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**Sven Schneider, Katharina Diehl, Christina Bock, Raphael M. Herr, Manfred Mayer,
Peter Lindinger und Tatiana Görig**

Terra incognita Hausarztpraxis – Tabakentwöhnung in der deutschen Primärversorgung

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Trends im Substanzkonsum Jugendlicher: Gibt es regionale Unterschiede?

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Übersichtsarbeit

Indication for the Assessment of Driver Fitness after Problematic Alcohol Consumption

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Abstract: *Objectives:* The present review of literature examines the relationship of alcohol consumption and fitness to drive. The legal limit (1,6 ‰) for establishing fitness to drive by means of a medical-psychological assessment (MPA) in Germany is analyzed on the background of published empirical research to present recommendations for the improvement of the current legal situation and administrative practice. *Methods:* 103 published articles have been analysed (inclusion criteria: completeness, comprehensibility, and experimental manipulation of the blood alcohol concentration [BAC]). The number of alcohol-induced impairments is to be shown in a quantitative analysis. The qualitative analyses of the studies will reveal the impaired areas of psychological and medical functioning. *Results:* It appears that 97 % of the documented impairments occur at a maximum BAC of 1,1 ‰. Numerous skills are impaired by low doses of alcohol (e.g. attention, memory, perception). *Conclusion:* Alcohol-induced impairments arise at a BAC far below 1.6 ‰, which marks the legal limit for a medical-psychological assessment (MPA) after drunk driving in Germany. The BAC limit in the current ordinance for assigning a medical-psychological fitness assessment cannot be confirmed on the basis of research findings. A reduction of this BAC limit to 1,1 ‰ is proposed.

Keywords: fitness to drive, medical and psychological assessment, alcohol-induced impairments, Driving Under Influence (DUI)

Indikation zur Fahreignungsbegutachtung nach problematischem Alkoholkonsum

Zusammenfassung: *Fragestellung:* Die Literaturanalyse untersucht den Zusammenhang zwischen Alkoholkonsum und psychofunktionalen Ausfallerscheinungen. Die Grenze der Blutalkoholkonzentration (BAK) von 1,6 ‰ für die Zuweisung einer Fahreignungsbegutachtung, im Speziellen der Medizinisch-Psychologischen Untersuchung (MPU), soll analysiert werden, um Empfehlungen für die rechtliche Situation und Verwaltungspraxis zu geben. *Methodik:* Es wurden 103 Studien analysiert, die die Eingangskriterien (Vollständigkeit, Nachvollziehbarkeit, experimentelle Manipulation der BAK) aufwiesen. Die Auswertung wurde in Form einer quantitativen (in welchen Bereichen der BAK zeigen sich Ausfallerscheinungen) und einer qualitativen Analyse (welche psychofunktionalen Bereiche sind durch Alkohol beeinträchtigt) vorgenommen. *Ergebnisse:* 97 % aller Ausfallerscheinungen treten bei einer BAK von maximal 1,1 ‰ auf. Verschiedene psychofunktionale Bereiche (Aufmerksamkeit, Motorik, Wahrnehmung etc.) sind auch bei moderater Alkoholisierung beeinträchtigt. *Schlussfolgerungen:* Alkoholinduzierte psychofunktionale Ausfallerscheinungen treten bereits bei einer BAK von weit unter 1,6 ‰ auf. Folglich lässt sich der Kennwert von 1,6 Promille für die Zuweisung zu einer Fahreignungsbegutachtung gemäß § 13 FeV empirisch nicht bestätigen. Es empfiehlt sich eine Anpassung des Grenzwertes auf 1,1 ‰.

