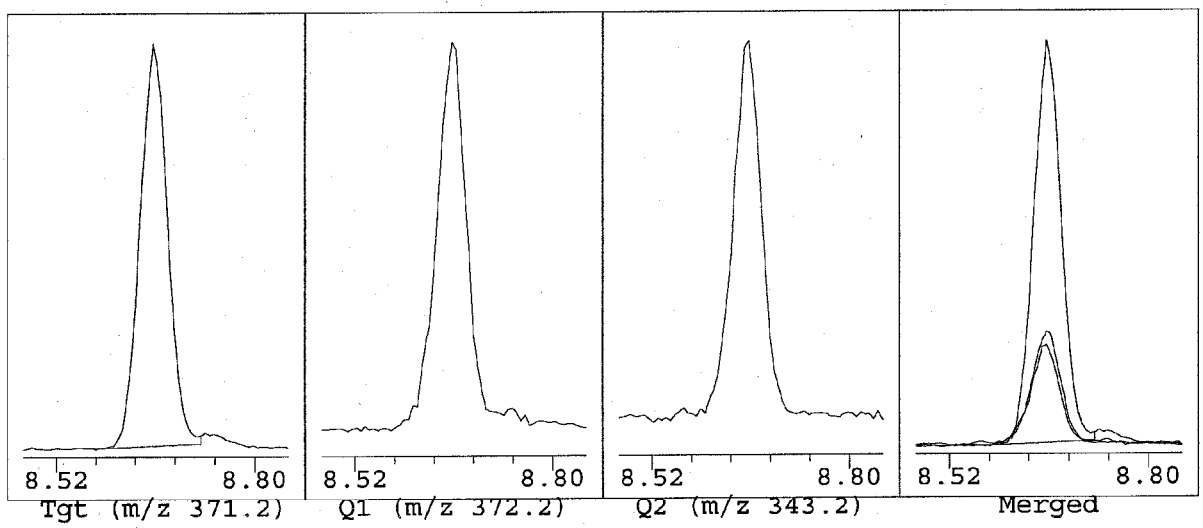



| | Signal | Ratios | Limits | | RT | Limits | Resp | Integ Type |
|---|---|---|---|---|---|---|---|---|
| Tgt | 374.20 | 100.0% | | | 8.63 | 8.20 | 15998 | events |
| Q1 | 375.20 | 27.7 | 23.4- | 31.7 | 8.63 | to | 4427 | events |
| Q2 | 346.20 | 23.8 | 20.5- | 27.7 | 8.63 | 9.06 | 3814 | events |
| Q3 | 0.00 | 0.0 | 0.0- | 0.0 | 8.63 | | 0 | auto |

f(x) = 0 X² + 1 X + 0 Coefficient is 0

---

Compound: Codein
Ret Time: 8.66 Concentration: 24.00 ng/ml
Pk # and Type: 2

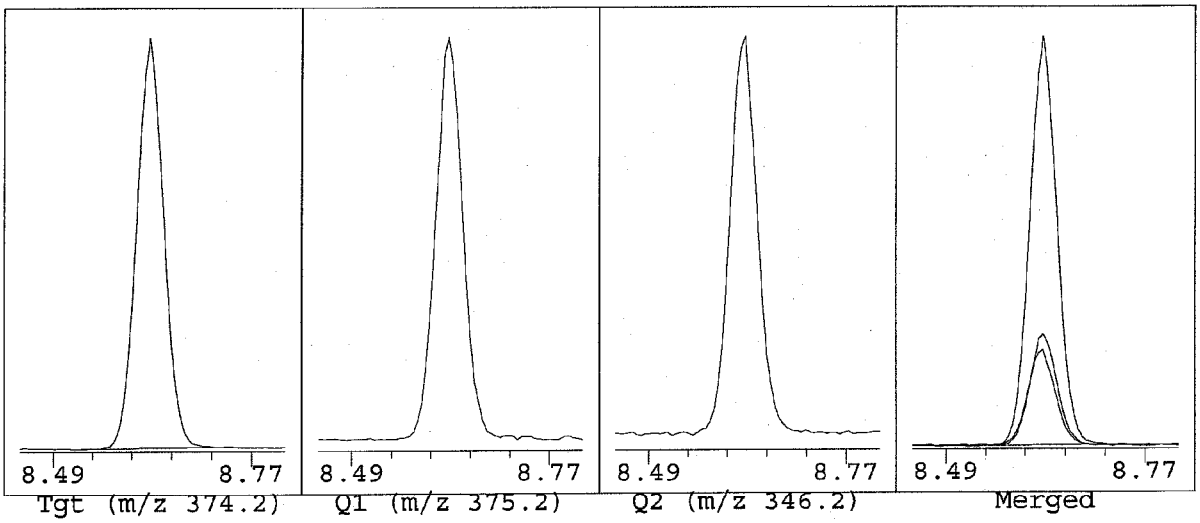



| | Signal | Ratios | Limits | | RT | Limits | Resp | Integ Type |
|---|---|---|---|---|---|---|---|---|
| Tgt | 371.20 | 100.0% | | | 8.66 | 8.44 | 5998 | events |
| Q1 | 372.20 | 30.7 | 26.0- | 35.1 | 8.66 | to | 1843 | events |
| Q2 | 343.20 | 25.3 | 21.7- | 29.4 | 8.66 | 8.88 | 1517 | events |
| Q3 | 0.00 | 0.0 | 0.0- | 0.0 | 8.66 | | 0 | auto |

f(x) = 0 X² + 0.781127 X + 0 Coefficient is 0.998436

Diagram 8: Ion chromatogram of dihydrocodeine and dihydrocodeine-$d_3$

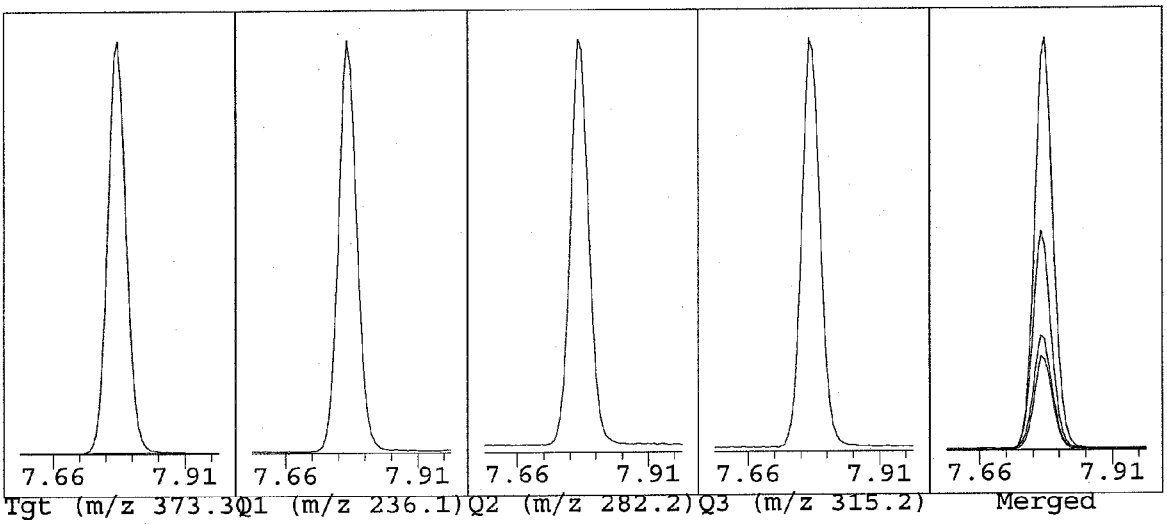
Compound: D3-Codein
Ret Time: 8.63 Concentration: 50.00 ng/ml
Pk # and Type: 3 *ISTD2




| | Signal | Ratios | Limits | | RT | Limits | Resp | Integ Type |
|---|---|---|---|---|---|---|---|---|
| Tgt | 374.20 | 100.0% | | | 8.63 | 8.20 | 15998 | events |
| Q1 | 375.20 | 27.7 | 23.4- | 31.7 | 8.63 | to | 4427 | events |
| Q2 | 346.20 | 23.8 | 20.5- | 27.7 | 8.63 | 9.06 | 3814 | events |
| Q3 | 0.00 | 0.0 | 0.0- | 0.0 | 8.63 | | 0 | auto |

f(x) = 0 X² + 1 X + 0 Coefficient is 0

Compound: Dihydrocodein
Ret Time: 7.79 Concentration: 138.28 ng/ml
Pk # and Type: 4

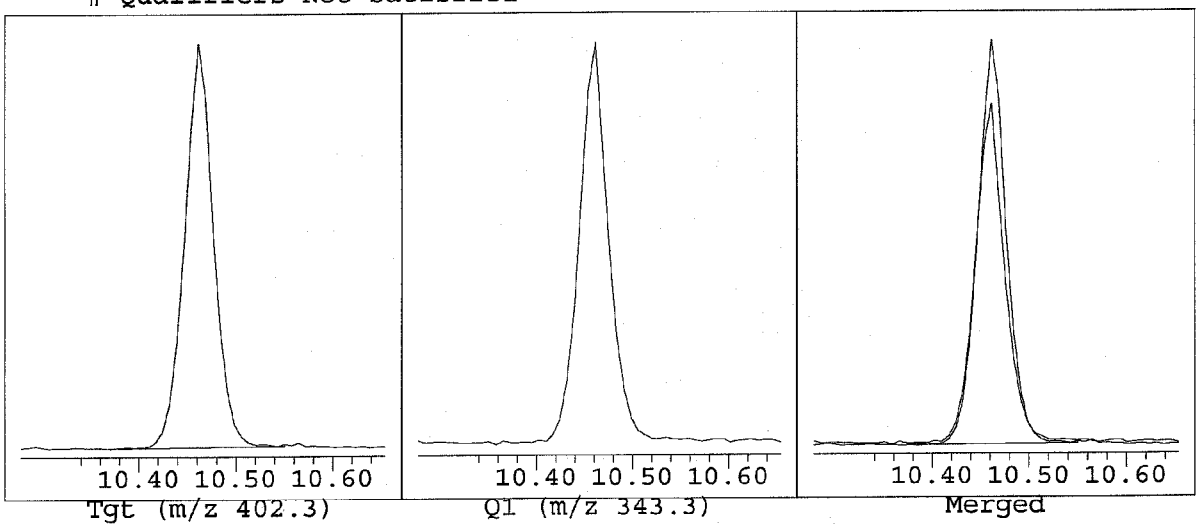



| | Signal | Ratios | Limits | | RT | Limits | Resp | Integ Type |
|---|---|---|---|---|---|---|---|---|
| Tgt | 373.30 | 100.0% | | | 7.79 | 7.60 | 66241 | events |
| Q1 | 236.10 | 49.7 | 42.1- | 57.0 | 7.78 | to | 32938 | events |
| Q2 | 282.20 | 27.0 | 23.0- | 31.1 | 7.78 | 7.98 | 17894 | events |
| Q3 | 315.20 | 22.1 | 18.8- | 25.4 | 7.78 | | 14668 | events |

f(x) = 0 X² + 1.49715 X + 0 Coefficient is 0.998497

Diagram 9: Ion chromatogram of monoacetylmorphine and monoacetylmorphine-$d_3$

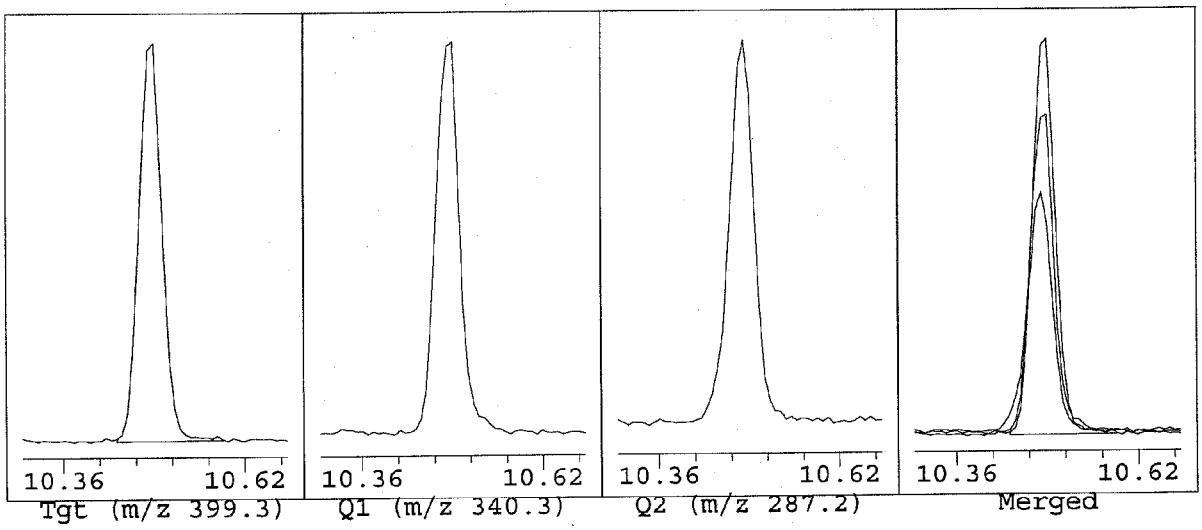
Compound: d3-MAM
Ret Time: 10.47 Concentration: 25.00 ng/ml
Pk # and Type: 7 *ISTD4
# Qualifiers Not Satisfied




| | Signal | Ratios | Limits | | RT | Limits | Resp | Integ Type |
|---|---|---|---|---|---|---|---|---|
| Tgt | 402.30 | 100.0% | | | 10.47 | 9.95 | 5466 | events |
| Q1 | 343.30 | 71.9 | 71.9- | 97.2 | 10.47 | to | 3928 | events |
| Q2 | 0.00 | 0.0 | 0.0- | 0.0 | 10.47 | 10.99 | 0 | auto |
| Q3 | 0.00 | 0.0 | 0.0- | 0.0 | 10.47 | | 0 | auto |

f(x) = 0 X² + 1 X + 0 Coefficient is 0

Compound: MAM
Ret Time: 10.49 Concentration: 11.08 ng/ml
Pk # and Type: 8




| | Signal | Ratios | Limits | | RT | Limits | Resp | Integ Type |
|---|---|---|---|---|---|---|---|---|
| Tgt | 399.30 | 100.0% | | | 10.49 | 10.22 | 2912 | events |
| Q1 | 340.30 | 81.8 | 69.8- | 94.4 | 10.49 | to | 2382 | events |
| Q2 | 287.20 | 55.1 | 46.8- | 63.3 | 10.49 | 10.75 | 1606 | events |
| Q3 | 0.00 | 0.0 | 0.0- | 0.0 | 10.49 | | 0 | auto |

f(x) = 0 X² + 1.20216 X + 0 Coefficient is 0.999543

### *5.3.11 Evaluation*

For quantification, the following peak height indices are drawn upon (see also diagrams 6 to 9): Morphine: Height index of the ions 429,3 (morphine) / 432.3 (morphine-$d_3$); codeine: Height index of the ions 371.2 (codeine) / 374.2 (codeine-$d_3$); 6-monoacetylmorphine: Height index of the ions 399.3 (MAM9 / 402.3 (MAM-$d_3$); dihydrocodeine: Height index of the ions 373.3 (dihydrocodeine) / 374.2 (dihydrocodeine-$d_3$).

The first quantitative evaluation using the saved calibration data and the composition of the report are performed according to the instructions of the GC/MS software manufacturer. Then in a second step, the complete data necessary for further thorough evaluation are entered in predefined cells of a spreadsheet. We used Microsoft EXCEL supplied by Hewlett Packard. On one sheet, up to 8 data sets can be stored in consecutive columns. Furthermore, all data describing the boundary conditions are entered as variables. These data include especially the single opiate concentrations of the reference standards, the amount of sample used for the preparation and the amount of the internal standard (*D3* blend) added to the sample. The data table contains also details concerning the nature of the sample tested (serum, blood etc.) and the set points for the retention times and the peak height indices of the qualifier ions.

From the data derived from the GC/MS software (peak heights, retention times, calculated concentrations), the peak height indices and the absolute recovery rate for the deuteriated internal standards (besides other data) are calculated for every sample. In addition, the concentration data supplied via the GC/MS software are constantly recalculated via the reference standard which is measured anew at the start of each series, and by taking the sample size into account. Thus, the saved calibration line data is verified before each series, drawing on the current state of the analysing system.

Diagram 10 shows the evaluation report including amongst other data the calculated peak height indices, absolute recovery and concentration figures. Because up to 8 consecutive analyses are stored on the one sheet, whereby the first and last are the reference standard, it is easy to gain an overview concerning the quality of the single analyses in the series. In this way, it can be reliably ascertained whether the series returned good results or whether a particular or even all analyses should be repeated. As this data sheet is a part of the case-related laboratory documents, it is possible—even after years have gone by—to quickly obtain comprehensive information about the state of the analytics and the quality of the series measured at that particular time. 5.3.11

Diagram 10: Evaluation Report

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| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Datum: 30.07.97 | | | File: | VGL1-1.D | 6573HSE.D | 6461HSE.D | 6630SER.D | 6156BLU.D | 6669BLU.D | URIN.D | VGL1-2.D |
| Version: 26.02.97 | | | Name: | | H-6573 | H-6461 | H-6630 | H-6156 | H-6669 | Urin | |
| Methode: OPI | | | Datum: | 29 Jul 97 | 29 Jul 97 | 29 Jul 97 | 29 Jul 97 | 30 Jul 97 | 30 Jul 97 | 30 Jul 97 | 29 Jul 97 |
| | | | Zeit: | 12:16 pm | 3:21 pm | 3:58 pm | 7:04 pm | 12:39 am | 3:45 am | 9:36 am | 4:35 pm |
| | Zeilentitel | (Einh.) Ion | Sollwerte | | | | | | | | |
| | Probenvol. | (in µl) | 1000µl | 1000 | 1000 | 500 | 1000 | 500 | 1000 | 100 | 1000 |
| d3-Codein | Ret.-zeit | (in min.) | 8.57 | 8.63 | 8.62 | 8.59 | 8.56 | 8.54 | 8.54 | 8.6 | 8.57 |
| | Wiederf. | (in %) | 100.0% | Vgl. | 42.5% | 49.5% | 52.8% | 57.4% | 41.7% | 52.2% | 103.8% |
| | Tgt. | 374.20 | 100.0% | 15945 | 6780 | 7900 | 8414 | 9157 | 6649 | 8326 | 16555 |
| | Q1 / Tgt. | 375.20 | 27.5% | 27.7% | 30.6% | 28.3% | 27.1% | 28.6% | 28.5% | 29.6% | 28.3% |
| d3-Morphin | Ret.-zeit | (in min.) | 9.36 | 9.42 | 9.4 | 9.37 | 9.33 | 9.32 | 9.31 | 9.39 | 9.36 |
| | Wiederf. | (in %) | 100.0% | Vgl. | 20.9% | 25.7% | 24.4% | 26.5% | 17.0% | 25.4% | 105.0% |
| | Tgt. | 432.30 | 100.0% | 8791 | 1841 | 2257 | 2147 | 2329 | 1491 | 2236 | 9229 |
| | Q1 / Tgt. | 199.20 | 162.5% | 162.4% | 182.0% | 161.7% | 165.8% | 172.9% | 172.4% | 163.2% | 167.2% |
| | Q2 / Tgt. | 404.30 | 26.0% | 26.0% | 32.1% | 28.1% | 29.9% | 29.2% | 35.1% | 28.1% | 26.9% |
| Codein | Ret.-zeit | (in min.) | 8.60 | 8.66 | 0 | 8.62 | 0 | 0 | 0 | 8.63 | 8.6 |
| | Konz. | (in ng/ml) | 25.00 | 24.08 | 0.00 | 13.20 | 0.00 | 0.00 | 0.00 | 279.15 | 25.88 |
| | Tgt. | 371.20 | 100.0% | 5998 | 0 | 784 | 0 | 0 | 0 | 3497 | 6446 |
| | Q1 / Tgt. | 372.20 | 30.5% | 30.7% | 0.0% | 36.6% | 0.0% | 0.0% | 0.0% | 30.2% | 28.8% |
| Dihydrocodein | Ret.-zeit | (in min.) | 7.73 | 7.79 | 0 | 0 | 7.71 | 0 | 7.7 | 0 | 7.73 |
| | Konz. | (in ng/ml) | 150.00 | 138.74 | 0.00 | 0.00 | 6.47 | 0.00 | 151.82 | 0.00 | 159.70 |
| | Tgt. | 373.30 | 100.0% | 66241 | 0 | 0 | 1508 | 0 | 27956 | 0 | 73220 |
| | Q1 / Tgt. | 236.10 | 49.5% | 49.7% | 0.0% | 0.0% | 58.2% | 0.0% | 47.6% | 0.0% | 47.9% |
| | Q2 / Tgt. | 282.20 | 27.0% | 27.0% | 0.0% | 0.0% | 41.5% | 0.0% | 27.2% | 0.0% | 26.2% |
| Morphin | Ret.-zeit | (in min.) | 9.39 | 9.46 | 0 | 9.41 | MI 9.36 | MI 9.35 | 0 | 9.43 | 9.39 |
| | Konz. | (in ng/ml) | 25.00 | 23.50 | 0.00 | 37.96 | 4.57 | 17.03 | 0.00 | 45.85 | 25.91 |
| | Tgt. | 429.30 | 100.0% | 4497 | 0 | 876 | 201 | 406 | 0 | 209 | 4893 |
| | Q1 / Tgt. | 196.20 | 148.5% | 148.6% | 0.0% | 168.6% | 0.0% | 0.0% | 0.0% | 167.7% | 162.2% |
| | Q2 / Tgt. | 401.30 | 27.0% | 26.9% | 0.0% | 35.5% | 0.0% | 0.0% | 0.0% | 52.2% | 28.9% |

# 6 Results

## 6.1 Samples Investigated

Since July 1st 1994, blood sampling has been regularly performed by the police in cases where drug influence was suspected, and these samples were accordingly sent in for testing. In total, 912 cases were analysed in the frame of the research project, and the findings evaluated from the various sources (blood test report, medical report and police report) including contraindications to driving and accident reports where applicable.

