

LINKING BEHAVIORAL INDICATORS TO SAFETY: WHAT IS SAFE AND WHAT IS NOT?

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*Submitted to the 3rd International Conference on Road Safety and Simulation,
September 14-16, 2011, Indianapolis, USA.*

ABSTRACT

Safety is defined by the interactions and relationships between road-users, vehicles and the infrastructure. But what is it that determines whether a situation is critical or unsafe? Due to the many disadvantages of analyzing accident statistics, safety is often defined as its 'output measures', or proximal or behavioral safety indicators. Examples are speed, speed variability, time headway, SDLP, TLC and TTC. But where do we draw the line, what are good cut-off values for these behavioral indicators? In order to come up with international standards, more research is needed to fill in knowledge gaps. This article provides an overview of the link between behavioral indicators and traffic safety. It also discusses earlier attempts and new possibilities for setting cut-off values. The central research question in a new TNO project is how to link behavioral indicators to what can be qualified as safe or unsafe. This paper is a call to join forces and combine the existing data of naturalistic driving studies and field experiments with new research. There is a need to combine behavioral indicators into one risk factor, and add the link with behavior in specific surroundings. Cut-off values can be the end result of a large research proposal, combining data from alcohol studies, visual distraction data and driver drowsiness studies.

Keywords: Traffic safety, road user behavior, behavioral indicators, proximal safety indicators, experimental studies, cut-off values, international standard.

INTRODUCTION

Traffic safety is commonly expressed in terms of the number of accidents and their consequences (deaths, injuries or material damage only). Accidents are a good indicator of safety; an accident implies that something unsafe has occurred. While this approach is useful for identifying locations with specific safety problems or monitoring (inter)national trends, it does have its limitations. First of all, counting the number of accidents is a reactive approach to safety issues; a safety problem can only be identified after a number of accidents has been recorded. This approach, therefore, does not allow ex-ante evaluations. Secondly, it is commonly known that traffic accidents are underreported (the more serious an accident, the higher the chance that it will be reported). Thirdly, despite the good work of accident analysis

teams, it is often impossible or at least very difficult to find the actual cause of the accident. Eye witness testimonies are not always reliable (Memon, Mastroberardino and Fraser, 2008) and drivers do not easily admit that they were not paying attention or were driving under the influence. Finally, since accidents are (fortunately) rare, it can take quite some time before unsafe situations actually become apparent. Quick safety scans based on accident data are, therefore, not very feasible.

An alternative to investigating traffic safety without using actual accidents is often used in behavioral studies. Traffic is characterized by a much broader set of events than accidents alone, ranging from undisturbed passages, normal interactions, and conflicts to collisions. This broad set of events is shown in Figure 1 as a continuum of traffic events, which describes the traffic process (Hydén, 1987).

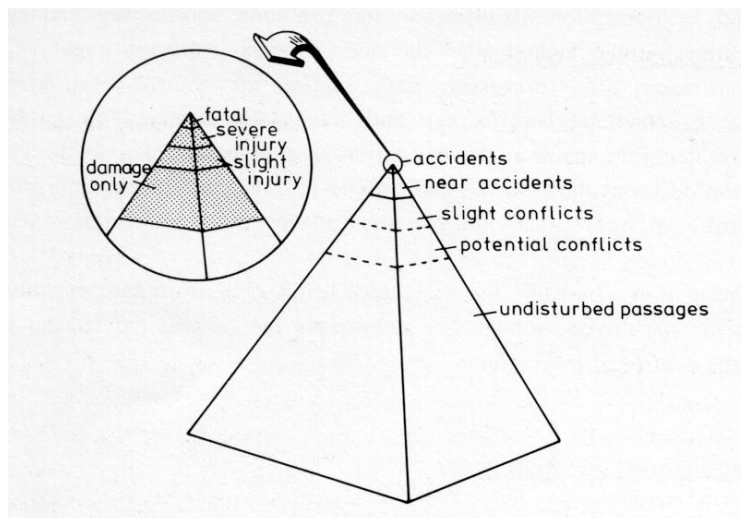


Figure 1 The Pyramid, continuum of traffic events from undisturbed passages to fatal accidents (Hydén, 1987).