Schlüsselwörter: Fahreignung, Medizinisch-Psychologische Untersuchung, alkoholinduzierte Ausfallerscheinungen, Trunkenheitsfahrten

Introduction

Above all the Constitution of the Federal Republic of Germany guarantees that everybody has the right of life, physical integrity and personal freedom. These rights may only be restricted by law. So each individual can decide whether he or she takes part in traffic or not. But driving a motor vehicle increases the danger for the general public. The state has the duty to protect all citizens – also by means

of traffic safety. Therefore, people who do not qualify for driving a motor vehicle cannot own a driver's license. In the Road Traffic Act (*Straßenverkehrsgesetz*) and the Driving License Ordinance (*Fahrerlaubnis-Verordnung*) it is stated who is allowed to drive a car and/or other motor vehicles. The German Road Traffic Act defines a suitable driver as someone who fulfils the necessary physical and mental needs and has not significantly or repeatedly violated traffic rules or criminal law.

The appendix of the Driving License contains a list of physical and mental diseases and impairments that may lead to doubts in the fitness to drive. This list includes the problem of alcohol abuse and alcohol addiction. After an incident of driving under the influence of alcohol (DUI)¹ the administrative authority (Office of Driving Licenses in Germany) is entitled to request a medical or medical-psychological assessment of a driver's fitness, if the driver had a blood alcohol concentration (BAC) of $\geq 1,6 \text{ ‰}$ ². The medical-psychological assessment (MPA), also known as "assessment of fitness to drive", is intended to help the licensing authority to make a decision on the withdrawal or renewal of a driving license.

The MPA is divided into a medical and a psychological examination (interview, performance tests). After the assessment the applicant concerned receives a written expert opinion (report) that he can submit to the Office of Driving Licenses in order to eliminate the official doubts in his driving ability and to get his driving privileges re-installed. The Office of Driving Licenses then decides on relicensing. The formal written expert opinion follows specific rules that are set out in the requirements of the Federal Highway Research Institute (BAST).

In addition to the BAC limit of 1.6 ‰ there are other BAC limits in the German legislation concerning traffic safety. Driving with a blood alcohol concentration of 0.5 ‰ or more is a misdemeanour according to § 24 of the Road Traffic Act (StVG). With a BAC of 1.1 ‰ or more a driver is absolutely unfit to drive and the offence is therefore a criminal offence (§ 24 Criminal Code, StGB). It needs to be clearly stated that blood alcohol concentrations from 0.3 ‰ to 0.5 ‰ may constitute a criminal offence if driving errors were observed. That may result in an immediate loss of the license. Accordingly, the legislator provides a sentence even at low blood alcohol concentration; however, the assessment of driver fitness is only mandatory for DUI offenders with a BAC $\geq 1.6 \text{ ‰}$ or repeated DUI offences. The legislature is explaining the current BAC limit with the recent state of research. It is not explained what exactly is meant by "current state of research". The legislator also does not provide a differentiated picture of the sources. Yet, these BAC limits are the basis for administrative decision.

As some 54 % out of 106.082 medical-psychological assessments are due to DUI alcohol is the most common reason for a MPA in 2011 (BAST, 2012). Figure 1 provides an overview of the frequency distribution of the different assessment reasons for an MPA in 2011.

An evaluation study on the recidivism rate of DUI offenders after the MPA found that between 91,7 % and 93,5 % of the MPA participants were not re-offending. The recidivism rate differs between 6,5 % (first-time offenders) and 8,3 % (multiple offenders) (Hilger et al., 2012).

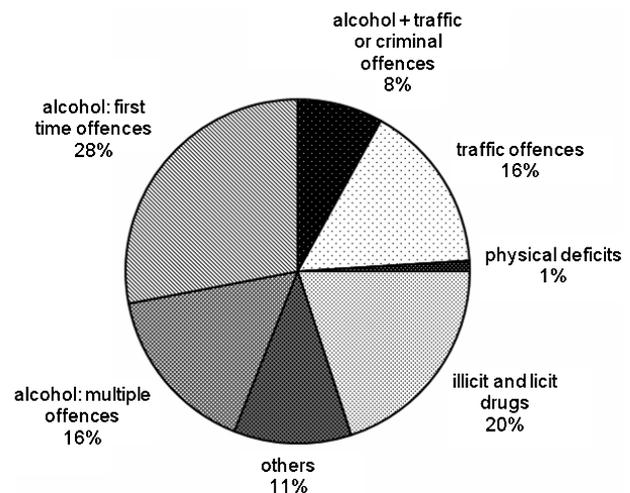


Figure 1. Reasons for MPA in 2011.