## 6.2 Sample Sources

The samples were sent in by the police stations under the jurisdiction of the Düsseldorf district authority. In the following table the senders, the number of cases per sender and the respective local population are summarised: 6

Table 5: Sample Sources

| Catchment area (sender of sample) | Population of catchment area | Number of blood samples | Blood samples per 100 000 inhabitants |
|---|---|---|---|
| Police HQ Essen | 622 380 | 166 | 27 |
| Police HQ Duisburg | 536 797 | 114 | 21 |
| Mettmann District Police | 506 262 | 112 | 22 |
| Motorway Police Stations | - | 95 | - |
| Police HQ Düsseldorf | 574 936 | 90 | 16 |
| Wesel District Police | 459 109 | 69 | 15 |
| Police HQ Wuppertal | 679 320 | 60 | 9 |
| Neuss District Police | 430 913 | 53 | 12 |
| Kleve District Police | 281 921 | 49 | 17 |
| Police HQ Krefeld | 249 565 | 32 | 13 |
| Viersen District Police | 282 091 | 31 | 11 |
| Police HQ Mönchengladbach | 265 312 | 17 | 6 |
| Police HQ Oberhausen | 226 025 | 8 | 4 |
| Police HQ Mülheim | 177 175 | 7 | 4 |
| Other | - | 9 | - |

## 6.3 Frequency of Intoxicant Detection

In 841 of the 912 cases (= 92.2 %), the consumption of intoxicants was detected. As the following table shows, 76 had consumed only alcohol, and 765 had consumed other intoxicants.

Table 6: Frequency of positive tests

| | Number | Percent |
|---|---|---|
| Negative | 71 | 7,8 |
| Only alcohol | 76 | 8,3 |
| Other intoxicants | 765 | 83,9 |
| Total number | 912 | 100 |

The next table shows the breakdown of the positive tests. As numerous test subjects also took more than one intoxicant, the sum of the positive tests amounts to 1 308, and to 1 620 when alcohol is included. Cannabis was the most frequent by a large margin, followed by the opiates.

Table 7: Frequency of other intoxicants consumed

| Drug/drug group | Number of positive tests | Amount in percent (765 = 100 %) |
|---|---|---|
| Cannabinoids | 515 | 67,3 |
| Opiates | 290 | 37,9 |
| Benzodiazepines | 214 | 28,0 |
| Cocaine | 203 | 26,5 |
| Amphetamines | 75 | 9,8 |
| LSD | 3 | 0,4 |
| Other intoxicants | 8 | 1,0 |

## 6.4 Main Event which led to Blood Sampling

Having been supplied with the documents from the police, we tried to find out the main event which led to further investigation of the driver in question. Evidently, it was often ascertained in the context of a routine check that a driver had possibly taken drugs. This shows that the training of police officers to be able to recognise drivers under the influence of drugs is very important.

Most frequently, though, drug impairment was recognised during the assessment at the scene of accidents. Table 8 shows a breakdown of the main events.

Table 8: Main events prompting further police investigation

| Main event | Number of cases | Percent |
|---|---|---|
| Accident | 281 | 30,8 |
| Routine check | 267 | 29,3 |
| Conspicuous driving | 176 | 19,3 |
| Traffic offence | 71 | 7,8 |
| Other | 117 | 12,8 |
| Total | 912 | 100 |

## 6.5 Accidents

281 of the 912 test subjects were involved in an accident. 86 left the scene of the accident unlawfully. Drawing on the documents made available to us, the accidents were divided into three groups of accident severity: Minor, serious and very serious (table 9).

Table 9: Number and category of accidents

| | Number | Percent |
|---|---|---|
| Minor accident | 174 | 61,9 |
| Serious accident | 91 | 32,4 |
| Very serious accident | 16 | 5,7 |

## 6.6 Conspicuous Driving / Traffic offences

In 364 cases, erratic driving or severe traffic offences were observed and noted in the files accordingly. Some of the points deemed relevant for the judgement of a driver being fit are summarised in table 10. By a large margin, the most frequent driving error in the group investigated was weaving (road tracking impairment). 6.6

Table 10: Conspicuous behaviour in road traffic (several choices may apply).

| Type | Number |
|---|---|
| Weaving | 153 |
| Leaving the road | 60 |
| Driving too fast | 54 |
| Failure to give way | 36 |
| Conspicuously slow speed | 25 |
| Other driving abnormalities | 83 |
| Misc. breaches of Traffic Regulation | 76 |

## 6.7 User Groups

The subjects can be divided into eight groups according to their consumption pattern. To the following, the criteria have been added which led to the allocation to one of the eight groups:

| | |
|---|---|
| Opiate users: | Consumption of opiates and possibly other additional intoxicating substances. |
| Heroin users: | Opiate user, who was proved to have used heroin or morphine (this is designed to exclude people who took opiates exclusively in the form of codeine or codeine-containing medication). |
| Cannabis users: | Only cannabis, and in some cases additional alcohol or centrally acting medication, but no heroin, cocaine or amphetamines / amphetamine derivatives were consumed. |
| Cocaine users: | No heroin, but cocaine and possibly other additional intoxicating substances were consumed. |
| Amphetamine users: | No heroin or cocaine were used. Only amphetamines or amphetamine derivatives (Ecstasy) and in some cases additional cannabis, alcohol or centrally acting medication were consumed. |
| LSD users | LSD was the only significant drug consumed. |
| Medication users: | No illegal drugs were consumed, only centrally acting medication and, in some cases, alcohol. |
| Alcohol users: | Apart from alcohol, no other intoxicant was consumed. |

If the 841 subjects who tested positive for intoxicating substances are categorised according to the 8 user groups above, the following scenario appears (table 11):

Table 11: Distribution of user groups.

| | Number | Percent |
|---|---|---|
| Opiat users | 290 | 34,5 |
| (of which heroin users) | (248) | (29,5) |
| Cannabis users | 303 | 36,0 |
| Cocaine users | 83 | 9,9 |
| Alcohol users | 76 | 9,0 |
| Amphetamine users | 56 | 6,7 |
| Medication users | 30 | 3,6 |
| LSD users | 3 | 0,3 |
| total | 841 | 100 |

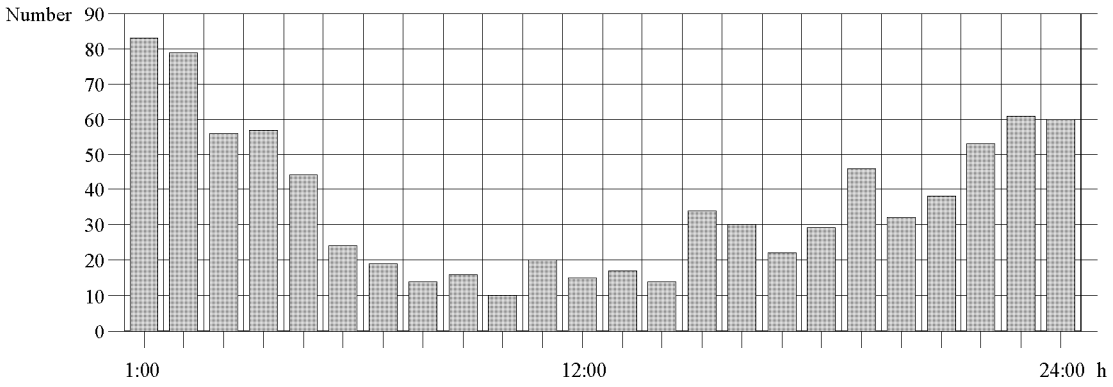
Thus, according to the figures, the opiate and cannabis users comprise the largest groups from all people tested.

## 6.8 Time of Day of Offences

Based on the whole group tested (see diagram 11), the time of the offences reached a maximum after midnight, and decreased continuously to a plateau between 8 a.m. and 2 p.m.. After this, the frequency of cases increases until midnight, displaying two maxima – one between 3 p.m. and 4 p.m., and then again just before 7 p.m.. These maxima after the end of the working day are known from other studies [68].

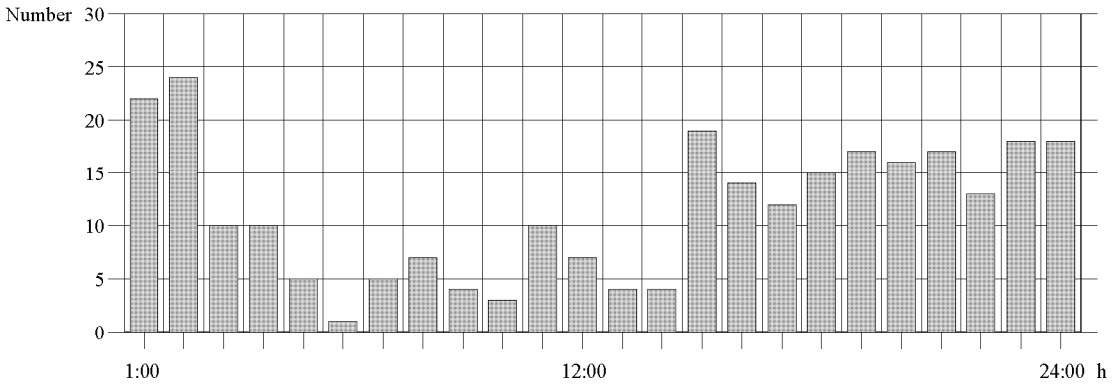
[68] Legat, St.: Alkoholbeeinflußte Verkehrsteilnahme im Bereich bayerischer Untermain. Blutalkohol 22 (1985) 272-289

Diagram 11: Distribution of the time of the offences based on the entire test group.




The time of the offence was habitually somewhat different for the opiate users (see diagram 12). Between 3:00 p.m. and midnight, the number of cases is on a constantly high level. They reach a maximum after midnight, but then the rate falls rapidly. It is evident that the opiate users can be detected on the road at all times of day and night in significant numbers and that, in contrast to alcohol and cannabis consumers, they do not show a clear preference for indulging in the evening hours. This particular behaviour of the opiate users, which can be seen in the relationship between the number and time of day of the registered cases, is explained by the distinctive physical and psychological dependence of heroin addicts. Very often, they can hold out for only several hours before requiring the next dose of heroin or substitute.

Diagram 12: Distribution of the offence times of opiate users




## 6.9 Age Structure and Distribution Between Sexes

It can be seen that the average age of the typical opiate user who is conspicuous in road traffic is 28 years, this being older than the rest of the consumer groups. The youngest are the "only cannabis" and the amphetamine/ecstasy consumers. The oldest group includes those people who were found to be under the influence of medication. At slightly over 10 percent, the proportion of women is on a relatively low level, which has been observed in other studies. The Federal

Criminal Investigation Agency[69] indicates the proportion of female suspects in drug offences as being 12 %; in illegal trading or smuggling of cannabis products, the proportion of women is only 7.4 %. In this study, the percentage of women in the group "only cannabis" consumers is even lower, returning a figure of 5.9 %, (see table 12).

Table 12: Age-sex distribution

| Consumer group | Number | Mean age (± SD) | Age range | Female proportion (%) |
|---|---|---|---|---|
| Opiate users | 290 | 28,0 (± 6,7) | 17 - 56 | 10,4 |
| Cannabis users | 303 | 24,5 (± 6,7) | 16 - 47 | 5,9 |
| Only cannabis | 167 | 22,9 (± 5,7) | 16 - 47 | 3,0 |
| Cocaine users | 83 | 26,5 (± 5,7) | 18 - 44 | 10,8 |
| Amphetamine users | 56 | 23,7 (± 6,6) | 17 - 49 | 12,5 |
| Alcohol consumers | 76 | 28,7 (± 8,9) | 16 - 55 | 17,3 |
| Other substances | 33 | 35,1 (±12,0) | 18 - 69 | 12,1 |
| Drug negative | 71 | 28,8 (± 9,6) | 14 - 57 | 16,9 |
| Total | 912 | 26,8 (± 7,7) | 14 - 69 | 10,2 |

## 6.10 User Type and Conspicuous Driving

### *6.10.1 User Type and Accidents*

We investigated whether or not the different user groups displayed a particular pattern of driving behaviour. Firstly, the accidents were reviewed (table 13). 6.10

[69] Federal Criminal Investigation Agency: „Rauschgiftjahresbericht Bundesrepublik Deutschland 1996“ (Annual Drug Report for the Federal Republic of Germany 1996), Federal Criminal Inverstigation Agency, Wiesbaden, pp.54-55.

Table 13: User / accident profile

| User group | Number in group | Number of minor accidents | Number of serious accidents | Number of very serious accidents |
|---|---|---|---|---|
| Opiate users | 290 | 50 | 37 | 2 |
| Cannabis users | 303 | 49 | 20 | 9 |
| Cocaine users | 83 | 13 | 12 | 0 |
| Alcohol consumers | 76 | 20 | 7 | 0 |
| Amphetamine users | 56 | 13 | 3 | 0 |
| Medication consumers | 30 | 14 | 7 | 2 |
| LSD users | 3 | 0 | 0 | 0 |
| Drug negative | 71 | 15 | 5 | 3 |
| Total | 912 | 174 | 91 | 16 |

It can be seen that the opiate user is most frequently involved in especially those accidents of a serious nature. Similarly remarkable is also the relatively high number of very serious accidents among the cannabis users.

### *6.10.2 User Type and Tendency to Leave the Scene of the Accident*

In total, 86 cases of someone leaving the scene of the accident were registered. The most frequent in absolute terms were the cannabis and opiate user groups, but proportionally, the amphetamine and ecstasy consumers returned the highest figures (table 14). These consumers did not appear as a separate group in the report on cannabis. This evaluation demonstrates that the amphetamine users and their road behaviour require special consideration.

Table 14: User type and tendency to leave the scene of the accident

| User group | Number in group | Number of cases | Proportion of total cases (%) | Frequency within group (%) |
|---|---|---|---|---|
| Opiate users | 290 | 25 | 29,1 | 8,6 |
| Cannabis users | 303 | 29 | 33,7 | 9,6 |
| Cocaine users | 83 | 5 | 5,8 | 6,0 |
| Alcohol consumers | 76 | 9 | 10,5 | 11,8 |
| Amphetamine users | 56 | 9 | 10,5 | 16,1 |
| Other substances | 33 | 5 | 5,8 | 15,2 |
| Drug negative | 71 | 4 | 4,7 | 5,6 |
| Total | 912 | 86 | 100 | 9,4 |

### *6.10.3 User Type and Driving Errors*

#### *6.10.3.1 Weaving*

The incidence of weaving (road tracking impairment) was found to be relatively equal across all groups (see table 15). In the group investigated here, it is interesting to note that weaving was below average for those drivers who had only consumed alcohol.

Table 15: User type and driving errors (weaving)

| User group | Number in group | Number of cases | Proportion of total cases (%) | Frequency within group (%) |
|---|---|---|---|---|
| Opiate users | 290 | 50 | 32,68 | 17,2 |
| Cannabis users | 303 | 50 | 32,68 | 16,5 |
| Cocaine users | 83 | 16 | 10,46 | 19,3 |
| Amphetamine users | 56 | 11 | 7,19 | 19,6 |
| Alcohol consumers | 76 | 9 | 5,88 | 11,8 |
| Other substances | 33 | 5 | 3,27 | 15,2 |
| Drug negative | 71 | 12 | 7,84 | 16,9 |
| Total | 912 | 153 | 100 | 16,8 |

*6.10.3.2 Speeding*

The test criterion "speeding" stands out due to the fact that those drivers who were caught exceeding the limit proved more often to be drug negative. From this it can be concluded that the police officers who observe this behaviour believe that the drivers' inhibitions have possibly been lowered by taking drugs. The justification for this supposition can be seen in the higher incidence of speeding especially amongst the cannabis and cocaine users. Remarkably, the amphetamine users evidently do not tend to speed.

Table 16: User Type and "Speeding"

| User group | Number in group | Number of cases | Proportion of total cases (%) | Frequency within group (%) |
|---|---|---|---|---|
| Opiate users | 290 | 15 | 27,7 | 5,2 |
| Cannabis users | 303 | 21 | 38,9 | 6,9 |
| Cocaine users | 83 | 8 | 14,8 | 9,6 |
| Amphetamine users | 56 | 0 | 0 | 0 |
| Alcohol consumer | 76 | 3 | 5,6 | 3,9 |
| Other substances | 33 | 0 | 0 | 0 |
| Drug negative | 71 | 7 | 13,0 | 9,9 |
| Total | 912 | 54 | 100 | 5,9 |

*6.10.3.3 Failure to Give Way*

Similarly to speeding, we found an increased frequency in the drug negative group (see table 17). Presumably, the police officers also suspected impairment by intoxicants in these cases. The number, however, is very small. It can be assumed that the number of unrecorded cases is extremely high. Clear differences between the groups can not be found.