An important advantage of describing safety in terms of near accidents, slight conflicts or potential conflicts (compared to the accident approach) is the fact that relatively unsafe driving behavior or potential conflicts occur more frequently than accidents and therefore a shorter period of observation is required. Svensson (1992) even argues that in some cases the expected number of accidents is better predicted by proximal safety indicators that represent the temporal and spatial proximity characteristics of unsafe interactions than by historical accident figures. Research is often conducted to provide an ex-ante prediction of the safety effects of a specific (in-vehicle) measure, or to study whether a specific situation is not too dangerous. In that case, accident research is not possible and proximal safety indicators or behavioral safety indicators seem the most promising solution.

A third approach is found in making a link between observable microscopic events and the likelihood of a relevant crash. In recent decades, the potential of microscopic simulation in traffic safety and traffic conflict analysis has been recognized (Darzentas et al, 1980; Coopers and Ferguson, 1976; Sayed et al, 1994; Cunto, 2008). Cunto (2008) claims that the usefulness of microscopic simulation for assessing safety depends on the ability of these models to capture complex behavioral relationships that could lead to crashes and to establish a link between simulated safety measures and crash risk. Model inputs have to be based on observational data in order to estimate safety performance that can be verified from real world observations. Before the methodology of Cunto can be used by researchers for road safety

studies, more comprehensive microscopic traffic algorithms that account for a wider range of behavioral attributes such as misjudgments of speed and distance, fatigue and lapses of attention are required. Also, these models only apply to vehicle-vehicle interactions, and not to safety measure for single road users.

PURPOSE OF STUDY

For many years safety has often been defined by behavioral or proximal safety indicators, like speed or time headway. Driving studies describe safety effects by means of reporting significant changes in these indicators, such as a substantial change in speed or time headway. This is based on the relationship between these indicators and actual or potential conflicts or accidents.

However, safety is defined by the interactions and relationships between road-users, vehicles and the infrastructure. But what determines a situation as critical or unsafe? A speed of 80 km/h is not safe or unsafe. How safe or unsafe this actually is depends on the road width, the speed of the other vehicles and of the steering capacity of the road user. While it is true to state that any statistically significant increase in speed is unsafe in itself, this is only of significance on a macro level. The problem is that experimental results tend not to lend themselves too easily to translation to that level, and on an individual, or micro, level an increase in speed does not necessarily have any significance.

The questions we want to answer is: What is unsafe driving at an individual level? What is an appropriate cut-off value for behavioral indicators to claim that the safety risk for an individual driver is no longer acceptable? This is the focus of a four-year research project begun by TNO in 2011.

In this paper, we provide an overview of the relationships between behavioral safety indicators and traffic safety risk and of earlier attempts to define general or individual cut-off criteria.

BEHAVIORAL INDICATORS AND RISK

Mean Speed

Speed is one of the most commonly used parameters to link behavior to safety. The best known functions relating average driving speed to accident risk have been proposed by Nilsson (e.g., Nilsson 1982, 1997; see Figure 2). Nilsson's functions are based on a series of naturally occurring before-and-after situations when speed regimes were changed a number of times in Sweden during the 70's and 80's. The Nilsson functions are power functions of average speed V , with the power depending on whether only the fatalities are considered, or whether they also include serious injuries or all injuries. Based on several studies measuring the effect of speed changes in Sweden between 1967 and 1972, mainly on rural highways, Nilsson (1984, 2004) stated that if the mean speed changes from V_0 to V_1 , the ratio of accidents (N_1/N_0) was proportional to the ratio $(V_1 / V_0)^a$, with $a = 4$ for fatal accidents, $a = 3$ for fatal and serious injury accidents and $a = 2$ for all injury accidents.