It was also noted that alcohol-related impairments occur in various psycho-functional areas even at much lower blood alcohol concentrations. Moskowitz and Robinson (1988) analysed 177 studies of the 1950s until 1985. They concluded that alcohol-induced impairments occur at a BAC of $\geq 0.8 \text{ ‰}$ in 66 % of the studies, and was detected at a BAC of $\geq 1.0 \text{ ‰}$ in almost all studies. In a later report by Moskowitz and Fiorentino (2000), in which 112 studies from 1981–1997 had been included, in 94 % of the studies alcohol induced impairments occurred at a BAC of $\geq 0.8 \text{ ‰}$. These results suggest that the legislatively specified limit of a BAC of 1.6 ‰ for the assignment of a MPA probably is set too high.

The risk in road traffic and hence a threat to the public interest cannot be lowered if only hardcore drunken drivers are rated dangerous. It seems appropriate to assess also those drivers who take part in traffic despite visible alcohol-related impairments. Considering that serious alcohol-related impairments occur at about 0.8 ‰ (and should be noticed by the driver) the fitness to drive should be questioned especially when the driver feels able to operate a vehicle with such a BAC.

This study examines the association between alcohol consumption and driving ability with a particular focus on attention performance. It is to be investigated, at which BAC level deficits occur and what psycho-functional areas are affected.

The investigation will be used to analyse, review and evaluate the statutory parameters of blood alcohol concentrations. Furthermore, it is checked whether the legislative history regarding the 1998 reduction of 1.99 ‰ to 1.6 ‰ today, meets the current state of knowledge and research.

Methods

The aim of this study is to analyse which BAC leads to impairments and what kinds of impairments occur under the influence of alcohol. For this purpose, published articles

¹ A DUI-offence in this article always refers to alcohol related offences and not to other drugs.

² In Germany, the blood alcohol concentration is measured in per mille (1 ‰ = 1 g/kg = 1,06 g/l and 1 g/l = 0,94 g/kg = 0,94 ‰).

have been collected and analysed. The following keywords were used in German and English:

- alcohol / attention
- alcohol / driving
- alcohol / performance

Based on the first studies found, more keywords were created that were related to the given psycho-functional areas, e.g. tracking, perception and similar ones.

The research of published studies was conducted with the help of the search engine “Google scholar” as well as “PsycINFO[®]” and “PubMed” to search different scientific publishing companies and servers at a time.

The research time started in January 2010. Articles that were found or sent afterwards could not be included into the analysis.

A total of 129 studies have been scanned for the literature review.

For the further analyse the 129 studies had to meet the following inclusion criteria:

- The papers had to be complete. An abstract of a paper as only source was a reason to exclude the study from the analysis of literature. In case an abstract was found and the content seemed to meet the other inclusion criteria it was tried to get a full text version of the article whether by further online search or by contacting the author. If it was not possible to receive a full text article of a study the study was then excluded from this analysis.
- The methods had to be comprehensible and verifiable.
- The BAC had to be manipulated and reported in the paper.
- There had to be performance changes that could be attributed to the alcohol intoxication. A change of the performance had to be proved by statistical significance testing using at least $p < 0,05$. Findings that concluded there is a “trend” of alcohol-induced performance changes – meaning the performance decreased but the test of statistical significance was lower than the critical value of $p < 0,05$ – the study was excluded from the analysis of the studies with significant findings because the probability is high that the difference or relationship happened by chance. In a second step the studies with statistically significant and non-significant findings were compared.

Of the 129 found articles, 103 studies fulfilled the inclusion criteria. These articles were published from 1958 to 2009. The search for articles was finished in April 2010.

In these 103 studies, 190 singular impairments were identified.

The analysis of the publications was purely descriptive. A closer inspection of effect sizes was not possible because the necessary data had not been reported in the majority of the studies.