Table 17: User type and failure to give way (red light, stop sign)

| User group | Number in group | Number of cases | Proportion of total cases (%) | Frequency within group (%) |
|---|---|---|---|---|
| Opiate users | 290 | 11 | 30,6 | 3,8 |
| Cannabis users | 303 | 10 | 27,7 | 3,3 |
| Cocaine users | 83 | 2 | 5,6 | 2,4 |
| Amphetamine users | 56 | 3 | 8,3 | 5,4 |
| Alcohol consumer | 76 | 2 | 5,6 | 2,6 |
| Other substances | 33 | 1 | 2,8 | 3,0 |
| Drug negative | 71 | 7 | 19,4 | 9,9 |
| Total | 912 | 36 | 100 | 3,9 |

### *6.10.3.4 Incidence of the Vehicle Leaving the Road*

The last test criterion was chosen to be those drivers who left the road. Here, there was no differentiation between the vehicle having veered off to the left or right hand side. Evaluation of the accident statistics for 1994 within the Düsseldorf district authority revealed that drivers under the influence of alcohol were very conspicuous in their tendency to leave the road (see appendix 6). In the group examined here, the documents supplied indicated in 60 cases that the vehicle had left the road (table 18). 6.10.3.4

Table 18: User type and incidence of leaving the road

| User group | Number in group | Number of cases | Proportion of total cases (%) | Frequency within group (%) |
|---|---|---|---|---|
| Opiate users | 290 | 10 | 16,7 | 3,4 |
| Cannabis users | 303 | 20 | 33,4 | 6,6 |
| Cocaine users | 83 | 11 | 18,3 | 13,3 |
| Amphetamine users | 56 | 2 | 3,3 | 3,6 |
| Alcohol consumers | 76 | 8 | 13,3 | 10,5 |
| Other substances | 33 | 3 | 5,0 | 9,1 |
| Drug negative | 71 | 6 | 10,0 | 8,5 |
| Total | 912 | 60 | 100 | 6,6 |

## 6.11 Summary

Surveys and statistical investigations have shown repeatedly, that relatively speaking, there are much fewer heroin consumers than, for example, consumers of cannabis, cocaine or of other stimulants such as amphetamines or ecstasy. As has already been quoted in this report, in a survey, 95.4 % of the 14 to 25-year-old narcotic consumers admitted that they were currently also consuming cannabis, and 4.5 % admitted that the narcotic they used was heroin. If one selects the regular (chronic) adult users, then the projected number for Germany of those who consume cannabis at least once a week (n = 420 000) or once daily (n = 240 000) exceeds the number of "heavy" heroin users (n = 100 000) by the factor 2.4 to 4.2[70]. Thus, there are significantly more people who consume cannabis than people who consume heroin. In spite of this, the number of opiate users caught by the police whilst in charge of a motor vehicle is almost as high as the number of cannabis consumers caught. The opiate users clearly outweigh the cannabis consumers in the accident statistics. Unequivocally, these findings demonstrate the danger posed by drivers under the influence of opiates. 6.11

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[70] Bundeszentrale für gesundheitliche Aufklärung: Die Drogenaffinität Jugendlicher in der Bunderrepublik Deutschland. Wiederholungsbefragung -1993/1994-, Referat 25, Köln, Dezember 1994, pp. 51-52. Herbst, K., Kraus, L. und Scherer, K.: Repräsentativerhebung zum Gebrauch psychoaktiver Substanzen bei Erwachsenen in Deutschland. Institut für Therapieforschung, München, 1996, pp. 42

# 7 The Heroin User

One of the main targets of this inquiry was to ascertain whether it is possible to draw conclusions about people being fit to drive according to §§ 315 c and 316 StGB (German penal code) solely on the basis of a blood test.

The inquiry "Cannabis in Road Traffic" was successful in presenting a larger number of cases in which the consumption of cannabis alone had led to conspicuous driving behaviour. Evaluation of the data from this group showed that with cannabis, a relationship exists between the magnitude of the CIF (Cannabis Influence Factor) derived from blood analysis, and the induced medical / driving deficiency symptoms observed. Correspondingly, this inquiry ("Heroin in Road Traffic") should investigate the deficiency symptoms displayed by heroin users in a similar way, and show which relevance the simultaneous consumption of other intoxicants has on this group.

## 7.1 Concerning Drug Combination (Poly-drug use)

It is a known phenomenon that heroin consumers simultaneously consume—sometimes in huge amounts—other narcotics, hypnotics (soporifics), analgesics and alcohol. There are various reasons for this. In the majority of the cases, other drugs are taken to bridge the gap between doses of heroin, for suppression of withdrawal symptoms, for the treatment of insomnia and states of panic and, in the case of cocaine, for enhancement of the exhilaration experienced and also for (occasionally) counteracting the depressive effects of other substances simultaneously consumed.

The absolute number of cases where only heroin / morphine was consumed came to 28; this corresponds to a proportion of only 9.7 % based on the group of opiate users. As this number is so small, we can safely assume that poly-drug use is the norm for heroin users.

Table 19 shows the substances additionally consumed by the group investigated.

Table 19: The various combinations of opiates and other intoxicants among opiate users, omitting the cases where only heroin / morphine was consumed (n = 262).

| Combinations of ..... in addition to at least | Amphetamines | Benzodiazepines | Cocaine | Cannabis (CIF = 0) | Cannabis (CIF = 1 - 9) | Cannabis (CIF ≥ 10) | Alcohol (BAK bis 0.49 ‰) | Alcohol (BAK 0.5 bis 1.09 ‰) | Alcohol (BAK ≥ 1.10 ‰) |
|---|---|---|---|---|---|---|---|---|---|
| Opiates (= op) + | 8 | 137 | 119 | 72 | 21 | 33 | 15 | 39 | 13 |
| Op + alcohol + amphetamines + | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| Op + alcohol + benzodiazepines + | 1 | 30 | 7 | 6 | 3 | 4 | 7 | 19 | 4 |
| Op + alcohol + cannabis + | 1 | 13 | 6 | 13 | 4 | 9 | 5 | 14 | 7 |
| Op + alcohol + cocain + | 0 | 7 | 11 | 3 | 2 | 1 | 3 | 6 | 2 |
| Op + amphetamines + benzodiazepines + | 6 | 6 | 0 | 2 | 2 | 1 | 0 | 1 | 0 |
| Op + amphetamines + cannabis + | 6 | 5 | 0 | 2 | 2 | 2 | 0 | 1 | 0 |
| Op + amphetamines + cocaine + | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Op + benzodiazepines + cannabis + | 5 | 58 | 23 | 33 | 11 | 14 | 1 | 10 | 1 |
| Op + benzodiazepines + cocaine + | 0 | 51 | 51 | 15 | 5 | 3 | 2 | 4 | 1 |
| Op + cannabis + cocaine + | 0 | 23 | 52 | 37 | 9 | 6 | 0 | 4 | 2 |

No preference can be recognised. The combination op + benzodiazepines + cannabis occurred particularly often (58 times), and also op + benzodiazepines + cocaine (51 times). The latter was additionally accompanied by cannabis in 23 cases (see combination op + benzodiazepines + cannabis + cocaine = 23). The term "benzodiazepines" includes a great many active substances contained in medication, such as Diazepam (e.g. contained in Valium®), Flunitrazepam (e.g. contained in Rohypnol®) or Bromazepam (e.g. contained in Lexotanil®), to name only the most commonly used substances quoted by heroin users. Differentiation of the single benzodiazepines would have split once again the total number of combinations. However, it can generally be said that the benzodiazepines enhance the effect of the opiates as central nervous system depressants, irrespective of the individual. Thus it seemed justified to quote them as one group of substances.

The opiates, however, must also be differentiated between as stemming from the consumption of heroin / morphine on the one hand, and from codeine- or dihydrocodeine-containing medication on the other. All blood samples were analysed accordingly. In 37 of the 290 positive samples it was proved that heroin consumption had not taken place, but instead a dose of dihydrocodeine or

codeine had produced the positive result. In a further 5 cases, not enough sample was available to be able to differentiate between the individual opiates. These 48 cases were subsequently omitted from the inquiry, as the target of the study is to objectify the dangers arising from the use of heroin by road traffic participants. All remaining 248 cases were then classified as heroin users, bearing in mind that one can not conclude that a positive test for the heroin metabolite morphine has arisen through the consumption of heroin or from the consumption of morphine. However, experience has shown that the number of drivers whose driving fitness impairment was due to taking morphine-containing painkillers is negligible. Not one such case has been registered at the Institute of Forensic Medicine, Düsseldorf.

A further cause for the detection of morphine in blood is the taking of codeine-containing medicine. In these cases, either the amount of codeine detected in relation to the amount of morphine is high, or, if a considerable time period has elapsed since the drug was taken, so little free morphine is present that detection is almost impossible. In isolated cases therefore, distinguishing clearly between [recent] consumption of small amounts of heroin and consumption of codeine in the semi-recent past is not possible by blood testing alone. Thus it cannot be ruled out that the test group includes sporadic cases where the positive test actually resulted from the subject having taken codeine, and not heroin.

## 8 Morphine Concentration in Blood and Conspicuous Behaviour

To gain knowledge concerning the relationship between the morphine concentration found in the blood sample and the corresponding conspicuous behaviour or driving error[71] ascertained by the police or physician who took the sample, four morphine concentration ranges were chosen, and the influence of the substances taken in addition to morphine were taken into account. Table 20 shows the frequency of occurrence of the various substances detected in the blood sample.

Table 20: Number of cases where the action of heroin / morphine was strongly influenced by the additional consumption of other substances[72]

| Substance additionally found: | Free morphine concentration in blood | | | |
|---|---|---|---|---|
| | < 10 ng/mL n = 62 | 10 - 19,9 ng/mL n = 62 | 20 - 49,9 ng/mL n = 73 | ≥ 50 ng/mL n = 51 |
| Cocaine (BZE ≥ 100 ng/mL) | 19 | 23 | 26 | 19 |
| Alcohol (BAK ≥ 0.30 ‰) | 9 | 6 | 8 | 2 |
| Alcohol (BAK ≥ 1.10 ‰) | 3 | 2 | 1 | 1 |
| Benzodiazepines | 26 | 27 | 33 | 25 |
| Dihydrocodeine/codeine > 100 ng/mL | 9 | 5 | 10 | 8 |
| Cannabis (CIF ≥ 10) | 12 | 7 | 6 | 3 |
| Regular cannabis consumption (SCK > 150) | 5 | 6 | 3 | 6 |
| Amphetamines | 2 | 0 | 2 | 1 |
| No or very slight additional consumption | 13 | 14 | 13 | 11 |

It is shown, that in 51 cases only very slight poly-drug use had taken place, thus the deficiency symptoms found can be completely attributed to the effect of heroin. In 25 cases, relevant alcoholic intoxication with BAC values equal to or above 0.30 ‰ was found; in 7 cases the BAC was, at 1.10 ‰, over the normal absolute limit for being unfit to drive. 28 heroin users had additionally consumed so much cannabis, that their CIF was equal to or above 10, this value often being high enough for "only cannabis" consumers to become conspicuous through driving errors. 20 of the heroin users seemed also to be regular cannabis consumers. 87 had, in addition to heroin, taken such large doses of cocaine, that the cocaine derivative BZE was present in blood in clearly

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71 See also appendix 8.

72 BZE = benzoylecgonine; CIF = Cannabis Influence Factor (see report from study „Cannabis im Straßenverkehr“ (Cannabis in Road Traffic); SCK = Serum Cannabinoid Concentration (cannabinoids determined via immunoassay, particularly THC-COOH and THC-COOH-glucuronide).

measurable concentrations of 100 ng/mL or more. Numerous cases demonstrated the simultaneous consumption of benzodiazepines and larger amounts of cocaine or dihydrocodeine.

The number of cases where alcohol (BAC 1.10 ‰) and cannabis (CIF 10) were also consumed decreases with increasing blood morphine concentration. This trend was not found among the other substances.

## 8.1 Relationship between the Morphine Concentration and Conspicuous Driving Behaviour

In table 21, the various driving errors and several typical traffic offences are quoted. Their frequency is shown in relation to the morphine concentration.

Table 21: Frequency of conspicuous driving depending on the blood morphine concentration of heroin users (n = 248)

| | Free morphine concentration in blood (ng/mL) | | | |
|---|---|---|---|---|
| Total number of cases of conspicuous driving: | < 10<br>n = 37<br>(100 %) | 10 - 19,9<br>n = 31<br>(100 %) | 20 - 49,9<br>n = 43<br>(100 %) | ≥ 50<br>n = 27<br>(100 %) |
| Type of driving error / conspicuous behaviour | | | | |
| Accident | 22 (59,5 %) | 20 (64,5 %) | 21 (48,8 %) | 12 (44,4 %) |
| Minor accident | 15 (40,5 %) | 11 (35,5 %) | 10 (23,2 %) | 5 (18,5 %) |
| Serious accidentl | 7 (18,9 %) | 9 (29,0 %) | 10 (23,2 %) | 6 (22,2 %) |
| Very serious accident | 0 (0 %) | 0 (0 %) | 1 (2,3 %) | 1 (3,7 %) |
| Leaving the scene of the accident | 6 (16,2 %) | 6 (19,4 %) | 5 (11,6 %) | 2 (7,4 %) |
| Vehicle leaving the road | 1 (2,7 %) | 0 (0 %) | 4 (9,3 %) | 2 (7,4 %) |
| Weaving | 10 (10 %) | 10 (32,3 %) | 15 (34,9 %) | 7 (25,9 %) |
| Failure to stop at a red light | 1 (2,7 %) | 3 (9,7 %) | 3 (7,0 %) | 0 (0 %) |
| Ignoring a stop sign | 1 (2,7 %) | 0 (0 %) | 1 (2,3 %) | 0 (0 %) |
| Excessive speed | 6 (16,2 %) | 2 (6,5 %) | 4 (9,3 %) | 1 (3,7 %) |
| Conspicuously slow speed | 1 (2,7 %) | 2 (6,5 %) | 1 (2,3 %) | 0 (0 %) |
| Miscellaneous driving irregularities | 5 (13,5 %) | 5 (16,1 %) | 4 (9,3 %) | 5 (18,5 %) |
| Miscellaneous traffic offences | 4 (10,8 %) | 3 (9,7 %) | 5 (11,6 %) | 4 (14,8 %) |

It can be seen that, in terms of numbers, the heroin users attracted the police's attention the most frequently by way of accidents, followed by weaving. A clear tendency of percent increase of the cases with increasing morphine concentration cannot be seen. Only when the highest concentration class is bracketed out can a possible tendency be interpreted, for example going across the table in "weaving", "serious accidents" and "leaving the road". At high morphine concentrations, however, proportionally more serious and very serious accidents are observed. The ratio of the serious/ very serious accidents to the minor accidents increases continuously from 7/15 = 0.47 at morphine concentrations under 10 ng/mL, up to 7/5 = 1.4 at morphine concentrations above 50 ng/mL.

## 8.2 Relationship between Poly-drug use, Morphine Concentration and Behavioural Irregularities

Based on the [nature of the] poly-drug use ascertained for each individual, it was judged as to whether this had a stimulating or rather a depressive effect on the central nervous system, or if the substances had even cancelled out each other's effect (e.g. when high doses of cocaine are accompanied by soporific drugs or sedatives). This additional differentiation divides the heroin users into 4 subgroups:

- heroin and additional stimulant
- heroin and additional depressant and stimulant
- heroin and additional depressant
- no poly-drug use

In terms of numbers, the heroin users' distribution among the 4 subgroups is shown in table 22:

Table 22: Poly-drug use habits of the heroin users (n = 248)

| Additional influence | Number | Percent |
|---|---|---|
| By stimulants | 42 | 16,9 % |
| By stimulants and CNS depressants | 45 | 18,1 % |
| By CNS depressants | 110 | 44,4 % |
| No or negligible poly-drug use | 51 | 20,6 % |

At the time the blood sample was taken, the majority were under the influence of central nervous system depressants.

In the following section, the frequency of each single driving error or incidence of conspicuous driving is shown separately for each subgroup, in relation to the morphine concentration.

### *8.2.1 Conspicuous driving of heroin users under the additional influence of CNS stimulants*

Drivers under the influence of heroin and stimulants who displayed conspicuous driving tendencies are rather under-represented in the group examined. A possible cause is that the mutual cancelling out of effects leads to less driving errors or, more probably, that the consumption of these intoxicants does not lead to easily recognisable deficiency symptoms, thereby precluding the justification for taking a blood sample.

Evaluation of the few data concerning accidents and weaving shows the prevalence of these two tendencies at morphine concentrations above 10 – 20 ng/mL. It can however be expected, that more than 26 % of the drivers who have taken this combination of drugs already display driving irregularities at concentrations under 10 ng/mL (see in-depth explanation of 26 % value in appendix 6).

Table 23: Frequency of driving errors and conspicuous behaviour of heroin users (n = 42) who had also consumed predominantly central nervous system stimulants.

| Type of driving error / conspicuous behaviour | Free morphine concentration in blood (ng/mL) | | | |
|---|---|---|---|---|
| | < 10 | 10 - 19,9 | 20 - 49,9 | ≥ 50 |
| Accident | 2 | 0 | 3 | 1 |
| Minor accident | 2 | 0 | 2 | 0 |
| Serious accident | 0 | 0 | 1 | 0 |
| Very serious accident | 0 | 0 | 0 | 1 |
| Leaving the scene of the accident | 1 | 0 | 1 | 0 |
| Vehicle leaving the road | 0 | 0 | 0 | 0 |
| Weaving | 0 | 4 | 1 | 1 |
| Failure to stop at a red light | 0 | 0 | 1 | 0 |
| Ignoring a stop sign | 0 | 0 | 0 | 0 |
| Excessive speed | 0 | 0 | 1 | 0 |
| Conspicuously slow speed | 0 | 1 | 0 | 0 |
| Miscellaneous driving irregularities | 1 | 0 | 0 | 0 |
| Miscellaneous traffic offences | 0 | 0 | 2 | 1 |

Diagram 13: Accident frequency of heroin users under additional influence of **central nervous system stimulants** in relation to the free morphine concentration in blood. Cumulative frequency and 26 % value

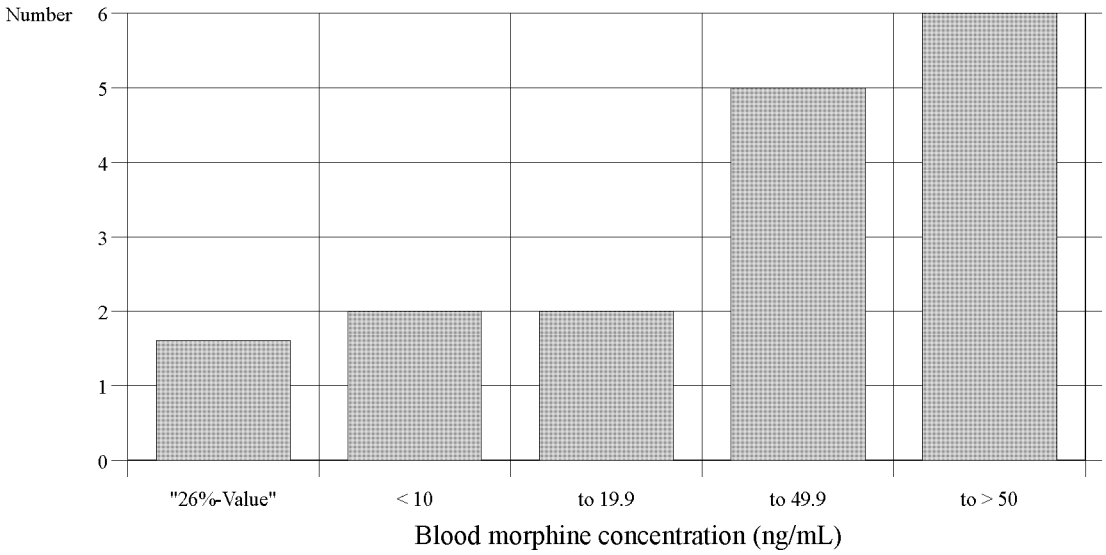
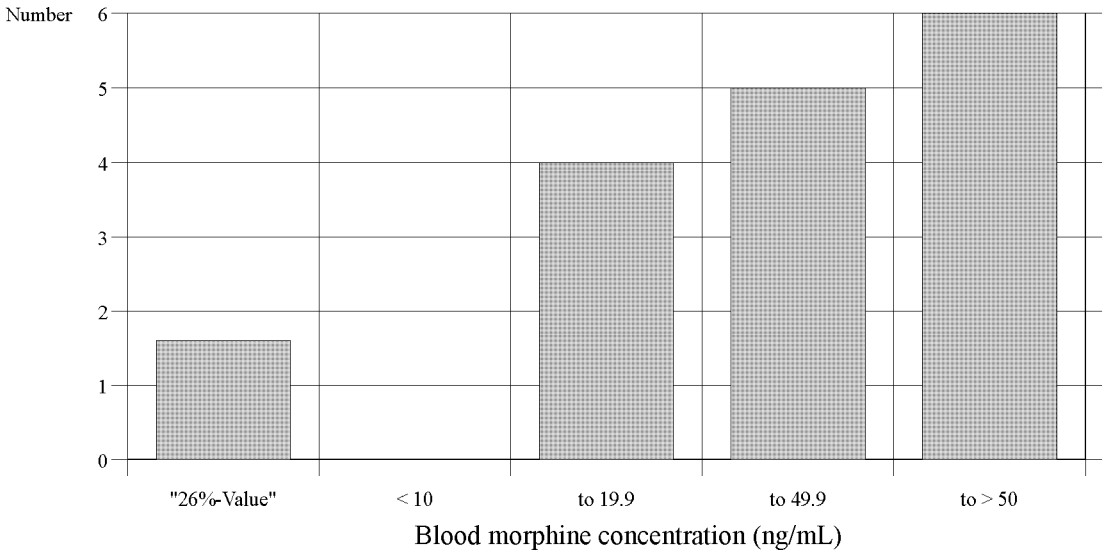



Diagram 14: Frequency of weaving among heroin users under additional influence of **central nervous system stimulants** in relation to the free morphine concentration in blood. Cumulative frequency and 26 % value




### *8.2.2 Conspicuous driving of heroin users under the additional influence of CNS depressants and CNS stimulants*

In this group it is striking how many serious accidents occur even at relatively low morphine concentrations, accompanied by only a small number of cases where weaving was observed (4 in total).