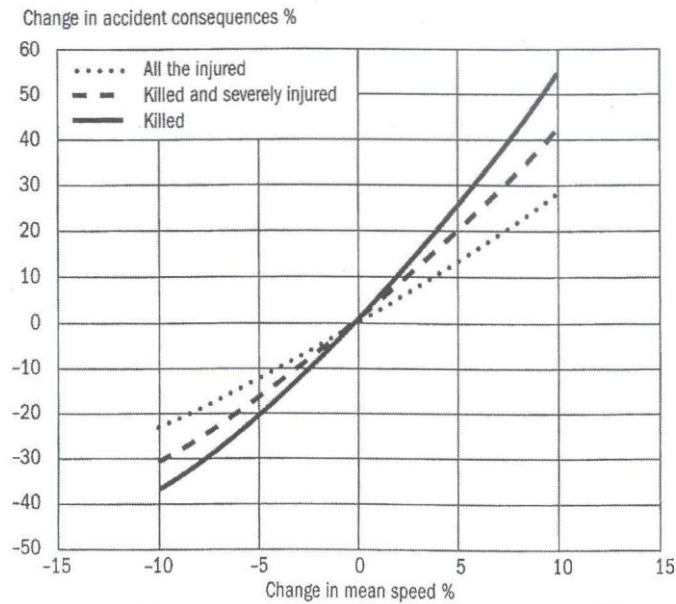


Figure 2 Speed-risk functions for different accident severities (Nilsson, 1982)

Since Nilsson’s study included relatively few evaluations of urban speed limit changes, Elvik et al. (2004) conducted a meta-analysis study of a large number (98) of evaluation studies that related to a large extent to low speed zones in urban areas. **¡Error! No se encuentra el origen de la referencia.** shows the power estimates based on this study. In contrast to Nilsson’s power model, these estimates represent mutually exclusive categories of the injury level of the crashes or victims.

Table 1 Meta-analysis for the mutually exclusive injury categories (Elvik et al., 2004)

Severity	Estimate of a	Standard error
Fatalities	4.90	0.17
Seriously injured road users	1.76	0.42
Slightly injured road users	1.56	0.26
All injured road users (including fatality)	2.40	2.24
Fatal accidents	3.65	0.83
Serious injury accidents	1.59	0.84
Slight injury accidents	1.05	0.84
All injury accidents (including fatal)	2.61	0.55
Property damage only accidents	0.73	0.97

However, Cameron and Elvik (2010) raised doubts on the applicability of the model in urban areas or lower speed zones. Whereas Elvik (2004) did not perform separate analyses for different road types, Cameron and Elvik did record the type of road or traffic environment on which each evaluation study was based. Based on these categorizations the raw data were re-analyzed by Cameron and Elvik, taking road type into account. Despite the fact that this new analysis provided power estimates comparable with Nilsson’s (2004) for rural highways and freeways, analyses confirmed clearly lower power estimates for urban roads with respect to

the serious casualty victims. Cameron and Elvik concluded that whereas on rural highways the mean speed is adequate for representing the influence of speed on crashes, a single speed parameter is not sufficient for assessing the influence on casualty crashes on urban roads. Here, the coefficient of variation of speed distribution also needs to be taken into account. Another problem with the speed power model is that a change in road trauma can be predicted by only one parameter, that is (a change in) mean travel speed. The question is whether this represents a direct causal relationship or simply an association mediated by other factors. If the latter is the case, it is risky to apply the model in single cases (for example, to estimate the decrease in safety when the speed limit is raised on a specific road).