The analysis differentiated between quantitative and qualitative results. The qualitative analysis primarily investigated the type of alcohol-induced impairments while the number of impairments in certain blood alcohol concentrations was examined in the quantitative analysis.

International studies use various units of measurement for blood alcohol concentration, e.g. g/l, g/kg, ‰, ‰ or mg/100 ml. The different units were multiplied or divided by the corresponding factor to obtain the BAC in ‰ as it is common in Germany. In some studies included in the review, the BAC was determined by measuring the breath alcohol concentration. The values given always refer to BAC and have been reported in the studies.

Results

Qualitative results

The tests for identifying impaired functions of each study were analysed and categorized for the classification of psycho-functional areas that are impaired by alcohol. The resulting categories then defined the areas of impairment which were summarized and generalized. In Table 1, the categories and the impaired areas are listed.

Quantitative results

In order to identify the BAC levels at which the categorized psycho-functional areas are impaired, the data were evaluated on a quantitative level. The results in table 2 illustrate that the majority of the studies found impairments in the electrophysical activity, memory, reaction time and attention.

The quantitative results demonstrate that in 54 % of all studies alcohol-induced deficits occur at a BAC of less than 0,8 ‰. 94 % of the analysed impairments were detected at a BAC of less than 1,1 ‰.

Two older reviews (Moskowitz & Robinson, 1988; Moskowitz & Fiorentino, 2000) were used to compare these results. In the study by Moskowitz and Robinson (1988) 177 studies from 1950 to 1988 were analysed. In another study by Moskowitz and Fiorentino (2000) 112 articles from 1981 to 1997 were reviewed. 28 articles of this analysis of literature have also been analysed in one of this two comparative studies³. Those articles were not excluded from the analysis to avoid a bias. The comparison of the two literature reviews as well as the current one shows similar distributions of different BAC levels that caused impairment with a peak between 0,5 and 1,1 ‰. 90 to 97 % of all alcohol-induced deficits in these three reviews occur at a BAC of up to 1,1 ‰.

To summarize the results so far, about half of all examined impairments occur at a BAC of 0,5 ‰. Almost all

³ The fact the “only” 28 articles in this analysis were also found by Moskowitz et al. 1988 and 2000 might be due to the different research methods since the development of the internet and especially the improvement of search engines in the last years. Also this analysis was started 10 years after the last Moskowitz study so that a lot of newer studies were published in the meantime.

Table 1
Psychological categories and functions impaired by alcohol

Category	Impaired function
Attention	Alertness Shift of attention Sustained attention Divided attention Selective attention Vigilance Visual attention
Detection	Visual detection Audio detection
Electrophysiological Activity	The following event related potential and frequency bands were impaired under the influence of alcohol: P1, P2, P3, P3a N1, N1b, N2, N2b, N450 LPP, NSW, MMN, RRN Alpha-Band Gamma-Band Theta-Band
Driving	This category refers to all studies using a driving simulator.
Memory	Short term memory Working memory Long term memory Spatial memory Visual short and long term memory
Brain physiology	The following anatomical and functional areas of the brain showed abnormalities in inebriation: Striatum Cingulum basal ganglia Paraventricular system Bilateral brain volume Right Hemisphere Interhemispheric Transmission processing speed Neural Latency TMS-reaction
Intellectual Skills	Abstracting Associating Categorizing Coding Cognitive flexibility Logical thinking Concentration in math Mental Transformation Problem Solving Spatial performance Reasoning

Table 1
Psychological categories and functions impaired by alcohol (Continued)

Category	Impaired function
Motor skills	Equilibrium Reflexes Physical co-ordination Posture Muscle response
Reaction time	Simple reaction time Choice reaction time Inspection time
Visual performance	Field of vision Eye movement Accommodation
Tracking	Visuomotor coordination Hand-eye-coordination Compensatory Tracking
Inhibitory control	Performance monitoring Inhibitory control
Perception	Auditive and visual discrimination Perception