The enhancement of the depressive effect on the central nervous system by other intoxicants, and the attempt to compensate this by the action of a stimulant—especially by

cocaine—constitutes quite obviously a great risk. The effect resulting from this interaction is unpredictable, as the substances undergo change independently of each other in the body, and especially as the effect of the stimulants decreases more rapidly than that of the depressants. Through this, the state of the consumer can suddenly change from being alert in one instance to being oblivious in the next, with obvious results if he is driving a motor vehicle at the time. This explains the high number of serious accidents. This is why especially the item "accident" returns an expectedly low 26 % figure: it is lower than 10 ng/mL morphine.

Table 24: Frequency of driving errors and conspicuous behaviour of heroin users (n = 45) who had also consumed predominantly **central nervous system depressants and stimulants**.

| Type of driving error / conspicuous behaviour | Free morphine concentration in blood (ng/mL) | | | |
|---|---|---|---|---|
| | < 10 | 10 - 19,9 | 20 - 49,9 | ≥ 50 |
| Accident | 5 | 4 | 4 | 1 |
| Minor accident | 2 | 2 | 2 | 0 |
| Serious accident | 3 | 2 | 2 | 1 |
| Very serious accident | 0 | 0 | 0 | 0 |
| Leaving the scene of the accident | 0 | 1 | 2 | 0 |
| Vehicle leaving the road | 1 | 0 | 1 | 0 |
| Weaving | 1 | 2 | 0 | 1 |
| Failure to stop at a red light | 0 | 0 | 1 | 0 |
| Ignoring a stop sign | 0 | 0 | 0 | 0 |
| Excessive speed | 0 | 0 | 1 | 0 |
| Conspicuously slow speed | 0 | 0 | 0 | 0 |
| Miscellaneous driving irregularities | 1 | 1 | 1 | 3 |
| Miscellaneous traffic offences | 0 | 0 | 0 | 0 |

Diagram 15: Frequency of accidents among heroin users under additional influence of **central nervous system depressants and stimulants** in relation to the free morphine concentration in blood. Cumulative frequency and 26 % value

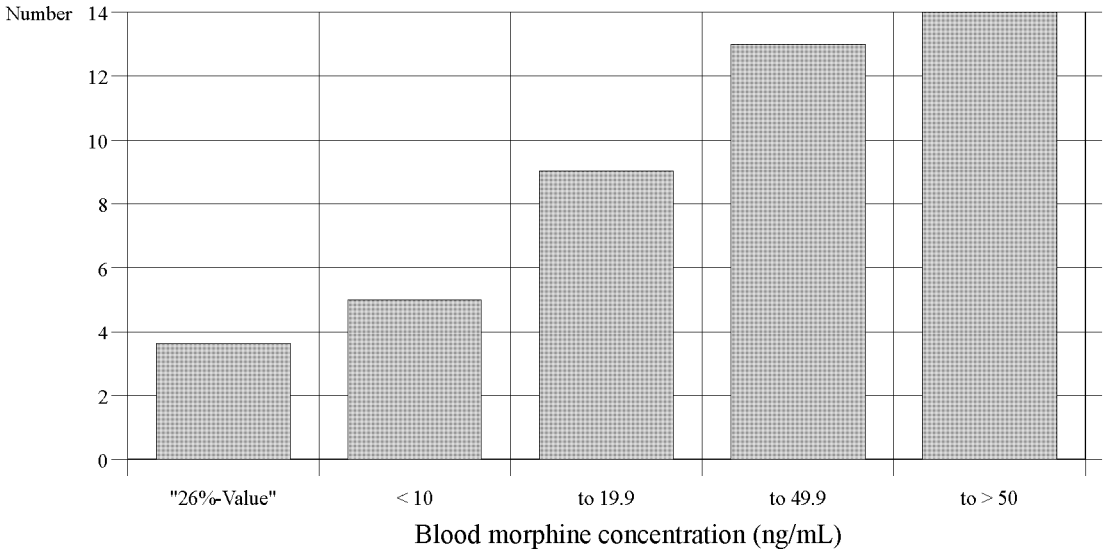
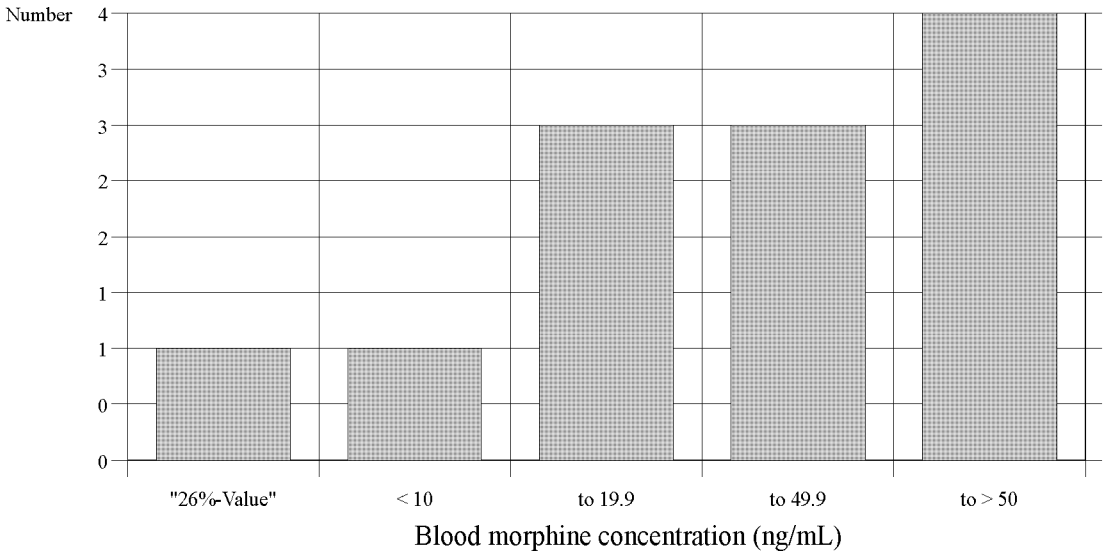



Diagram 16: Frequency of weaving among heroin users under additional influence of **central nervous system depressants and stimulants** in relation to the free morphine concentration in blood. Cumulative frequency and 26 % value



### *8.2.3 Conspicuous driving of heroin users under the additional influence of CNS depressants*

The most frequently conspicuous species on the road by far were the heroin users who had combined heroin with one or more CNS depressant. 45 of the 75 heroin users who had been involved in an accident were found to have partaken in drug cocktails. This corresponds to 60 %. This was also found to occur frequently in the item "weaving". Here, a particularly high number of cases was found with morphine concentrations between 20 and 50 ng/mL. The cumulative frequency shows the 26 % value to be under and just over 10 ng/mL respectively.

Table 25: Frequency of driving errors and conspicuous behaviour of heroin users (n = 110) who had also consumed predominantly **central nervous system depressants**.

| Type of driving error / conspicuous behaviour | Free morphine concentration in blood (ng/mL) | | | |
|---|---|---|---|---|
| | < 10 | 10 - 19,9 | 20 - 49,9 | ≥ 50 |
| Accident | 12 | 12 | 11 | 10 |
| Minor accident | 8 | 6 | 5 | 5 |
| Serious accident | 4 | 6 | 5 | 5 |
| Very serious accident | 0 | 0 | 1 | 0 |
| Leaving the scene of the accident | 3 | 2 | 2 | 2 |
| Vehicle leaving the road | 0 | 0 | 1 | 2 |
| Weaving | 5 | 3 | 13 | 1 |
| Failure to stop at a red light | 1 | 2 | 1 | 0 |
| Ignoring a stop sign | 0 | 0 | 1 | 0 |
| Excessive speed | 1 | 0 | 2 | 0 |
| Conspicuously slow speed | 1 | 1 | 1 | 0 |
| Miscellaneous driving irregularities | 3 | 2 | 2 | 2 |
| Miscellaneous traffic offences | 2 | 1 | 2 | 1 |

Diagram 17: Frequency of accidents among heroin users under additional influence of **central nervous system depressants** in relation to the free morphine concentration in blood. Cumulative frequency and 26 % value

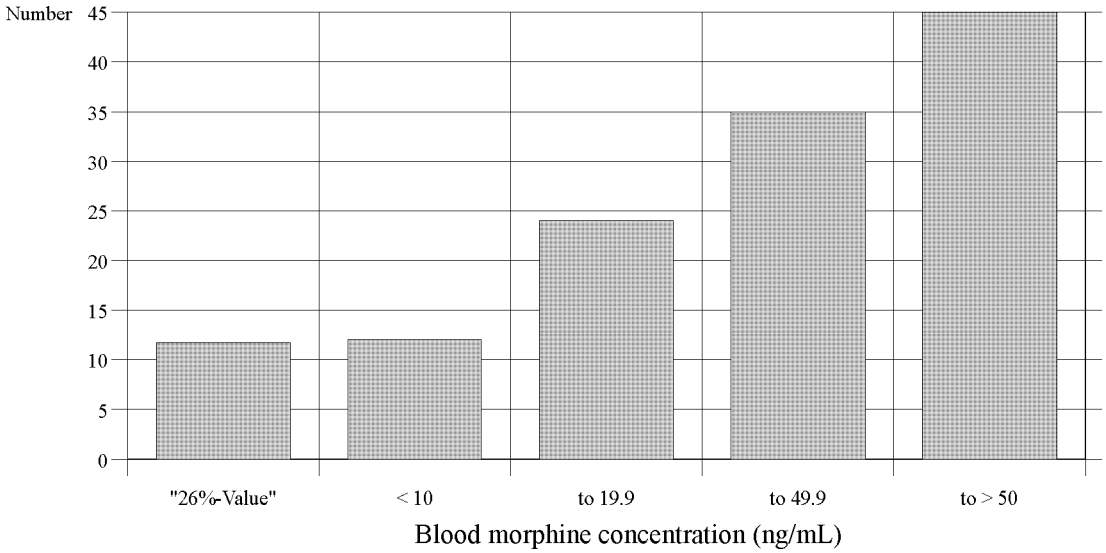
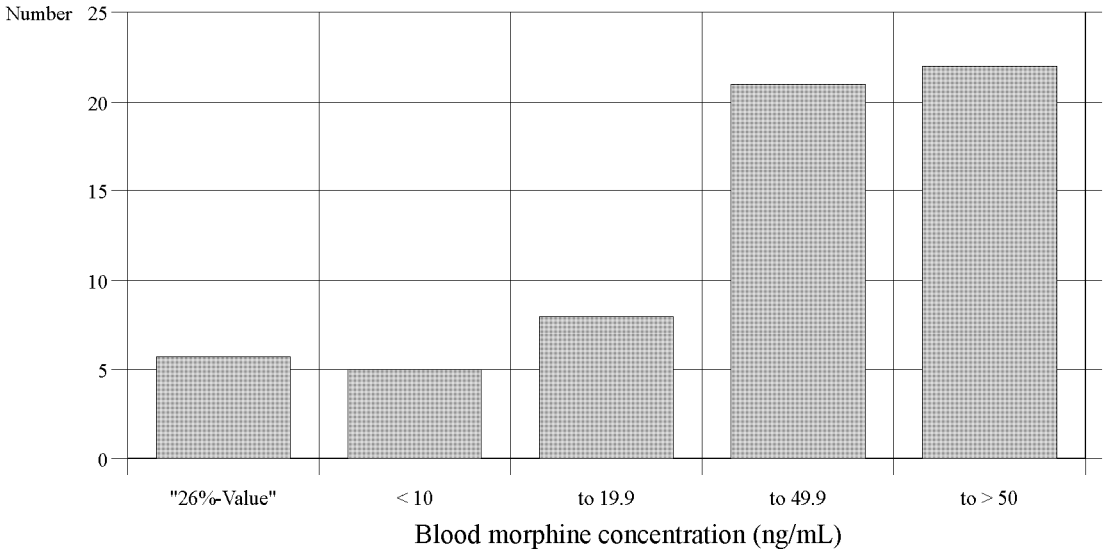



Diagram 18: Frequency of weaving among heroin users under additional influence of **central nervous system depressants** in relation to the free morphine concentration in blood. Cumulative frequency and 26 % value



### *8.2.4 Conspicuous driving of heroin users who were shown to have no discernible additional impairment by other intoxicants*

A total of 51 heroin users were shown to have consumed no other intoxicants besides heroin (or the amount was so low, or the time of consumption was so long ago), that it can be assumed that no significant effect was superimposed on that of heroin. The high occurrence of accidents or weaving at morphine concentrations below 10 ng/mL is remarkable. The 26 % values are also correspondingly low, these also being under 10 ng/mL. Also striking is that in comparison to the three other groups, the item "speeding" is most frequent in this group (8 of the 13 total entries = 61.5 %). It can be assumed that the group contains the "occasional" users—those who have not yet reached a high level of addiction—so that possibly the euphoric, fear-reducing effect of the heroin still predominates. This would explain why no poly-drug use has taken place, and why speeding was frequently observed. 8.2.4

Table 26: Frequency of driving errors and conspicuous behaviour of heroin users (n = 51) who showed **no (or negligible) poly-drug use**

| Type of driving error / conspicuous behaviour | Free morphine concentration in blood (ng/mL) | | | |
|---|---|---|---|---|
| | < 10 | 10 - 19,9 | 20 - 49,9 | ≥ 50 |
| Accident | 3 | 4 | 3 | 0 |
| Minor accident | 3 | 3 | 1 | 0 |
| Serious accident | 0 | 1 | 2 | 0 |
| Very serious accident | 0 | 0 | 0 | 0 |
| Leaving the scene of the accident | 2 | 3 | 0 | 0 |
| Vehicle leaving the road | 0 | 0 | 2 | 0 |
| Weaving | 4 | 1 | 1 | 4 |
| Failure to stop at a red light | 0 | 1 | 0 | 0 |
| Ignoring a stop sign | 1 | 0 | 0 | 0 |
| Excessive speed | 5 | 2 | 0 | 1 |
| Conspicuously slow speed | 0 | 0 | 0 | 0 |
| Miscellaneous driving irregularities | 0 | 2 | 1 | 0 |
| Miscellaneous traffic offences | 1 | 2 | 1 | 2 |

Diagram 19: Frequency of accidents among heroin users who showed **no (or negligible) poly-drug use**, in relation to the free morphine concentration in blood. Cumulative frequency and 26 % value

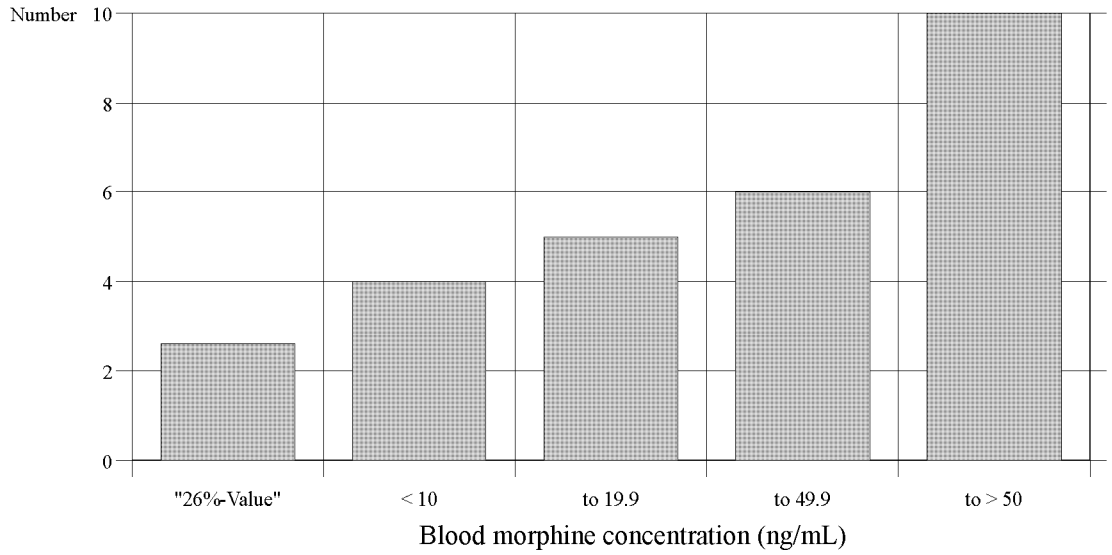
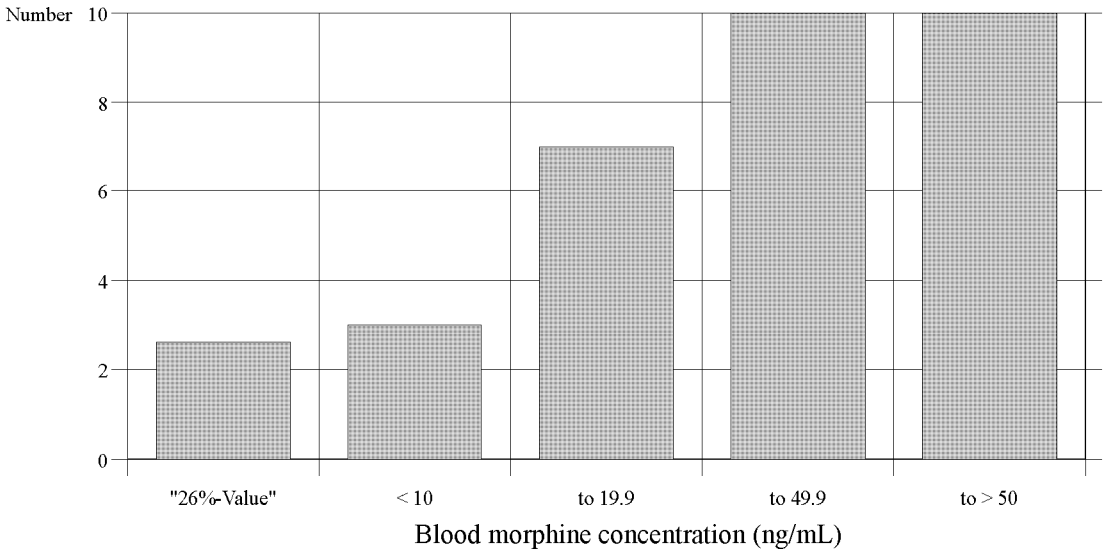



Diagram 20: Frequency of weaving among heroin users who showed **no (or negligible) poly-drug use**, in relation to the free morphine concentration in blood. Cumulative frequency and 26 % value



## 8.3 Relative Frequency of Driving Errors or Conspicuous Behaviour in Road Traffic Depending on the Type of Intoxicants Simultaneously consumed

Table 27 shows the impact on road safety posed by the additionally consumed intoxicants alone. The absolute figures prove, as already shown in the previous chapters, that those heroin users who have also consumed CNS depressants are the most conspicuous species due to their representation in the most diverse traffic offences. It is also possible, however, that the majority of the heroin users prefer this combination anyway, so that the high number of cases found is due to this, and not due to the fact that this combination leads to the most incidences of conspicuous behaviour. The relative frequency, calculated for each single group from the total number and the number of single cases shows clearly, however, that this combination actually stands out in a negative sense among the accidents. In 41 % of the cases (relative frequency 0.41), this combination led to an accident, and even 31 % of the cases where the combination heroin - stimulants - CNS depressants was used led to an accident. Weaving was also observed in these two groups (relative frequency 0.2).

The heroin users noticed least in road traffic are those who have additionally only consumed stimulants (cocaine). The number of cases here is clearly even lower than the number of cases where only heroin was consumed, although this combination is particularly popular. There are two possible explanations for this: 1) The effects of tiredness produced by the heroin are cancelled out by the cocaine, and 2) The cocaine makes the typical heroin-typical symptoms—such as constricted pupils—disappear, rendering the investigating police officer unable to ascertain whether or not the driver has taken drugs.