Table 2
BAC levels of alcohol-induced impairments for the psychological functions

Category	≥ 0,0 ‰	≥ 0,3 ‰	≥ 0,5 ‰	≥ 0,8 ‰	≥ 1,1 ‰	≥ 1,6 ‰	Sum
Attention	0	7	9	5	1	0	22
Detection	1	1	3	2	0	0	7
Electrophysiological Activity	0	3	11	17	0	0	31
Driving	0	0	6	3	1	0	10
Memory	0	0	11	17	0	0	28
Brain physiology	0	0	7	2	0	0	9
Intellectual skills	0	0	11	10	0	0	21
Motor skills	0	1	3	4	0	0	8
Reaction time	1	2	11	9	1	1	25
Visual performance	1	0	1	0	1	0	3
Tracking	0	0	7	6	0	0	13
Inhibitory control	0	0	5	4	0	0	9
Perception	0	0	2	2	0	0	4
Sum	3	14	87	81	4	1	190

deficits occur at a BAC of up to 1,1 ‰. Only few studies examined deficits at 1,6 ‰ BAC or higher.

To view the results of the scientifically proven alcohol-induced impairments into a broader context, we need to have a closer look at those psycho-functional areas that were not impaired by alcohol.

Hence, published studies were analysed according to deficits that did not show up at a certain BAC level, con-

cluding that there was no significant impairment caused by the consumption of alcohol. An equivalent overview was used to present the “negative results” meaning non-significant or non-existent changes in different areas by alcohol (possibly due to insufficient methods to detect changes).

Table 3 shows the same categories as used before and the number of impairments that could not be proven at the induced BAC level.

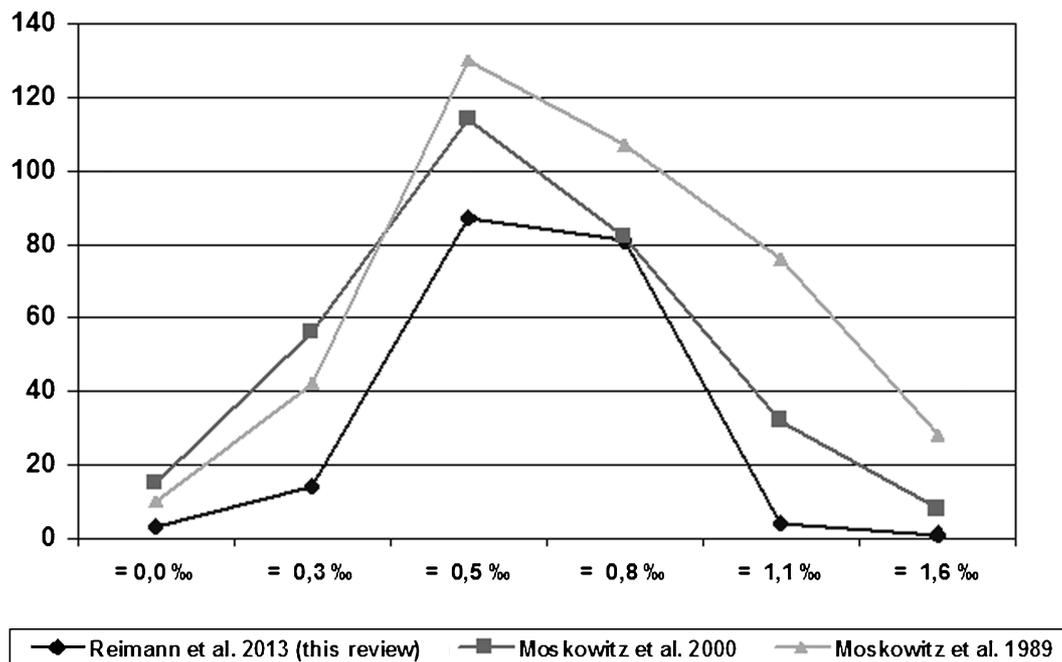


Figure 2. Comparison of the number of alcohol-induced impairments by BAC level of three literature reviews.

Table 3

Categories of impairments that could not be verified in the studies by means of statistical significance. The figures reflect the quantified number of impairments (multiple impairments per article possible)

Category	≥ 0,0 ‰	≥ 0,3 ‰	≥ 0,5 ‰	≥ 0,8 ‰	≥ 1,1 ‰	≥ 1,6 ‰	Sum
Attention	3	11	6	4	0	0	24
Detection	0	0	1	0	0	0	1
Electrophysiological Activity	0	15	14	10	0	0	39
Driving	1	2	3	0	0	0	6
Memory	1	7	10	11	0	0	29
Brain physiology	0	0	0	0	0	0	0
Intellectual skills	0	8	6	7	0	1	22
Motor skills	1	2	0	0	0	0	3
Reaction time	3	8	7	3	0	0	21
Visual performance	0	1	1	1	2	0	5
Tracking	0	4	3	2	0	0	9
Inhibitory control	0	0	0	0	0	0	0
Perception	0	0	1	0	0	0	1
Sum	9	58	52	38	2	1	160

Differences become obvious in comparison with the proven impairments (Table 2). As an example, there were only significant impairments for brain physiology and inhibitory control. In other categories there were almost as many proven as unproven deficits, i.e. attention, electrophysical activities, memory, intellectual skills, reaction time and tracking. Comparing the summarized graphs of significant and non-significant alcohol-induced impairments,

it is descriptively obvious that, overall, there are more proven impairments caused by alcohol (Figure 3).

Hence, the impairments depend on the BAC level. While it is more difficult to prove an impairment at a BAC of below 0,5 ‰, there are many proven impairments at a BAC between 0,5 and 1,1 ‰. The experimental examination of physiological and psychological changes caused by alcohol with a BAC of more than 1,1 ‰ does not seem to be

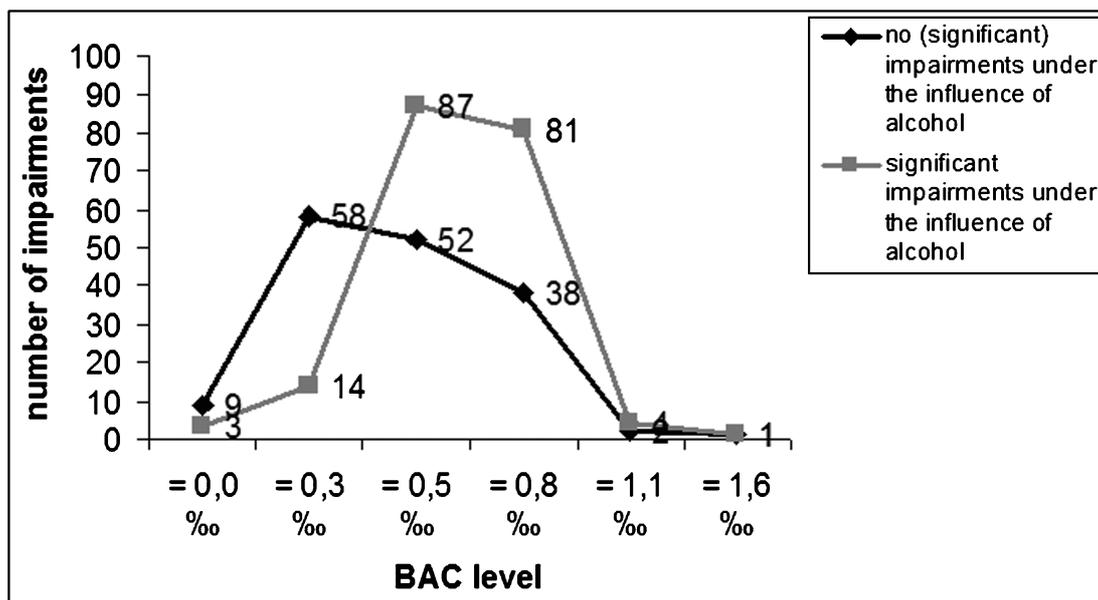


Figure 3. Comparison of significant and non-significant impairments caused by alcohol (multiple impairments per study possible).

of much research interest, because only one out of 129 studies examining that BAC level could be found.