Also clearly to be seen in the table is the relative frequency of speeding among the "only heroin" users (relative frequency 0.16).

Table 27: Relationship between conspicuous driving behaviour and nature of poly-drug use. Absolute values and relative frequency (in brackets).

| Type of driving error / conspicuous behaviour | No or only negligible poly-drug use (n = 51) | Additional influence from stimulants (n = 42) | Additional influence from stimulants and CNS depressants (n = 45) | Additional influence from CNS depressants (n = 110) |
|---|---|---|---|---|
| Accident | 10 (0,20) | 6 (0,14) | 14 (0,31) | 45 (0,41) |
| Minor accident | 7 (0,14) | 4 (0,10) | 6 (0,13) | 24 (0,22) |
| Serious accident | 3 (0,06) | 1 (0,02) | 8 (0,18) | 20 (0,18) |
| Very serious accident | 0 (0,00) | 1 (0,02) | 0 (0,00) | 1 (0,01) |
| Leaving the scene of the accident | 5 (0,10) | 2 (0,05) | 3 (0,07) | 9 (0,08) |
| Vehicle leaving the road | 2 (0,04) | 0 (0,00) | 2 (0,04) | 3 (0,03) |
| Weaving | 10 (0,20) | 6 (0,14) | 4 (0,09) | 22 (0,20) |
| Failure to stop at a red light | 1 (0,02) | 1 (0,02) | 1 (0,02) | 4 (0,04) |
| Ignoring a stop sign | 1 (0,02) | 0 (0,00) | 0 (0,00) | 1 (0,01) |
| Excessive speed | 8 (0,16) | 1 (0,02) | 1 (0,02) | 3 (0,03) |
| Conspicuously slow speed | 0 (0,00) | 1 (0,02) | 0 (0,00) | 3 (0,03) |
| Miscellaneous driving irregularities | 3 (0,06) | 1 (0,02) | 6 (0,13) | 9 (0,08) |
| Miscellaneous traffic offences | 1 (0,02) | 2 (0,05) | 1 (0,02) | 3 (0,03) |

## 8.4 Comparison of the Heroin Users' Deficiency Symptoms observed by the Police and Physician taking the Blood Sample

One of the highlights of the inquiry was that, not only the physician taking the blood sample noted the observed behaviour of the subject, but also that the observations of the police officer attending the case were recorded. The police officer has at his disposal only limited diagnostic resources, but has also the advantage of seeing the subject before the physician, so that the deficiency symptoms produced by intoxicants are sometimes more pronounced. Thus it can be expected that the police officer observes strong deficiency symptoms more often than the physician, but the latter recognises—due to his experience and access to testing equipment—the underlying drug influence more frequently. In this way, differences arising between observations made by the police and the physician can be explained.

For simplicity, the results recorded on the form were assigned to one of three categories: no, small/moderate or strong deficiency symptoms. All forms which were not able to be assigned to a category due to lack of findings (e.g. when the subject refused to have tests performed by the physician, or the physician didn't fill out the blood sampling report, or the police report was absent) were entered under "reliable judgement not possible".

Table 28 shows the result of this evaluation. No relevant deficiency symptoms were found by the police and the physician in only 8 of the 248 cases. In these cases, obviously other evidence had convinced the police that a blood sample should be taken.

Table 28: Comparison of the degree of impairment as observed by the police and the physician taking the sample respectively.

| | | Deficiency symptoms according to physician's report | | | | |
|---|---|---|---|---|---|---|
| | | None | Slight to moderate | Strong | Reliable judgement not possible. | Sum |
| Deficiency symptoms according to police report | None | 8 | 11 | 4 | 3 | 26 |
| | Slight to moderate | 11 | 12 | 5 | 2 | 30 |
| | Strong | 17 | 45 | 45 | 12 | 119 |
| | Reliable judgement not possible | 10 | 18 | 20 | 25 | 73 |
| | Sum | 46 | 86 | 74 | 42 | 248 |

On evaluation of the police reports, the ratio of slight to moderate (n = 30) and strong (n = 119) deficiency symptoms to none (n = 26) deficiency symptoms is 5.7 : 1 ([30 + 119] : 26), but only 3.5 : 1 ([86 + 74] : 46) using the data from the physicians' reports. This reduction is, without doubt, attributable to the sobering up of the subject in the period of time from the moment of apprehension to blood sampling (time difference incident blood sampling = ca. 1-2 h[73]).

For 158 heroin users, both police reports and physicians' reports were available concerning deficiency symptoms (shaded area in table 28). Agreement was found between police and physicians' reports for 65 (8 + 12 + 45) of the 158 cases (= 41 %). In 15 cases (11 + 4), deficiency symptoms were observed by the physician but not the police, and vice versa for 28 cases (11 + 17). Heroin users showed only slight to moderate deficiency symptoms during the police interview and strong deficiency symptoms in the physician's, and vice versa in 45 cases. These figures demonstrate clearly, that the police and physicians' reports complement each other in a useful way when it comes to evaluation of the deficiency symptoms and therefore the drivers' fitness impairment.

### *8.4.1 Degree of Impairment in Relation to Morphine Concentration in Blood*

Firstly, the toxicological findings relating to a blood sample are valid only for the moment in which the sample was taken. The fact that conclusions can be drawn concerning drug levels at the time of the incident and before by applying knowledge relating to the metabolism of substances in the body over time (drug pharmacokinetics) does not change the matter. To answer the question therefore, whether a relationship exists between the blood morphine concentration and deficiency symptoms, only the report findings entered by the physicians were drawn upon.

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[73] See appendix 8.

*8.4.1.1 Blood Morphine Concentration less than 10 ng/mL*

In a total of 62 cases, the blood morphine concentration was under 10 ng/mL. Without taking poly-drug use into account, 21 showed slight to moderate and 18 even showed strong deficiency symptoms (see table 29). The result is interesting if one calculates the ratio of impairment to non-impairment depending on the type of poly-drug use: the subjects showing no poly-drug use returned the lowest figure with 2.25 : 1. The ratio found was practically the same when depressants and stimulants were used (the possible and temporary mutual cancellation of effects has already been discussed). The simultaneous consumption of soporific drugs/ sedatives or stimulants increases the ratio to 3.8 and 4.0 : 1 respectively, so that a clear effect enhancement can be assumed. On the other hand, withdrawal symptoms among heroin users at advanced stages of addiction at these low morphine concentrations may explain the increase in the ratio.

Table 29: Degree of impairment according to physician's report in relation to the blood morphine concentration and the influence of other substances consumed. N° of cases in the group of heroin users with morphine concentrations **under 10 ng/mL** (n = 62).

| Morphine concentration < 10 ng/mL | | | | | | |
|---|---|---|---|---|---|---|
| Additional influence by: | | No additional substances | CNS depressants | Stimu-lants | Stimulants and CNS depressants | Total |
| Deficiency symptoms according to physician's report | None | 4 | 5 | 1 | 3 | 13 |
| | Slight to moderate | 4 | 9 | 4 | 4 | 21 |
| | Strong | 5 | 10 | 0 | 3 | 18 |
| | Reliable judgement not possible | 0 | 6 | 1 | 3 | 10 |
| Ratio of cases with : without impairment | | 2,25 | 3,8 | 4,0 | 2,3 | 3,0 |

*8.4.1.2 Blood Morphine Concentration between 10 and 19.9 ng/mL*

In this group, there is also a total of 62 cases (see table 30). The ratio impairment : no impairment for the group without poly-drug use has now increased from 2.25 to 3.3; a positive correlation to the morphine concentration is now evident. The increase was, however, much greater for those who had combined stimulants and depressants with heroin: as opposed to 2.3, the ratio here is 9.0. No correlation was found for those who had consumed only depressants in addition to heroin; here, the figure returned [3.2] was slightly below the high ratio of 3.8 found for morphine concentrations under 10 ng/mL, despite the higher morphine concentration range. Similarly, the figure for those who had simultaneously consumed stimulants was clearly lower than for the <10 ng/mL bracket. The ratio of 2.3 found here corresponds to the value returned for the group who had consumed only small amounts of heroin and whose blood morphine concentration was less than 10 ng/mL. Especially the use of cocaine as stimulant in these cases can be responsible for countering the effects of heroin and morphine, without the accompanying withdrawal symptoms.

Table 30: Degree of impairment according to physician's report in relation to the blood morphine concentration and the influence of other substances consumed. N° of cases in the group of heroin users with morphine concentrations **between 10 and 19.9 ng/mL** (n = 62).

| Morphine concentration between 10 and 19,9 ng/mL | | | | | | |
|---|---|---|---|---|---|---|
| Additional influence by: | | No additional substances | CNS depressants | Stimu-lants | Stimulants and CNS depressants | Total |
| Deficiency symptoms according to physician's report | None | 3 | 5 | 3 | 1 | 12 |
| | Slight to moderate | 8 | 5 | 6 | 3 | 22 |
| | Strong | 2 | 11 | 1 | 6 | 20 |
| | Reliable judgement not possible | 1 | 4 | 2 | 1 | 8 |
| Ratio of cases with : without impairment | | 3,3 | 3,2 | 2,3 | 9,0 | 4,7 |

*8.4.1.3 Blood Morphine Concentration between 20 and 49.9 ng/mL*

This group contains 72 cases (see table 31). At first glance, it seems astounding that in spite of the overall higher amount of morphine present in the blood in comparison to the previous group, the ratio of the cases with / without impairment has dropped to 2.3. Pharmacologically, this can be explained if we first assume that the group contains a large proportion of those users who have—through regular opiate abuse—brought about changes to the receptors in the central nervous system and thereby acquired a higher tolerance; these users require a larger amount of active substance (resulting in higher blood concentrations) than the non-accustomed, to produce the same intoxicating effect. Each and every type of poly-drug use in this concentration bracket leads to a clear increase of the impairment : no-impairment ratio.

Table 31: Degree of impairment according to physician's report in relation to the blood morphine concentration and the influence of other substances consumed. N° of cases in the group of heroin users with morphine concentrations **between 20 and 49.9 ng/mL** (n = 73).

| Morphine concentration between 20 and 49,9 ng/mL | | | | | | |
|---|---|---|---|---|---|---|
| Additional influence by: | | No additional substances | CNS depressants | Stimu-lants | Stimulants and CNS depressants | Total |
| Deficiency symptoms according to physician's report | None | 3 | 5 | 3 | 1 | 12 |
| | Slight to moderate | 4 | 10 | 6 | 4 | 24 |
| | Strong | 3 | 13 | 5 | 3 | 24 |
| | Reliable judgement not possible | 3 | 6 | 2 | 3 | 13 |
| Ratio of cases with : without impairment | | 2,3 | 4,6 | 3,7 | 7,0 | 4,0 |

*8.4.1.4 Blood Morphine Concentration above 50 ng/mL*

Levels of morphine in blood over 50 ng/mL can be classified as very high indeed. Nevertheless, we still found 51 people with levels of this magnitude. Principally, the only type of drug user in this bracket likely to be caught driving is the heavy addict. The results obtained for the ratio impairment / no impairment support this supposition (see table 32). It can be seen, that when heroin is combined with both stimulants and depressants, the ascertainable degree of impairment increases dramatically (in the medical examination, drug influence was observed in every case), whereas the combination with a stimulant or sedative/ soporific drug renders a high proportion of the subjects undetectable on grounds of impairment. The ratio of 2.0 is the lowest found in the whole inquiry.

Table 32: Degree of impairment according to physician's report in relation to the blood morphine concentration and the influence of other substances consumed. N° of cases in the group of heroin users with morphine concentrations **equal to or above 50 ng/mL** (n = 51).

| Morphine concentration □ 50 ng/mL | | | | | | |
|---|---|---|---|---|---|---|
| Additional influence by: | | No additional substances | CNS depressants | Stimu-lants | Stimulants and CNS depressants | Total |
| Deficiency symptoms according to physician's report | None | 2 | 5 | 2 | 0 | 9 |
| | Slight to moderate | 4 | 9 | 2 | 4 | 19 |
| | Strong | 2 | 1 | 2 | 7 | 12 |
| | Reliable judgement not possible | 3 | 6 | 2 | 0 | 11 |
| Ratio of cases with : without impairment | | 3,0 | 2,0 | 2,0 | (□) | 3,4 |

*8.4.1.5 Degree of Impairment and Blood Morphine Concentration*

Table 33 was produced by including all cases which had been fully documented by a physician, and subsequently grouping them according to their morphine concentration bracket, without taking into account the type of poly-drug use. A correlation was found between the increase in deficiency symptoms and the magnitude of the blood morphine concentration; an increase is found up to 50 ng/mL, but does not continue at levels above 50 ng/mL. Overall, the ratio impairment / no impairment is between 3.0 and 4.0. From this high ratio it can be concluded that when heroin is consumed, and when free morphine can be detected in the blood accompanied by easily recognisable outward symptoms, that this can be substantiated in the majority of cases (75 to 80 %) by the relevant findings in the medical examination.

Table 33: Relationship between the degree of impairment (according to the physician's report) and the free morphine concentration in blood. N° of cases and proportion in % (n = 206)

| Free morphine concentration in blood: | | < 10 ng/mL | 10 - 19,9 ng/mL | 20 - 49,9 ng/mL | ≥ 50 ng/mL |
|---|---|---|---|---|---|
| Impairment according to physician's report | None | 13 (25,0 %) | 12 (22,2 %) | 12 (20,0 %) | 9 (22,5 %) |
| | Slight to moderate | 21 (40,4 %) | 22 (40,7 %) | 24 (40,0 %) | 19 (47,5 %) |
| | Strong | 18 (34,6 %) | 20 (37,0 %) | 24 (40,0 %) | 12 (30,0 %) |
| | Total number | 52 (100 %) | 54 (100 %) | 60 (100 %) | 40 (100 %) |
| Ratio of cases with : without impairment | | 3,0 | 3,5 | 4,0 | 3,4 |

### *8.4.2 Relationship Between Degree of Impairment and Type of Poly-Drug Use*

It has already been shown in the previous chapter that the frequency of impairment observed in the medical examination seems to depend on the type of poly-drug use. Table 34 compares deficiency symptoms of the various poly-drug types. As has already been shown, a lack of deficiency symptoms is relatively seldom noticed when the heroin is accompanied by both CNS stimulants and depressants (ratio 6.8 : 1). These users, along with those who had taken in addition only CNS depressants, tended to exhibit pronounced deficiency symptoms (48.7 and 39.9 % respectively), whereas in the other two groups (no poly-drug use and additional use of stimulants) no or slight deficiency symptoms predominate (45.4 and 52.5 % respectively). This result can be explained by way of pharmacodynamic considerations as the hypnotic, consciousness-depressing effect of heroin is at least reinforced or enhanced additively by similarly acting substances.

Table 34: Relationship between the degree of impairment (according to the physician's report) and the type of influence by substances additionally consumed. N° of cases and proportion in % (n = 205).

| Additional impairment by: | | No poly-drug use | CNS depressants | Stimulants | Stimulants and depressants |
|---|---|---|---|---|---|
| Impairment according to physician's report | None | 12 (27,3 %) | 20 (22,7 %) | 9 (26,5 %) | 5 (12,8 %) |
| | Slight to moderate | 20 (45,5 %) | 33 (37,5 %) | 18 (52,9 %) | 15 (38,5 %) |
| | Strong | 12 (27,3 %) | 35 (39,8 %) | 7 (20,6 %) | 19 (48,7 %) |
| | Total number | 44 (100 %) | 88 (100 %) | 34 (100 %) | 39 (100 %) |
| Ratio of cases with : without impairment | | 2,7 | 3,4 | 2,8 | 6,8 |

## 9 Heroin Consumption and Absolute Unfitness to Drive

The evaluation of the 248 heroin users selected from the total group of 912 cases showed by way of both the behavioural irregularities in road traffic and the deficiency symptoms observed by the police and physician taking the blood sample, that considerable impairment of driving fitness can be expected even at very low blood morphine levels.

Simultaneous consumption of other intoxicants is typical among heroin users; more than 90 % had other substances in their blood besides opiates, and in 80 %, concentrations were classed as significant. As a rule, therefore, poly-drug use is normal for heroin users.

A free morphine concentration in blood or serum of under 10 ng/mL can be classified as very low; routine analyses for morphine in blood often approach the detection threshold at these levels. Therefore, the lowest concentration range was chosen to be 10 ng/mL for the evaluation of the data. It was expected that this group would contain many test subjects whose deficiency symptoms are rather seldom noticeable, at least to the physician. This was, however, not the case. The ratio of deficiency symptoms yes/no for this group of 62 subjects is relatively high (between 2.25 and 4 with average 3), depending on the presence /type of poly-drug use. In the next morphine concentration bracket 10 – 19.9 ng/mL, the ratio increases to an average of 4.7 (range 2.3 – 9), but falls again to an average of 4.0 (range 2.3 – 7) in the next group (morphine concentration 20 – 49.9 ng/mL), and further to 3.4 in the concentration bracket of 50 ng/mL and above. This is only slightly higher than the value returned for the first group. This shows then, that numerous people whose blood contains only very low morphine levels exhibit deficiency symptoms. It is known that regular consumption of morphine and heroin (its chemical predecessor) can lead to different tolerance levels depending on the individual. It can therefore be assumed that, in the group investigated, all imaginable levels are represented, which possibly obscures any trends otherwise present in the frequency of deficiency symptoms. In the under 10 ng/mL concentration bracket, it can be supposed that a higher amount of users is represented who (still) have low tolerance, and therefore more readily exhibit symptoms. This group is just as likely to include heavy addicts whose morphine level has decreased so far as to make them conspicuous through the presence of withdrawal symptoms. At the other end of the scale (above 50 ng/mL), we can suppose that the group contains a higher proportion of users who have reached a high level of tolerance and who do not always display strong deficiency symptoms. Thus, the result obtained is not implausible. This also means though, that after evaluation of the police and physician's reports regarding the observed deficiency symptoms resulting from heroin consumption, blood morphine concentrations under 10 ng/mL are very often sufficient to produce the symptoms.

In order to judge the heroin users' driving errors, we turned again to our handy tool, the "26 % value" (see appendix 6). Similar to the study "Cannabis in Road Traffic", it was not possible to compare the results obtained to a sober control group for fundamental reasons. Also, no data were available which were derived from controlled, normable conditions; we were only able to analyse blood samples which had been taken on order of the police in light of incriminating factors (criminal offence under the influence of drugs).

Likewise, the data can be classed as "selected", whereby the selection criteria were again not normable. Numerous individuals (in this case the police officers) had decided in the most diverse cases (random incidents) whether a blood sample should be taken or not.

Table 35: The cases in which the 26 % value of the blood morphine concentration was exceeded and which either ended in an accident or weaving was observed.

| **Accidents after consumption of heroin** | **Morphine concentration in blood** (26 % value exceeded) |
|---|---|
| Simultaneous consumption of stimulants | Under 10 ng/mL |
| Simultaneous consumption of stimulants and CNS depressants | Under 10 ng/mL |
| Simultaneous consumption of CNS depressants | Under 10 ng/mL |
| No poly-drug use | Under 10 ng/mL |
| **Weaving** | |
| Simultaneous consumption of stimulants | Between 10 and 19,9 ng/mL |
| Simultaneous consumption of stimulants and CNS depressants | Under 10 ng/mL |
| Simultaneous consumption of CNS depressants | Between 10 and 19,9 ng/mL |
| No poly-drug use | Under 10 ng/mL |

To be able to carry out a statistical evaluation, it was necessary to evaluate data from another group in addition, whose blood samples had been obtained by applying similar selection criteria. For this, the group of drivers under the influence of alcohol was chosen, whose vehicle had left the road. The catchment area was within the jurisdiction of the Düsseldorf Regional Police, in 1994. This type of accident is frequently encountered when alcohol is involved. It can therefore be assumed that in the majority of cases, that the influence of alcohol has led to a driving error and in turn to an accident.