Discussion

The literature analysis had impressively shown that alcohol-induced impairments occur already at moderate BACs. 97 % of all deficits that were reported in the analysed studies arise at a BAC of less than 1,1 ‰.

The comparison of impairments that were experimentally proven with those that could not be verified at a certain BAC level has demonstrated that there are no constant impairments – especially at a BAC level below 0,5 ‰ for some areas, i.e., attention and electro-physical activity. This might be due to an intra-individual variability. On the other hand, the tests used might not be comparable. Nonetheless it is obvious that alcohol-induced impairments clearly influence human performance at a BAC of 0,5 ‰ and more.

Despite the number of 103 analysed studies the literature analysis underlies certain limitations in its interpretation range. The “apples and oranges problem” or uniformity problem is known from meta-analysis research. Studies are mixed and compared that differ in important criteria such as sample, characteristics of the subjects or evaluation methods. Thus the comparability is limited. The problem was counteracted by using the experimental method to categorize the psycho-functional areas and not adopting the dependent variable(s) named by the author (s). The limited comparability of sample characteristics (sex, age, education, etc.) could not be resolved, however, and must be considered when interpreting the data.

To make generalizations another limitation in the findings has to be taken into account – the so called

“publication bias”. It is caused by the selection process for the publication of studies and their results. In general more studies are published that find a significant effect whereas non-significant findings remain unpublished in the drawer of the researcher (“file drawer problem”). As a consequence, there might be a number of studies that are not accessible because they were never published due to a lack of statistical significance. In this review non-significant results were included. Most of them were reported within papers that also reported significant impairments caused by alcohol consumption. Only one study reported no significant effects at all (Talland, 1966) and two studies proved significant performance improvements (Mann, Cho-Young & Vogel-Sprott, 1984; Parker et al., 1981). This small number of studies does suggest that the bias exists primarily through the publication of significant findings.

A final issue lies in the differing quality of studies. The quality of the examination affects key parameters of the power of an investigation, such as the effect size. These values were not used in this literature analysis, since they also were not always reported in the publications. Trying to obtain some quality control the entrance criterion of verifiability was installed.

In summary, all psycho-functional activities are severely impaired at a maximum BAC of 1.1 ‰. Drivers with a BAC of 1.1 ‰ show a variety of substantial impairments. If someone still feels able to drive with such a BAC an “unusual habituation to toxin” (term used by German legislation: “ungewöhnliche Giffestigkeit”) is indicated. This means that the person concerned is used to alcohol in such an amount that he does not register the caused impairments. Such a driver shows less impairment than someone with less experience in drinking alcohol with the same BAC (Schubert & Mattern, 2009). The DUI offenders are required by law to notice their alcohol-induced impairments despite their

reduced risk-awareness and self-assessment. Consequently, if a drunk driver with a BAC of around 1.1 ‰ is still willing to drive a car he or she is either a heavy drinker and not able to notice impairments or wilfully ignoring them.

Hence it can be assumed that DUI offenders with a BAC of even less than 1.6 ‰ are a special danger for traffic safety. Demanding an MPA only at a BAC of 1.6 ‰ or more covers “the tip of the iceberg”.

The impact of a BAC of more than 1.1 ‰ is rarely investigated in scientific studies because impairments generally occur at a lower BAC.

These science-based facts prove that the limit of 1.6 ‰ no longer corresponds to the scientific consensus as presented in the explanatory memorandum by the government.