Within the group, the distribution of the blood alcohol concentration (BAC) was determined. Of particular interest to us was how many of the drivers had a BAC of under 1.10 ‰. The evaluation revealed that 26 % of the drivers had a BAC under this level, meaning that 74 % of them had a BAC in the region "absolutely unfit to drive". Analogously, the conclusion was drawn that a threshold BAC exists, which has been reached or exceeded by ca. ¾ of all drivers who caused an alcohol-typical accident. We drew on this factor to enable us to also establish a reasonable threshold for those driving under the influence of heroin to be unfit to drive. Detailed

evaluation was carried out in those cases where the influence of heroin had either caused an accident (total number = 75), or where weaving was observed (total number = 42). Here, both the blood morphine concentration and the presence of simultaneously consumed stimulants and CNS depressants was taken into account. The corresponding proportion of cases having exceeded the 26 % value is the basis of the blood morphine concentrations quoted in table 35.

It was shown, as evaluation of the deficiency symptoms recorded by the police and physician confirm, that even at morphine concentrations of under 10 ng/mL, the frequency of irregularities displayed by the heroin user in road traffic suggests unfitness to drive comparable to a driver with a BAC of 1.10 ‰ or more. We believe that the study proves that even the consumption of small amounts of heroin is incompatible with safe driving.

As résumé of the inquiry, it is suggested that if in future any driver of a motor vehicle is suspected of having used heroin, that a blood sample be analysed for morphine, and that, irrespective of the type and quantity of any additional intoxicants found, a blood concentration of free morphine of 10 ng/mL or above indicates that the driver is unfit to drive according to §§ 315 c and 316 StGB (German penal code).

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APPENDIX

**Appendix 1**: Examination form

Inquiry: Drugs in Road Traffic * Institute for Forensic Medicine, Heinrich-Heine-Universität Düsseldorf

Sender (stamp)

Prof. Dr. Thomas Daldrup
Institute of Forensic Medicine
Heinrich-Heine University Düsseldorf
Moorenstraße 5

40225 Düsseldorf

## Application for Analysis

The accompanying blood /urine sample of:

Surname:_____ First or Christian name_____ Date of Birth_____

❑ Male ❑ Female

should be analysed for drugs (cannabinoids, opiates, cocaine, amphetamines etc.) in the frame of the inquiry "Drugs in Road Traffic".

In addition, the blood sample should be tested for alcohol (BAC) ❑ Yes ❑ No

The following documents are supplied:

❑ Blood sampling records
❑ Blood sample
❑ Urine sample
❑ Physician's report (supplement)
❑ Police report
❑ Copy of accident report
❑ Copy of traffic offence notification
❑ Copy of prosecution
❑ Remarks / misc. Documents

_____

_____

The results of the analysis should be sent to:

Person responsible _____ Telephone _____

Reference _____

Date _____ Signature _____

APPENDIX

**Appendix 2**: Form "Police Report"

Inquiry: Drugs in Road Traffic * Institute for Forensic Medicine, Heinrich-Heine-Universität Düsseldorf

## Police Report

Surname, first or Christian name Police Station

**1. Incident:**
Type: _____
_____
Place: _____
Time: _____

**2. Driving Behaviour:**
❑ normal ❑ unsure gear change
❑ stalling / unnecessary revving of motor
❑ weaving (see description under 6.)

**3. Weather:**
❑ dry ❑ rain ❑ ice / snow
❑ strong winds / storm

**4. Road Surface:**
❑ good ❑ poor (see description under 6.)

**5. Road Illumination:**
❑ good ❑ poor

**6. Particular Remarks**

**7. Suspicion of Consumption of:**

**8. Statement of Person to Cannabis / Narcotic Consumption after Warning:**
Type: _____
Amount: _____
Time: _____

**9. Alcohol Test:**
❑ yes, on _____ at_____ o'clock
Result: _____ Instrument N°_____
❑ refused ❑ cannot be performed

Reason: _____

**10. German Language Capability**
❑ yes ❑ no ❑ limited

**11. Gait:**
❑ sure ❑ dragging / shuffling
❑ swaying ❑ staggering

**12. Eyes:**
❑ not conspicuous ❑ reddened conjunctiva
❑ glazed ❑ unsteady

**13. Pupils:**
❑ not conspicuous ❑ pinpoint
❑ strongly dilated (tested with: )

**14. Behaviour / Mood:**
❑ controlled ❑ communicative
❑ calm ❑ tired
❑ aggressive ❑ excited
❑ depressive ❑ cheerful
❑ talkative ❑ quiet
❑ apathetic ❑ weepy
❑ disinterested ❑ lethargic
❑ _____

**15. Comprehension:**
❑ good ❑ delayed
❑ slow-witted ❑ changeable
❑ confused ❑ cannot be judged

**16. Miscellaneous observations:**
❑ shivering ❑ restlessness
❑ sleepiness ❑ sweat
❑ nervosity ❑ _____

**Other:**

Recorded by:

Name and signature

APPENDIX

**Appendix 3**: Form "Supplementary Medical Report"

Inquiry: Drugs in Road Traffic * Institute for Forensic Medicine, Heinrich-Heine-Universität Düsseldorf

**Supplement to "B. Medical Report - Record and Application for Determination of Alcohol in Blood"**

**Surname:**

_____

**First name:**

_____

**Age:** _____ years
**Blood sampled** on _____ at _____o'clock

**1. Mood:**
❑ not conspicuous ❑ euphoric
❑ depressive ❑ does not fit situation

**2. Time Perception / Short-term Memory:**
❑ normal ❑ impaired

**3. Self-Judgement / Ability to be Criticised / Estimation of Present Situation:**

**4. Motor / Fine Motor Functions:**

**5. Blood Pressure:** mm Hg

**6. Pulse:** per minute

**7. Breathing Rate:** per minute

**8. Pupils:**
❑ not conspicuous
❑ strongly dilated ❑ pinpoint
Diameter: _____ mm
Reaction to light in _____ seconds

**9. Redness of Conjunctiva:**
❑ none ❑ slight
❑ clearly reddened ❑ strong reddening

**10. Appearance of Face**
❑ pale ❑ reddened
❑ swollen ❑ not conspicuous

**11. General Condition:**

**12. Data From Anamnesis:**

**13. Tobacco Consumption:**
❑ yes ❑ no

**14. Urine Sample:**
❑ yes ❑ no

**15. Patient appears to be under the influence of:**
❑ CNS depressants
❑ CNS stimulants
❑ hallucinogenic substances
❑ _____

**16. Patient appears to be:**
❑ not noticeably ❑ slightly
❑ clearly
under the influence of
❑ cannabis ❑ alcohol ❑ heroin
❑ cocaine ❑ amphetamine(s)
❑ cannabis: _____

**Other Remarks:**

Name, address of examining physician (stamp):

Signature

APPENDIX

**Appendix 4**: Form "Assessment Template"

**Institute of Forensic Medicine**
**Heinrich-Heine University Düsseldorf**
Research Project: Drugs in Road Traffic
Project Leader: University Professor Dr. Th Daldrup

Ch. Ident-N°: A - 0000

Please always include this reference!

Prof. Daldrup - Institute of Forensic Medicine - Postfach 101007 - D-40001 Düsseldorf

Police HQ XXXX
Dept XXX, Superintendent XXX
Street Address
Place, Postcode

## Report

The serum sample of: Joe Citizen
Injection reference number 1234

was analysed for opiates by immunoassay and GC / MS (with deuteriated standards) after special sample preparation. The following pertinent forensic results were obtained:

| | | | |
|---|---|---|---|
| Morphine: | 50.0 | ng/ml | (Methods: GC / MS) |
| Codeine: | 50.0 | ng/ml | (Methods: GC / MS) |
| Dihydrocodeine: | 50.0 | ng/ml | (Methods: GC / MS) |

Judgement (relevant box):

The opiates found are in concentrations corresponding to a person under

❑ strong ❑ slight

opiate influence at the time of blood sampling.

Furthermore, preliminary testing (immunoassay) indicated poly-drug use including the following intoxicants*:
Amphetamines, Benzodiazepines, cocaine, cannabinoids.
*Positive results require confirmation.

University Professor Th. Daldrup

Application for confirmation of analyses has been filed. Assessment will follow.

Abbreviations: ng/ml = nanogram per millilitre; GC / MS = gas chromatography / mass spectrometry

APPENDIX

**Appendix 5**: Program Listing for the PrepStation

[1] * Pierce eluate vial

[2] Evaporate eluate-vial at ambient temperature for 0.00 minutes

| | |
|---|---|
| Temperature = 0° C | Vial name = Eluate-Vial |
| Time = 0.00 min | Station name = SPE-Unit |
| Needle height = 16.00 mm | Upon completion = Return to tray |

[3] * Conditioning of DAU-Column

[4] SPE-Condition DAU-Column with 2.000 mL of MeOH

| | |
|---|---|
| Volume = 2.000 mL | Solvent = MeOH |
| Draw speed = 10.0 mL/min | Cartridge name = DAU-Column |
| Dispense speed = 2.0 mL/min | Station name = SPE-Unit |
| Prefill solvent path = Yes | |

[5] SPE-Condition DAU-Column with 2.000 mL of H2O

| | |
|---|---|
| Volume = 2.000 mL | Solvent = $H_2O$ |
| Draw speed = 10.0 mL/min | Cartridge name = DAU-Column |
| Dispense speed = 2.0 mL/min | Station name = SPE-Unit |
| Prefill solvent path = Yes | |

[6] SPE-Condition DAU-Column with 2.000 mL of 25 mM HCl

| | |
|---|---|
| Volume = 2.000 mL | Solvent = 25 mM HCl |
| Draw speed = 10.0 mL/min | Cartridge name = DAU-Column |
| Dispense speed = 1.6 mL/min | Station name = SPE-Unit |
| Prefill solvent path = Yes | |

[7] * Sample dilution and task

[8] Aspirate 0.800 mL from Sample-vial

| | |
|---|---|
| Volume = 0.800 mL | Vial name = Sample-vial |
| Aspirate speed = 3.0 mL/min | Station name = SPE-Unit |
| Needle height = 0.00 mm | Overshoot = 0.60 % |
| Pre-sample air gap = 0.010 mL | Wait for fill = 5 sec |
| Prefill solvent path = No | Prefill solvent = 25 mM HCl |
| Flow path = Dispense | |

[9] SPE Wash DAU-Column with 2.400 mL of 25 mM HCl

| | |
|---|---|
| Volume = 2.400 mL | Wash solvent = 25 mM HCl |
| Draw speed = 10.0 mL/min | Cartridge name = DAU-Column |
| Dispense speed = 1.0 mL/min | Station name = SPE-Unit |
| Flow path = Wash-Elute | Prefill solvent path = No |

[10] Dispense 0.800 mL of 25 mM HCl into Sample-vial

| | |
|---|---|
| Volume = 0.800 mL | Solvent = 25 mM HCl |
| Draw speed = 10.0 mL/min | Vial name = Sample-vial |
| Dispense speed = 10.0 mL/min | Needle height = 23.00 mm |
| Overshoot = 0.60 % | Station name = SPE-Unit |
| Flow path = Dispense | Prefill solvent path = No |

[11] Aspirate 1.400 mL from Sample-vial

| | |
|---|---|
| Volume = 1.400 mL | Vial name = Sample-vial |
| Aspirate speed = 3.0 mL/min | Station name = SPE-Unit |
| Needle height = 0.00 mm | Overshoot = 0.60 % |
| Pre-sample air gap = 0.010 mL | Wait for fill = 5 sec |
| Prefill solvent path = No | Prefill solvent = 25 mM HCl |
| Flow path = Dispense | |

[12] SPE-Wash DAU-Column with 2.400 mL of 25 mM HCl

| | |
|---|---|
| Volume = 2.400 mL | Wash solvent = 25 mM HCl |
| Draw speed = 10.0 mL/min | Cartridge name = DAU-Column |
| Dispense speed = 1.0 mL/min | Station name = SPE-Unit |
| Flow path = Wash-Elute | Prefill solvent path = No |

[13] * Rinse DAU column

[14] SPE - Wash DAU-Column with 3.000 mL of $H_2O$

| | |
|---|---|
| Volume = 3.000 mL | Wash solvent = $H_2O$ |
| Draw speed = 10.0 mL/min | Cartridge name = DAU-Column |
| Dispense speed = 1.5 mL/min | Station name = SPE-Unit |
| Flow path = Wash-Elute | Prefill solvent path = Yes |

[15] SPE - Wash DAU-Column with 3.000 mL of 0.1 M HCl

| | |
|---|---|
| Volume = 3.000 mL | Wash solvent = 0.1 M HCl |
| Draw speed = 10.0 mL/min | Cartridge name = DAU-Column |
| Dispense speed = 1.5 mL/min | Station name = SPE-Unit |
| Flow path = Wash-Elute | Prefill solvent path = Yes |

APPENDIX

[16] SPE - Wash DAU-Column with 3.000 mL of MeOH

| | |
|---|---|
| Volume = 3.000 mL | Wash solvent = MeOH |
| Draw speed = 10.0 mL/min | Cartridge name = DAU-Column |
| Dispense speed = 1.5 mL/min | Station name = SPE-Unit |
| Flow path = Wash-Elute | Prefill solvent path = Yes |

[17] SPE-Dry DAU-Column for 0.10 min using Wash-Elute flow path

| | |
|---|---|
| Time = 0.10 min | Cartridge name = DAU-Column |
| Flow path = Wash-Elute | Station name = SPE-Unit |

[18] * Elution of Sample into eluate vial

[19] SPE-Elute DAU-Column to <waste> with 1.500 mL of Dichlor / Iso / Amm

| | |
|---|---|
| Volume = 1.500 mL | Solvent = Dichlor / Iso / Amm |
| Draw speed = 10.0 mL/min | Vial name = <waste> |
| Dispense speed = 1.0 mL/min | Cartridge name = DAU-Column |
| Flow path = Wash Elute | Station name = SPE-Unit |
| Purge time = 0.00 min | Prefill solvent path = Yes |

[20] SPE-Elute DAU-Column to Eluat-Vial with 1.600 mL of Dichlor / Iso / Amm

| | |
|---|---|
| Volume = 1.600 mL | Solvent = Dichlor / Iso / Amm |
| Draw speed = 10.0 mL/min | Vial name = Eluat-Vial |
| Dispense speed = 1.0 mL/min | Cartridge name = DAU-Column |
| Flow path = Wash Elute | Station name = SPE-Unit |
| Purge time = 0.00 min | Prefill solvent path = No |

[21] * Rinse system

[22] Rinse - System with 2.000 mL of MeOH using Entire System flow path

| | |
|---|---|
| Volume = 2.000 mL | Solvent = MeOH |
| Draw Speed = 10.0. mL/min | Station name = SPE-Unit |
| Dispense speed = 10.0 mL/min | Flow path = Entire System |

END

Vial/Cartridge Information Table

| Name | Type | Number of Uses |
|---|---|---|
| Sample vial | sample | N/A |
| Eluate vial | empty vial | 1 |
| DAU-Column | cartridge | 1 |

APPENDIX

Solvent Information

| | | | |
|---|---|---|---|
| SPE-Unit | | SPE Module | 2.5 mL syringe |

| Station | Port | Solvent | Size |
|---|---|---|---|
| SPE-Unit | 1 | $H_2O$ | 1000.0 |
| SPE-Unit | 2 | MeOH | 500.0 |
| SPE-Unit | 6 | 0.1 M HCl | 500.0 |
| SPE-Unit | 7 | Dichlor / Iso / Amm | 200.0 |
| SPE-Unit | 8 | 25 mM HCl | 500.0 |
| SPE-Unit | - | Air | N/A |

APPENDIX

**Appendix 6**: Accident statistics for the year 1994 for the area under the jurisdiction of the Düsseldorf Regional Authority, and the 26 % value. (Taken from the final report of "Cannabis in Road Traffic")

All road accidents which had occurred in 1994 within the Düsseldorf Regional Authority and which had been included in the NRW[1] police statistics were investigated according to the type of accident, accident category and involvement of alcohol. In 1994, a total of 158253 accidents were registered within the Düsseldorf Regional Authority. Alcohol was involved in 4158 (= 2.6 %) of these. In table 1, the accidents with and without involvement of alcohol have been categorised. According to this, the frequency of the serious accidents involving alcohol (category 1 to 4) based on 100 incidents, is two times (category 3) to three times (category 4) higher than without involvement of alcohol.

Table 1: Road accidents with and without involvement of alcohol within the catchment area of the Düsseldorf Regional Authority.

| Accident category | Road accidents without alcohol | | Road accidents with alcohol | |
|---|---|---|---|---|
| | n | n per 100 accidents | n | n per 100 accidents |
| Cat. 1: Accident with fatalities | 245 | 0,2 | 27 | 0,6 |
| Cat. 2: Accident with serious injury | 4848 | 3,1 | 483 | 11,6 |
| Cat. 3: Accident with minor injury | 16045 | 10,4 | 850 | 20,4 |
| Cat. 4: Accident with serious property damage | 8404 | 5,5 | 936 | 22,5 |
| Cat 5: Minor accident | 103048 | 66,9 | - | - |
| Cat. 6: Minor accident involving alcohol or where the scene of accident was left | 21505 | 14.0 | 1862 | 44.8 |
| Number of fatalities | 270 | 0,2 | 28 | 0,7 |
| Number of victims seriously injured | 5379 | 3,5 | 543 | 13,1 |
| Number of victims slightly injured | 19594 | 12,7 | 1080 | 26,0 |

One can see in these accident statistics, that the number of accident fatalities without involvement of alcohol is 245, and "only" 27 with involvement of alcohol.

In the former West Germany, the number of road deaths decreased by 60 % in the period 1970 to 1990, despite increased traffic density. The intrinsic passive and active safety of modern vehicles, together with the general introduction and improvement of restraining mechanisms and air-bag systems for passengers have made the largest contribution to this reduction[2]. Due to technological progress it is, compared to the 1960s, very much less probable that fatalities occur in

accidents where alcohol is involved. The criterion "accident with fatalities" seems then to be no longer suitable in the present day as a basis for deriving the "absolute unfitness to drive".

The matter is different when so-called alcohol-typical accidents are analysed. Even Rudolf[3] was able to show that the most common causes of accidents among drunken drivers are statistically different from the generally most common causes. Here, the dominating accidents are not of the type "error whilst overtaking" or "failure to give way", but rather "crash without external influence" for cyclists, "leaving the road" and "rear-end collision in stationary traffic". Mueller et al.[4] frequently found, that drunken drivers strayed from the right hand lane for no apparent reason, fled from the scene of the accident, misjudged seemingly safe bends, veered off straight stretches of road with their vehicle, had a tendency to weave and went into skids for no readily apparent reason. Mallach and Stein[5] found accidents in bends particularly prevalent among drunken drivers, and Bürkle[6] the incidence of veering off the road.

Of the 158253 accidents registered in the police statistics in NRW, details pertaining to the type of accident were recorded in 55115 cases (table 2).

Table 2: Type of accident with and without the involvement of alcohol in the catchment area of the Düsseldorf Regional Authority, 1994

| Type of accident | Accidents without alcohol (n = 51047) | | Accidents with alcohol (n = 4068) | |
|---|---|---|---|---|
| Collision with another vehicle, which | n | n per 100 accidents | n | n per 100 accidents |
| (1) is driving off, or is stationary in stopped traffic | 5095 | 10,0 | 1119 | 27,5 |
| (2) is driving ahead or is waiting | 18372 | 36,0 | 438 | 10,8 |
| (3) is driving alongside in the same direction | 5300 | 10,4 | 113 | 2,8 |
| (4) is coming from the opposite direction | 2154 | 4,2 | 196 | 4,8 |
| (5) is turning off or cutting across | 1817 | 3,6 | 400 | 9,8 |
| (6) Collision with pedestrian | 10276 | 20,1 | 185 | 4,5 |
| (7) hits an object on the road | 3236 | 6,3 | 32 | 0,8 |
| (8) veers off the road to the right | 205 | 0,4 | 646 | 15,9 |
| (9) veers off the road to the left | 2582 | 5,1 | 486 | 11,9 |
| (0) Other type of accident | 2010 | 3,9 | 453 | 11,1 |

APPENDIX

It can be shown that, as is quoted in literary references, leaving the road on the left hand side—and for truck drivers particularly on the right hand side—is observed among drunken drivers. If we investigate the relationship between the increase in alcohol-typical accidents and the BAC value of the driver, then we see that truck drivers with a BAC between 0.6 and 0.7 ‰ veer off the road to the right or left three times as frequently as a sober truck driver (BAC up to max. 0.1 ‰); in the BAC range 1.00 – 1.10 ‰, this number almost doubles again (diagram 1). The same tendencies of increased risk were also statistically proved in the aforementioned survey "Alcohol in Traffic Offences". Thus, the evaluation of alcohol-typical accidents such as veering off the road also leads to the same result concerning the increased risk of drunken truck drivers, as Freudenberg 1966[7] achieved in the context of a survey after evaluation of road accidents with fatalities.

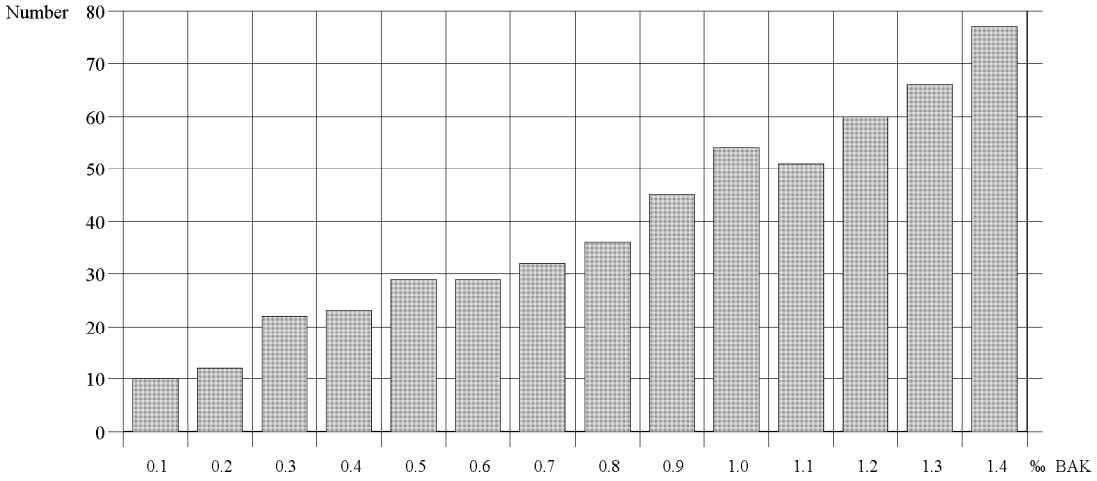


Diagram 1: BAC up to 1.4 ‰ and alcohol-typical accident (veering off the road). Evaluation of all accidents registered within the Düsseldorf Regional Authority in 1994 where alcohol was involved (accident type 8 / 9; police statistics NRW).

**The "26 % value"**

For the research project, the total accidents on the one hand, and those of the type "veering off the road" on the other were chosen and plotted in dependence of the BAC of those involved in the accidents, in order to find a correlation between the BAC and the frequency of driving errors. Of particular interest here was the group of drivers under the influence of alcohol but with a BAC below 1.10 ‰.

To find this out, all road accidents in 1994 registered by the Düsseldorf Regional Authority where alcohol was involved were counted, and classified according to their BAC level (up to 0.1 ‰, up to 0.2 ‰, up to 0.3 ‰ etc.). The results are shown in diagrams 2 and 3. It can clearly be seen that not only for the total accidents, but also for the type "veering off the road", that ca. 26 % of the drivers have a BAC of under 1.10 ‰. The "26 % value" can be interpreted as meaning that 74 % of the drivers causing the accidents had a BAC of 1.10 ‰, which rendered them completely

unfit to drive on grounds of alcohol consumption, and that for the remaining 26 %, the blood alcohol value alone is not sufficient on which to base the absolute unfitness to drive.

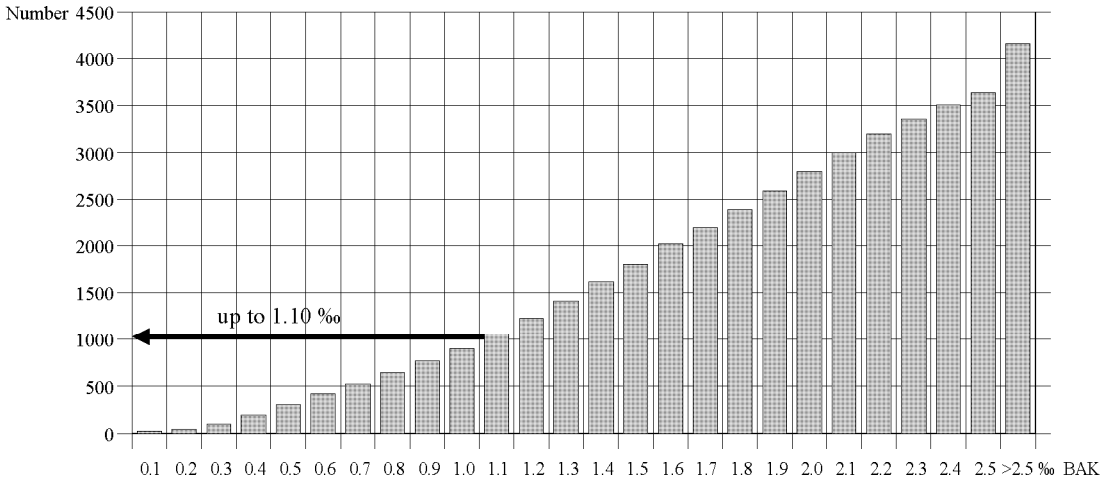


Diagram 2: BAC and accidents in 1994 within the catchment area of the Düsseldorf Regional Authority (total N° of accidents involving alcohol: 4158; of these, 1059 (= 25.5 %) had a BAC under 1.10 ‰)

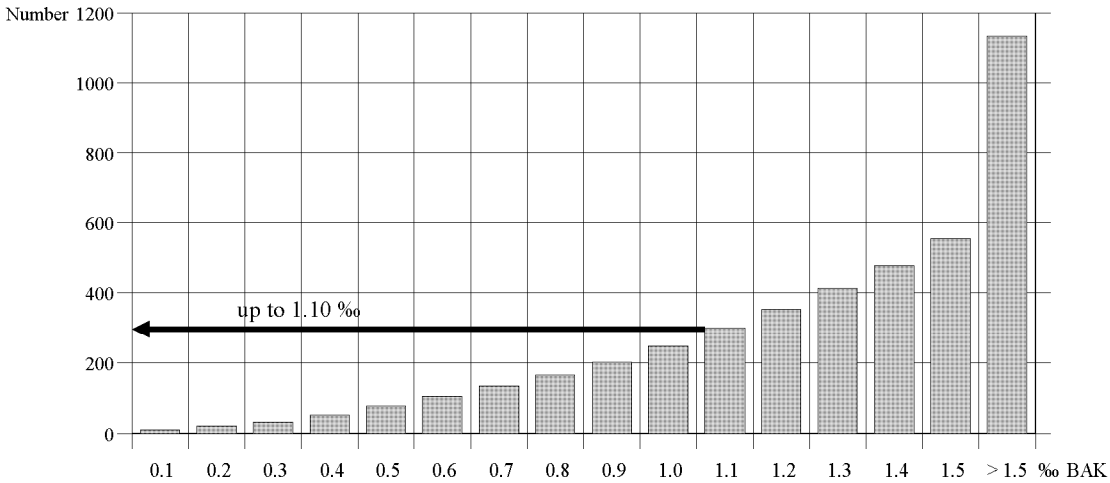


Diagram 3: BAC and accidents of type "vehicle left the road" in 1994 within the catchment area of the Düsseldorf Regional Authority (total N°: 1132; of these, N° of incidents where the BAC was under 1.10 ‰ amounted to 301 (= 26.6 %)).

This 26 % value was subsequently chosen, in order to establish a threshold level to discern between relative and absolute unfitness to drive through the use of drugs.

**Appendix 7**

# The drug-impaired driver

Appearance, effects, typical driving errors

Compiled by Prof. Dr. Th. Daldrup, Düsseldorf

## General problem: Poly-drug use

In addition to their main drug, almost all drug consumers consume alcohol, tobacco and as a rule, cannabis. Sleeping pills and sedatives are used regularly by heroin, cocaine and amphetamine users, either to enhance the effect in the case of heroin, or to suppress the stimulating effect of cocaine and amphetamines.

## The cannabis consumer

Cannabis is only consumed on its own, or possibly in combination with alcohol. Other drugs, primarily amphetamines, are sometimes tried. At the beginning the joint is preferred, and the pipe in cases of addiction.

Three phases of the effect can be differentiated between:

**- the acute phase**; shortly after consumption (duration 1 – 2 hours, if a large amount is consumed then longer): A dragging / shuffling gait can be present, words are pronounced with difficulty, the person generally speaks slowly, and is slow-witted. The eyes are reddened, the look somewhat glazed, the pupils dilated and slow to react to light sources.

- Typical conspicuous driving includes: change of speed for no reason; low speed; has difficulty keeping in lane with subsequent steering correction; attention easily diverted and inability to concentrate—thus inadequate reaction to unexpected happenings; failure to give way and tendency to "overlook" red lights and pedestrians crossing the road; no immediate reaction when the police signals to stop.

**- the sub-acute phase**; directly follows the acute, or is present after consumption of only a small amount of cannabis (duration ca. 4 to 6 hours or possibly longer): The lethargy of the first phase is gone. The underlying mood is one of exuberance (euphoria, happy feeling) and a carefree manner prevails. The ability to stand criticism is diminished, the person's own performance and abilities are exaggerated, eyes are red to normal, pupils dilated or normal.

- Typical conspicuous driving includes: risky driving with excessive speed; fleeing from the scene of the accident is not seldom; attention still easily diverted and inability to concentrate—thus inadequate reaction to unexpected happenings; failure to give way and tendency to "overlook" red lights.

**- the post-acute phase**; lasts apparently 12 to 24 hours, until the cannabis consumer has the feeling that his head is completely "clear" again. After regular, chronic consumption, this time is much longer. Concentration lapses, the person is easily distracted, dreaming occurs. It is well possible that conspicuous behaviour goes undetected in a routine road check.

- Typical conspicuous driving: is not known. It can be assumed that driving errors occur due to lack of concentration.

In addition to this, cannabis consumption is often followed by **circulation instability**, with nausea, dizziness, headache, shivering, cold sweats and even fainting (from an upright position). Those who drive in spite of these side-effects are conspicuous through their generally unsure and irregular style of driving (e.g. frequent stopping without apparent reason, driving very slowly etc.), which can be directly explained by the aforementioned symptoms.

Furthermore, the appearance of a cannabis psychosis with delusions can be expected from regular consumption of this drug. The users are confused and disorientated.

## The heroin consumer

Strictly speaking, a heroin addict is never fit to drive. This applies not only to the acute euphoric but also the withdrawal phase. Due to the additional uncontrolled parallel consumption of CNS depressants (e.g. Valium® or Rohypnol®), other opiates/opioids (codeine, dihydrocodeine, methadone etc.) or alcohol, the recovery between applications of heroin to a state of being fit to drive is not possible.

The popular combination of cocaine and heroin is extremely dangerous. As the stimulating effect of cocaine diminishes faster than the depressive effect of heroin (and other drugs possibly consumed), the sudden lapse into a semiconscious state is possible. If any driver has consumed this mixture, then serious accidents are almost pre-programmed.

The **deficiency symptoms** are dependent on which stadium of the heroin's effect has been reached.

In the acute phase, the CNS depressive action predominates: generally slowed down, dragging, unsteady gait; unclear diction. The pupils are constricted even in poor lighting conditions (the pupils should however not be checked in bright lighting conditions!).

If the effect of heroin wears off, and the first withdrawal symptoms appear, then nervosity, restlessness, shivering and inability to concentrate prevail. The pupils are no longer constricted, but more likely to be dilated.

The driving style is dependent on the current state of the driver and the current effect phase of the heroin, and on other miscellaneous intoxicants. It is possible that the slower, extremely unsafe driving style predominates, resulting in veering off the road /out of the lane, or rear-end collisions (e.g. shortly after consumption, possibly also with strong withdrawal symptoms); also possible is an uninhibited, aggressive style of driving, involving harassment of other drivers, dangerous overtaking manoeuvres, and ignorance of priority rules and signs (this behaviour is observed after comparatively small doses of heroin or after wearing off of the strong hypnotic (soporific) effects).

## The stimulant consumer (cocaine, amphetamine)

After consumption of stimulants, the powers of concentration are enhanced, and tiredness is suppressed. For these reasons, therefore, the fact that a driver is suffering from the acute effects of this drug is not apparent from observation of his driving behaviour.

A routine check, however, could awaken the suspicion of cocaine or amphetamine abuse if the symptomatic picture of dilated pupils, nervous manner, inexplicable restlessness and talkative

tendency is encountered. If driving irregularities are observed, then the uninhibited driving style predominates, whereby speeds are observed which are not adapted to the situation such as sharp bends, road works and poor weather conditions. The driver under the influence of these drugs overestimates his own ability, and also that of his vehicle.

This group of consumers appears more frequently whilst the effects of cocaine or amphetamine are wearing off, especially when—which is also frequent—they have taken high doses over a period of many hours or days. In the ensuing withdrawal phase, the **state of exhaustion** leads to a pathological need to sleep and depressive moods; also common are orientation disorders and confusion. It can well lead to psychosis or **pseudopsychotic states**, with delusions and paranoia of being constantly watched. These clear symptoms are easily recognised in a routine check.

Conspicuous driving results from the extreme tiredness (slow or changeable speeds, difficulty staying in lane etc.) and also from the orientation disorders (not knowing one's location or where one is going; considerable unsureness /lack of confidence at intersections; possibly stopping in the middle of the road etc.).

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**Appendix 8:** Concentration of morphine, codeine and dihydrocodeine, type of incident*, impairment according to police and medical report** and time difference between incident and blood sampling of the heroin user. The cases have been sorted starting with the lowest morphine concentration.

| No. | Morphine ng/mL | Codeine ng/mL | Dihydrocodeine ng/mL | Incident type* | Impairment according to medical report** | Impairment according to police report** | Time difference [h] between incident and blood sampling |
|---|---|---|---|---|---|---|---|
| 9324 | 0,4 | 0,0 | 101 | 11 | 1 | 1 | 0,75 |
| 9454 | 1,0 | 0,0 | 20 | 43 | 0 | 0 | 0,5 |
| 9339 | 1,0 | 0,0 | 0 | 43 | 3 | 3 | |
| 9341 | 1,0 | 0,0 | 0 | 43 | 0 | 3 | 2,92 |
| 9754 | 2,2 | 0,0 | 3 | 50 | 2 | 3 | 4,53 |
| 9351 | 2,8 | 0,0 | 0 | 12 | 1 | 3 | 0,8 |
| 9008 | 2,8 | 0,7 | 0 | 41 | 3 | 1 | 2,8 |
| 9313 | 2,9 | 1,0 | 0 | 12 | 1 | 3 | 0,83 |
| 9528 | 2,9 | 0,0 | 1 | 22 | 1 | 1 | 0,84 |
| 9814 | 3,0 | 2,7 | 0 | 23 | 2 | 1 | 0,67 |
| 9273 | 3,2 | 0,0 | 0 | 36 | 2 | 3 | |
| 9509 | 3,3 | 0,0 | 144 | 11 | 1 | 1 | |
| 9569 | 4,1 | 4,5 | 265 | 21 | 1 | 1 | 1,56 |
| 9580 | 4,3 | 0,1 | 0 | 22 | 0 | 3 | 1,11 |
| 9299 | 4,5 | 319 | 0 | 12 | 3 | 3 | 1,16 |
| 9576 | 4,7 | 0,0 | 0 | 41 | 1 | 1 | 4,63 |
| 9219 | 4,9 | 2,1 | 0 | 43 | 0 | 2 | 3,67 |
| 9650 | 4,9 | 0,0 | 0 | 11 | 1 | 1 | |
| 9652 | 5,1 | 0,0 | 0 | 33 | 2 | 1 | 0,9 |
| 9949 | 5,1 | 0,0 | 0 | 12 | 3 | 3 | 5,17 |
| 9321 | 5,2 | 2,8 | 3 | 50 | 3 | 3 | 0,25 |
| 9861 | 5,2 | 0,0 | 0 | 12 | 1 | 1 | 1 |
| 9435 | 5,3 | 1,6 | 0 | 21 | 2 | 0 | |
| 9251 | 5,9 | 12,3 | 208 | 21 | 1 | 1 | 1,08 |
| 9750 | 6,0 | 1,2 | 0 | 11 | 3 | 1 | 0,7 |
| 9616 | 6,0 | 0,0 | 0 | 11 | 1 | 1 | 1,02 |
| 9813 | 6,0 | 0,0 | 0 | 21 | 0 | 1 | 1,33 |
| 9818 | 6,1 | 0,0 | 0 | 43 | 2 | 3 | 0,42 |
| 9948 | 6,2 | 0,0 | 0 | 12 | 2 | 3 | 2,89 |
| 9932 | 6,3 | 1,8 | 0 | 43 | 2 | 3 | |
| 9968 | 6,5 | 2,0 | 0 | 23 | 2 | 1 | |
| 9275 | 6,5 | 2,1 | 0 | 33 | 1 | 0 | 0,5 |
| 9981 | 6,8 | 0,0 | 0 | 50 | 0 | 0 | 1,66 |
| 9579 | 6,8 | 2,0 | 0 | 22 | 2 | 0 | 0,75 |
| 9063 | 7,0 | 2,4 | 0 | 43 | 0 | 3 | 0,65 |
| 9908 | 7,1 | 1,5 | 0 | 23 | 1 | 1 | 1,08 |
| 9892 | 7,4 | 0,0 | 115 | 11 | 2 | 3 | 4,25 |
| 9434 | 7,5 | 0,0 | 24 | 43 | 2 | 1 | 0,75 |
| 9363 | 7,5 | 4,3 | 196 | 22 | 0 | 1 | 1,02 |
| 9907 | 7,5 | 1,7 | 0 | 11 | 0 | 1 | 1,58 |

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| No. | Morphine ng/mL | Codeine ng/mL | Dihydrocodeine ng/mL | Incident type* | Impairment according to medical report** | Impairment according to police report** | Time difference [h] between incident and blood sampling |
|---|---|---|---|---|---|---|---|
| 9221 | 7,6 | 0,0 | 0 | 50 | 1 | 0 | 1,22 |
| 9491 | 7,6 | 0,0 | 0 | 50 | 0 | 3 | 1 |
| 9778 | 7,6 | 0,0 | 0 | 22 | 1 | 1 | 1,07 |
| 9680 | 7,7 | 0,0 | 0 | 50 | 2 | 3 | 1,72 |
| 9782 | 7,7 | 0,0 | 0 | 12 | 2 | 3 | 2,35 |
| 9828 | 7,7 | 0,0 | 0 | 42 | 0 | 1 | 3,08 |
| 9635 | 7,8 | 2,0 | 10 | 50 | 1 | 3 | 1,05 |
| 9984 | 7,8 | 2,0 | 0 | 11 | 3 | 3 | |
| 9047 | 8,1 | 0,0 | 921 | 43 | 3 | 0 | |
| 9710 | 8,2 | 0,0 | 0 | 11 | 2 | 0 | 0,92 |
| 9598 | 8,3 | 0,0 | 329 | 50 | 3 | 3 | 3,43 |
| 9810 | 8,5 | 0,0 | 0 | 50 | 2 | 1 | 2,11 |
| 9671 | 8,6 | 0,0 | 0 | 11 | 2 | 3 | 1,75 |
| 9904 | 8,8 | 0,0 | 0 | 41 | 2 | 1 | 0,5 |
| 9894 | 8,8 | 2,1 | 0 | 11 | 2 | 1 | 1,33 |
| 9885 | 8,9 | 0,0 | 0 | 12 | 3 | 1 | 1,34 |
| 9790 | 9,1 | 0,0 | 0 | 43 | 2 | 0 | 0,8 |
| 9594 | 9,2 | 2,3 | 4 | 11 | 1 | 0 | |
| 9505 | 9,5 | 2,6 | 0 | 11 | 2 | 0 | 2,13 |
| 9681 | 9,5 | 0,0 | 0 | 50 | 1 | 3 | 1,35 |
| 9950 | 9,5 | 0,0 | 0 | 50 | 0 | 3 | 3,66 |
| 9805 | 9,9 | 0,0 | 0 | 50 | 0 | 2 | 2,97 |
| 9090 | 10,1 | 0,0 | 0 | 12 | 1 | 1 | 1,63 |
| 9658 | 10,2 | 0,0 | 721 | 11 | 0 | 0 | 1,17 |
| 9135 | 10,6 | 2,5 | 0 | 43 | 2 | 1 | 1,25 |
| 9716 | 10,6 | 0,0 | 50 | 42 | 1 | 3 | 1,25 |
| 9167 | 10,6 | 0,0 | 0 | 42 | 0 | 1 | 2,25 |
| 9107 | 10,6 | 2,4 | 0 | 42 | 2 | 0 | 0,5 |
| 9854 | 10,7 | 0,0 | 0 | 12 | 3 | 3 | 2,5 |
| 9215 | 10,7 | 1,5 | 0 | 11 | 1 | 3 | 0,62 |
| 9450 | 11,0 | 2,0 | 0 | 11 | 2 | 1 | |
| 9183 | 11,1 | 17,0 | 1 | 43 | 0 | 2 | 1,75 |
| 9198 | 11,3 | 4,0 | | 23 | 1 | 1 | 0,75 |
| 9503 | 11,4 | 2,9 | 0 | 11 | 2 | 1 | 1,49 |
| 9970 | 11,4 | 1,8 | 0 | 50 | 1 | 1 | 1,92 |
| 9992 | 11,7 | 3,9 | 0 | 11 | 2 | 2 | 1,17 |
| 9919 | 12,0 | 5,8 | 0 | 42 | 3 | 3 | 0,83 |
| 9235 | 12,0 | 3,0 | 0 | 22 | 2 | 2 | 0,88 |
| 9965 | 12,3 | 3,8 | 0 | 41 | 0 | 2 | 0,75 |
| 9776 | 12,4 | 0,0 | 0 | 43 | 0 | 0 | 0,92 |
| 9268 | 12,4 | 2,6 | 0 | 43 | 2 | 1 | 1,5 |
| 9487 | 12,6 | 5,3 | 0 | 50 | 2 | 3 | 1 |
| 9775 | 12,7 | 0,0 | 0 | 43 | 0 | 0 | 3,3 |
| 9895 | 13,1 | 0,0 | 0 | 12 | 1 | 1 | 1,25 |
| 9439 | 13,2 | 9,4 | | 34 | 1 | 1 | |