Because of the research results it must be concluded that there is a severe risk for road safety even at much lower BAC than 1.6 ‰. However, the decision of the legal BAC limits are imposed by legislation. Thus it is a political decision to lower the legal limit for assigning a MPA. The legislation has to estimate whether the risk is acceptable, or whether it is time to lower the legal guidelines from 1.6 to 1.1 ‰ in the interest of traffic safety and thus follow the empirical findings. As evaluation studies have shown, the MPA is an instrument to separate those DUI offenders with a high risk to re-offend from the “fitter” drivers. The German MPA is meant to help DUI offenders to sustain or re-obtain their mobility in traffic. This approach is different from other countries. The following examples show the consequences of a DUI offence in some countries (Schubert, 2010):

- In Italy and some U. S. states (e.g. California) the vehicle of a DUI driver with a BAC of 1.5 ‰ or more is confiscated and auctioned.
- In France every driver with a BAC of 0.5 ‰ or more will be punished in case of an accident – regardless of the question of guilt. The license may be revoked for up to 6 years and must be refiled afterwards. For very serious accidents that have led to work incapacity for 3 months and even deaths, the DUI offender is imprisoned and fined up to EUR 150,000.
- In Japan, the legal alcohol limit is 0.3 ‰. Drunk drivers, as well as passengers, car holder and alcohol sellers are punished with forced labor up to 5 years or fines of up to \$ 10,000.

These consequences of a DUI offence seem to be quite harsh compared to the German system of MPAs. But they reflect the risk of alcohol in traffic to some degree. Figure 4 displays the risk of causing an accident as a function of BAC. This risk increases by factor 30 between a BAC of 1.0 and 1.6 ‰. Politics and legislation have to decide whether they are willing to take this risk.

These findings have a number of implications for the system of driver's fitness assessment.

It is recommended to adapt the BAC limit for the indication of a driver's fitness assessment to 1.1 ‰ to increase road safety. Secondly, there should be a diagnostic investigation of the drunk driver immediately after the

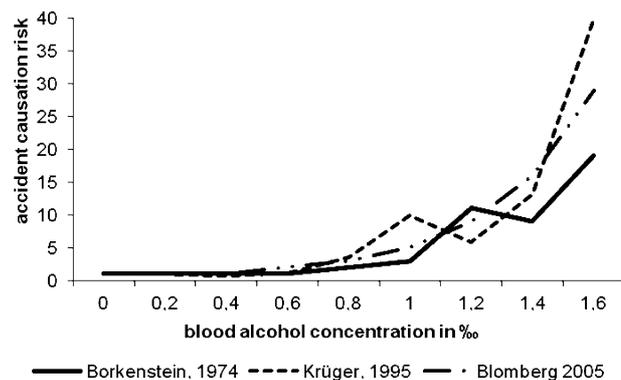


Figure 4. Risk of causing an accident and the influence of alcohol (Borckenstein, Crowther, Shumate, Ziel & Zylmann, 1974; Krüger, Kazenwadel & Vollrath, 1995; Blomberg, Peck, Moskowitz, Burns & Fiorentino, 2005).

DUI offence to identify the individual problem of the offender. Schubert and Mattern (2006) propose voluntary or mandatory counselling for the offender.

Recommending adequate and tailored treatment as soon as possible is necessary in terms of effectiveness. Therefore it is recommended to analyse more biochemical parameters from the blood sample that is taken on apprehension of the driver (to measure the BAC) which in addition helps reduce the administrative effort. Furthermore, the indication criteria for a driver's fitness assessment have to be adjusted to a European level. The current BAC limit of 1.6 ‰ is too high from an empirical perspective and is not used internationally.

The literature analysis should be extended in the future by adding additional publications. It would be interesting to investigate and compare the effect sizes of alcohol-induced impairments more thoroughly.

Implications for practice

- Alcohol causes impairments at a moderate dose.
- Serious impairments in multiple psycho-functional areas occur at 1,1 ‰.
- To improve traffic safety, an assessment of those drivers who feel fit enough to drive with a BAC of more than 1,1 ‰ is necessary.
- The MPA can help drunk drivers to contact counsellors about their (problematic) drinking habits even before they are clinically diagnosed as alcohol addicts and therefore, get help by the supporting and counselling system sooner.

Declaration of conflicts of interest

The authors declare that there is no conflict of interest relating to this article.

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