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| No. | Morphine ng/mL | Codeine ng/mL | Dihydrocodeine ng/mL | Incident type* | Impairment according to medical report** | Impairment according to police report** | Time difference [h] between incident and blood sampling |
|---|---|---|---|---|---|---|---|
| 9648 | 13,2 | 0,0 | 0 | 50 | 1 | 1 | 1,67 |
| 9278 | 13,4 | 3,5 | 0 | 21 | 2 | 1 | 1,09 |
| 9714 | 13,4 | 0,0 | 0 | 21 | 1 | 0 | 1,08 |
| 9124 | 14,0 | 5,0 | 0 | 12 | 2 | 3 | 0,42 |
| 9691 | 14,3 | 3,5 | 0 | 22 | 0 | 1 | 0,85 |
| 9988 | 14,3 | 2,0 | 0 | 42 | 0 | 1 | 2,59 |
| 9824 | 14,8 | 0,0 | 155 | 50 | 1 | 1 | |
| 9912 | 15,0 | 3,6 | 407 | 50 | 1 | 1 | 1,54 |
| 9091 | 15,0 | 0,5 | 0 | 43 | 2 | 1 | 2,25 |
| 9817 | 15,2 | 0,0 | 0 | 11 | 3 | 3 | 1,5 |
| 9488 | 15,2 | 0,0 | 0 | 43 | 2 | 3 | 1,58 |
| 9417 | 15,9 | 4,3 | 3 | 43 | 2 | 2 | 0,41 |
| 9836 | 16,0 | 4,0 | 0 | 12 | 3 | 3 | |
| 9752 | 16,4 | 4,3 | 700 | 50 | 1 | 1 | 1,17 |
| 9732 | 16,7 | 6,1 | 0 | 22 | 2 | 2 | 0,58 |
| 9986 | 16,8 | 2,8 | 0 | 12 | 1 | 1 | 0,65 |
| 9303 | 16,8 | 4,1 | 0 | 42 | 1 | 3 | 2,2 |
| 9875 | 16,9 | 4,2 | 0 | 50 | 1 | 3 | 1,13 |
| 9819 | 17,2 | 6,0 | 0 | 21 | 0 | 1 | 0,42 |
| 9477 | 17,4 | 0,0 | 0 | 43 | 1 | 3 | |
| 9359 | 17,4 | 5,4 | 90 | 11 | 2 | 1 | 1,45 |
| 9419 | 17,4 | 4,3 | 7 | 11 | 2 | 1 | 2 |
| 9150 | 17,4 | 0,0 | 0 | 43 | 2 | 0 | 0,66 |
| 9204 | 17,6 | 4,8 | 0 | 21 | 2 | 1 | 0,67 |
| 9572 | 17,7 | 2,4 | 0 | 43 | 3 | 2 | 0,5 |
| 9858 | 17,7 | 4,6 | 0 | 43 | 2 | 1 | 8,13 |
| 9329 | 18,1 | 3,6 | 9 | 12 | 3 | 3 | 0,5 |
| 9599 | 18,1 | 36,8 | 0 | 22 | 1 | 1 | 0,17 |
| 9636 | 18,1 | 4,8 | 1 | 43 | 0 | 3 | 0,75 |
| 9038 | 18,5 | 4,0 | 0 | 12 | 1 | 1 | |
| 9786 | 18,5 | 0,0 | 533 | 42 | 2 | 3 | 0,67 |
| 9057 | 18,8 | 0,7 | 12 | 11 | 3 | 1 | 1,5 |
| 9511 | 19,1 | 5,6 | 0 | 43 | 3 | 3 | |
| 9603 | 19,1 | 5,4 | 0 | 34 | 2 | 1 | 0,7 |
| 9606 | 19,4 | 5,3 | 27 | 11 | 1 | 3 | |
| 9364 | 19,6 | 0,0 | 0 | 11 | 2 | 2 | 2,78 |
| 9340 | 19,7 | 0,0 | 0 | 43 | 0 | 3 | |
| 9464 | 19,9 | 3,4 | 4 | 43 | 0 | 0 | |
| 9561 | 19,9 | 0,0 | 0 | 12 | 1 | 1 | 1,27 |
| 9154 | 20,1 | 3,9 | 0 | 42 | 1 | 1 | 0,41 |
| 9659 | 20,6 | 4,2 | 0 | 50 | 2 | 2 | |
| 9255 | 21,1 | 2,9 | 0 | 42 | 1 | 1 | 1,42 |
| 9625 | 21,9 | 9,0 | 671 | 11 | 1 | 1 | 2,34 |
| 9632 | 22,1 | 0,0 | 0 | 43 | 0 | 0 | 2,09 |
| 9437 | 22,7 | 4,8 | 4 | 43 | 0 | 2 | 1,17 |

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| No. | Morphine ng/mL | Codeine ng/mL | Dihydrocodeine ng/mL | Incident type* | Impairment according to medical report** | Impairment according to police report** | Time difference [h] between incident and blood sampling |
|---|---|---|---|---|---|---|---|
| 9061 | 23,0 | 3,6 | 0 | 12 | 2 | 0 | 1,08 |
| 9972 | 23,2 | 5,1 | 0 | 50 | 0 | 2 | 1,08 |
| 9539 | 23,4 | 3,3 | 0 | 43 | 0 | 2 | 1,08 |
| 9338 | 23,5 | 0,0 | 0 | 11 | 1 | 3 | 0,75 |
| 9496 | 23,7 | 0,0 | 18 | 11 | 1 | 1 | |
| 9277 | 23,8 | 5,3 | 0 | 22 | 3 | 1 | 1,75 |
| 9815 | 24,4 | 11,0 | 0 | 42 | 1 | 1 | 0,75 |
| 9232 | 24,7 | 8,5 | 0 | 31 | 1 | 1 | 0,58 |
| 9688 | 24,7 | 0,0 | 0 | 22 | 0 | 2 | 2,09 |
| 9513 | 24,8 | 4,3 | 0 | 43 | 3 | 3 | |
| 9873 | 24,9 | 7,1 | 0 | 21 | 1 | 1 | 0,76 |
| 9060 | 25,1 | 3,2 | 0 | 43 | 3 | 3 | 3 |
| 9266 | 25,9 | 4,6 | 0 | 12 | 1 | 3 | 0,66 |
| 9874 | 26,5 | 13,8 | 0 | 50 | 1 | 3 | 1,48 |
| 9287 | 26,7 | 0,0 | 1394 | 33 | 3 | 1 | 0,83 |
| 9515 | 27,1 | 5,9 | 0 | 43 | 1 | 2 | |
| 9335 | 27,2 | 6,2 | 3 | 43 | 2 | 0 | 1,58 |
| 9073 | 28,7 | 6,2 | 265 | 12 | 2 | 1 | 1,36 |
| 9285 | 28,8 | 13,5 | | 42 | 2 | 1 | 1,66 |
| 9383 | 29,0 | 5,2 | 0 | 42 | 2 | 1 | 2 |
| 9480 | 29,6 | 5,7 | 23 | 50 | 3 | 0 | |
| 9282 | 29,7 | 0,0 | 1462 | 21 | 2 | 1 | 0,75 |
| 9926 | 29,7 | 7,3 | 0 | 11 | 1 | 3 | 6,43 |
| 9127 | 30,0 | 2,0 | 7 | 22 | 1 | 1 | 0,7 |
| 9355 | 30,2 | 3,3 | 3 | 12 | 0 | 1 | 2,47 |
| 9191 | 30,3 | 10,1 | 0 | 36 | 2 | 0 | 2,16 |
| 9020 | 30,4 | 4,8 | 0 | 36 | 1 | 1 | 1,13 |
| 9766 | 30,9 | 7,5 | 0 | 43 | 2 | 3 | 3,05 |
| 9310 | 31,0 | 10,0 | 307 | 21 | 2 | 1 | 0,92 |
| 9356 | 31,0 | 6,4 | 1 | 23 | 3 | 1 | |
| 9927 | 31,4 | 7,3 | 0 | 12 | 1 | 1 | 1,08 |
| 9372 | 31,5 | 7,4 | 0 | 43 | 0 | 1 | 0,92 |
| 9208 | 32,0 | 2,4 | 0 | 11 | 0 | 3 | 8,5 |
| 9676 | 33,0 | 0,0 | 0 | 21 | 2 | 2 | 1,58 |
| 9682 | 33,1 | 5,4 | 0 | 21 | 0 | 1 | |
| 9475 | 33,1 | 5,8 | 4 | 43 | 1 | 2 | |
| 9662 | 34,0 | 0,0 | 168 | 12 | 3 | 3 | |
| 9512 | 34,1 | 5,1 | 0 | 43 | 3 | 3 | |
| 9301 | 34,4 | 0,0 | 0 | 22 | 0 | 1 | 1,2 |
| 9742 | 35,1 | 11,1 | 0 | 11 | 2 | 1 | 1,17 |
| 9230 | 35,4 | 11,8 | 0 | 43 | 1 | 3 | 0,48 |
| 9428 | 36,1 | 6,2 | 0 | 31 | 1 | 2 | 4,22 |
| 9399 | 37,6 | 3,2 | 0 | 43 | 1 | 1 | 3 |
| 9319 | 37,8 | 6,0 | 0 | 42 | 1 | 3 | 2,17 |
| 9872 | 38,6 | 8,7 | 9 | 25 | 2 | 1 | 1 |

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| No. | Morphine ng/mL | Codeine ng/mL | Dihydrocodeine ng/mL | Incident type* | Impairment according to medical report** | Impairment according to police report** | Time difference [h] between incident and blood sampling |
|---|---|---|---|---|---|---|---|
| 9578 | 38,9 | 8,1 | 0 | 11 | 3 | 1 | 1 |
| 9082 | 39,0 | 0,0 | 0 | 42 | 3 | 1 | |
| 9709 | 39,2 | 0,0 | 0 | 12 | 2 | 1 | 2,67 |
| 9647 | 39,6 | 0,0 | 0 | 25 | 0 | 2 | |
| 9160 | 39,9 | 6,8 | 0 | 43 | 2 | 1 | 1,33 |
| 9148 | 40,1 | 11,2 | 504 | 12 | 3 | 0 | |
| 9297 | 40,4 | 980 | 459 | 13 | 3 | 3 | 4,3 |
| 9712 | 42,0 | 13,2 | 23 | 21 | 2 | 2 | 0,92 |
| 9361 | 42,9 | 7,4 | 0 | 11 | 2 | 1 | 0,7 |
| 9176 | 43,5 | 17,0 | 0 | 43 | 2 | 1 | 1,16 |
| 9316 | 44,0 | 2,0 | 0 | 21 | 2 | 1 | 0,75 |
| 9320 | 44,4 | 5,5 | 5 | 21 | 1 | 1 | 1,08 |
| 9936 | 44,8 | 7,8 | 0 | 50 | 1 | 1 | 1,76 |
| 9887 | 45,1 | 15,0 | 0 | 21 | 2 | 1 | 1 |
| 9371 | 45,3 | 6,4 | | 12 | 1 | 3 | 1,25 |
| 9853 | 46,6 | 12,0 | 0 | 12 | 3 | 3 | 1,75 |
| 9286 | 46,9 | 9,4 | 0 | 21 | 2 | 1 | 1,38 |
| 9876 | 47,5 | 6,0 | 615 | 43 | 2 | 1 | 1,67 |
| 9452 | 48,0 | 12,0 | 0 | 11 | 0 | 2 | 1,92 |
| 9869 | 49,0 | 12,9 | 153 | 50 | 2 | 1 | 1 |
| 9740 | 49,3 | 9,1 | 0 | 41 | 1 | 2 | 1,5 |
| 9629 | 49,6 | 10,3 | 0 | 11 | 2 | 1 | 1,21 |
| 9526 | 50,0 | 5,8 | 0 | 43 | 0 | 1 | |
| 9093 | 50,0 | 17,0 | 1130 | 12 | 3 | 3 | |
| 9246 | 51,9 | 13,1 | 0 | 33 | 0 | 0 | 1,08 |
| 9995 | 52,3 | 12,1 | 0 | 11 | 0 | 1 | 1,03 |
| 9111 | 52,4 | 8,6 | 655 | 12 | 2 | 2 | 1,04 |
| 9459 | 54,0 | 0,0 | | 44 | 3 | 3 | |
| 9791 | 54,2 | 6,0 | 0 | 25 | 2 | 1 | 0,48 |
| 9375 | 54,3 | 9,1 | 0 | 43 | 2 | 0 | 2,55 |
| 9250 | 54,9 | 3,1 | 6 | 42 | 2 | 1 | 1,34 |
| 9039 | 55,6 | 10,2 | 0 | 43 | 0 | 2 | 2,08 |
| 9630 | 57,2 | 8,1 | 0 | 50 | 0 | 3 | |
| 9122 | 58,2 | 18,2 | 0 | 12 | 2 | 3 | 0,92 |
| 9242 | 58,5 | 10,2 | 3 | 50 | 0 | 3 | 0,67 |
| 9049 | 58,6 | 10,0 | 0 | 21 | 2 | 1 | 0,3 |
| 9631 | 59,4 | 17,7 | 564 | 23 | 2 | 1 | 1,33 |
| 9733 | 60,1 | 12,5 | 0 | 50 | 1 | 1 | 1,25 |
| 9751 | 62,2 | 11,6 | 1584 | 21 | 1 | 1 | 1,16 |
| 9342 | 62,7 | 0,0 | 0 | 25 | 1 | 1 | 0,8 |
| 9426 | 66,0 | 14,0 | | 11 | 2 | 1 | 0,67 |
| 9445 | 73,1 | 7,3 | 0 | 43 | 2 | 1 | 0,75 |
| 9864 | 73,1 | 14,2 | 0 | 21 | 1 | 2 | 1,16 |
| 9203 | 76,4 | 11,6 | 0 | 36 | 1 | 1 | |
| 9901 | 83,7 | 17,1 | 0 | 42 | 1 | 3 | 0,67 |

APPENDIX

| No. | Morphine ng/mL | Codeine ng/mL | Dihydrocodeine ng/mL | Incident type* | Impairment according to medical report** | Impairment according to police report** | Time difference [h] between incident and blood sampling |
|---|---|---|---|---|---|---|---|
| 9117 | 84,2 | 13,1 | 0 | 43 | 2 | 2 | 1,03 |
| 9269 | 86,0 | 13,6 | 0 | 22 | 2 | 3 | 1,16 |
| 9389 | 87,2 | 20,7 | 0 | 25 | 1 | 1 | 0,75 |
| 9743 | 89,0 | 9,0 | 0 | 15 | 2 | 1 | 1,33 |
| 9106 | 99,0 | 5,0 | 2 | 50 | 3 | 3 | |
| 9104 | (102) | 2,5 | 6 | 50 | 3 | 3 | 1,58 |
| 9753 | 103 | 16,0 | 1528 | 25 | 1 | 1 | 1,08 |
| 9239 | 108 | 16,6 | 74 | 11 | 3 | 1 | 0,92 |
| 9425 | 112 | 19,2 | 3 | 43 | 2 | 3 | 0,75 |
| 9292 | 114 | 12,7 | 0 | 11 | 0 | 1 | |
| 9109 | (114) | 11,0 | 10 | 43 | 3 | 3 | 1,5 |
| 9429 | 118 | 27,1 | 6 | 21 | 0 | 1 | 0,42 |
| 9062 | 132 | 8,0 | 0 | 43 | 2 | 2 | 1,25 |
| 9055 | 134 | 31,9 | 0 | 42 | 1 | 3 | |
| 9322 | 134 | 20,0 | 60 | 12 | 3 | 3 | |
| 9289 | 141 | 30,8 | 0 | 43 | 3 | 2 | 1,43 |
| 9641 | 156 | 43,7 | 0 | 43 | 1 | 3 | 0,93 |
| 9110 | (167) | 10,4 | 648 | 12 | 2 | 3 | 1,25 |
| 9114 | 179 | 15,1 | 0 | 43 | 2 | 2 | 1,25 |
| 9044 | (183) | 20,0 | 7 | 42 | 3 | 1 | 1,91 |
| 9170 | (187) | 7,0 | 0 | 13 | 3 | 3 | |
| 9542 | 190 | 26,0 | 0 | 43 | 1 | 1 | 1,03 |
| 9362 | 197 | 22,8 | 0 | 11 | 0 | 1 | 1,17 |
| 9381 | 215 | 41,7 | 0 | 42 | 1 | 1 | 1,17 |
| 7999 | (230) | 15,0 | 500 | 12 | 2 | 1 | 0,79 |
| 9136 | (296) | 26,0 | 6 | 22 | 2 | 1 | 1,33 |
| 9041 | (390) | 9,0 | | 43 | 2 | 1 | 1,67 |
| 9098 | (530) | 23,9 | 18 | 22 | 3 | 1 | |

# APPENDIX

Statistic

| | free morphine*** ng/mL | Codeine ng/mL | Dihydrocodeine ng/mL | Time difference [h] between incident and blood sampling |
|---|---|---|---|---|
| Average | 31,7 | 11,2 | 74,6 | 1,5 |
| σ | 35,4 | 65,2 | 245 | 1,16 |
| Min. | 0,4 | 0 | 0 | 0,17 |
| Max. | 215 | 980 | 1584 | 8,5 |
| n | 239 | 248 | 241 | 204 |

* Abbreviations:

Type of incident:

| | | |
|---|---|---|
| 11 minor accident | 12 serious accident | 13 very serious accident |
| 21 slight weaving | 22 pronounced weaving | 23 stalling motor |
| 24 incorrect lighting | 25 other conspicuous driving | |
| 31 red light offence | 32 ignored stop sign | 33 too fast |
| 34 too slow | 35 dangerous overtaking | 36 other |
| 41-43 routine check | 50 miscellaneous | |

**Impairment according to police / medical report: 0: none; 1: strong; 2: moderate to low; 3: cannot be judged

***The morphine concentration in brackets are values resulting from acid hydrolysis. In these cases, sample material for the retrospective determination of free morphine was no longer available.