Despite the strongly assumed association between speed and safety, the exact relationship is still under much debate (for a critical review on historical data on the relation between speed and accidents, see Hauer, 2009). Hauer argues that both mean speed and deviation from mean speed relate to safety, even though it is hard to demonstrate empirically. One of the reasons for this is the fact that in most accident data, no distinction has been made between slow and turning vehicles. Another reason Hauer (2009) mentions is that measured speeds on the road and speeds in crashes differ in terms of estimation accuracy. Without any reasonable doubt, accidents will be more severe (and therefore more likely to be reported) if speed increases, provided that other conditions (such as vehicles, roads and medical services) remain the same (see, for example, Josch, 1993; NHTSA, 2005). However, outcome severity does not directly depend on speed but rather on the difference in speed when two vehicles collide. This, in turn, depends not only on the speed of the crashing vehicle, but on many factors in which a crash occurs, such as road type and the material and speed of the objects.

Variation in Speed

Some of the models related in the preceding section already discuss the importance of speed variability. The speed variability-risk function reported by Salusjärvi (1990) has a quadratic form of (change in) speed variability (see also Figure 3). Its equation is:

- $\Delta \text{ risk} = 0.68 (\Delta \text{ SD})^2 - 6.4 (\%) \quad (1)$

A decrease in accidents exceeds 10% only when the dispersion is reduced by 3 km/h, and a corresponding change in accidents involving death or injuries is reached with a change of about 2 km/h in dispersion. Hereafter an equal decrease in dispersion causes an ever-increasing relative change in accidents. When the dispersion is reduced by 8 km/h, the accidents decrease by about 50%. If the curve is extrapolated beyond the empirical material, the accidents would decrease by 100% when the change in dispersion is about 12 km/h. A 12 km/h dispersion corresponds to an average speed of 80 km/h under free speed conditions. Thus a decrease of dispersion of 12 km/h means that the speed decreases by 80 km/h or an average speed of 0 km/h. This naturally means that there are no accidents.

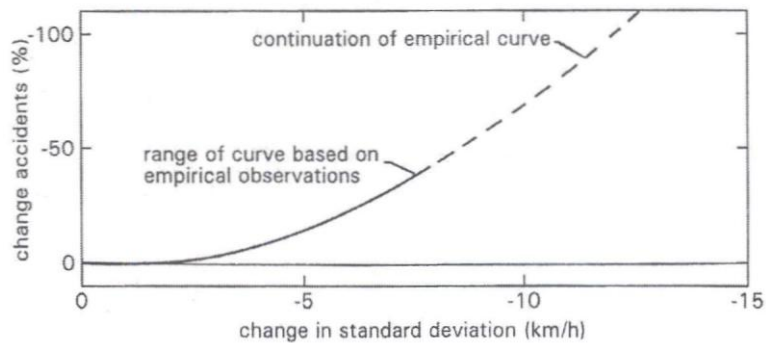


Figure 3 Relationship between speed variability and risk (Salusjärvi, 1990)

Kloeden et al. (2001) differentiate their speed variability-risk functions according to road type. It appeared, in particular, that the functions for rural roads (80-120 km/h) were much steeper than for urban roads (60 km/h). The functions reported are exponential in V_{diff} , which is the difference between actual speed and the average speed, plus even an additional term in $(V_{diff})^2$. Thus, V_{diff} is a way of describing the deviation from average speed, which is mathematically different from, although obviously related to, the standard deviation of speed.

In terms of risk functions, it is clear that it is important to include not only speed but also speed variability as a behavioral indicator in research. The link between speed and speed variability is supplemented with a link to the type of road on which behavioral changes take place.

Time Headway

Time headway (TH) is defined as the time that elapses between the front of the lead vehicle passing a point on the roadway and the front of the following vehicle passing the same point (e.g. Vogel, 2003).

What is considered a safe TH differs between countries and studies. For example in the US a TH of less than 2s is considered critical whereas in Sweden a TH of 1s is used for imposing fines (Vogel, 2003). Evans and Wiesalewski (1982) stated that drivers who maintain a short TH, shorter than 1s have a considerably increased chance of being involved in an accident. On the other hand, one year later they published a study in which no reliable relationship could be demonstrated between preferred headway and accident involvement. This can be explained by assuming that drivers opting for a shorter TH are more alert and respond faster to a lead vehicle braking, while older drivers choose a longer TH due to higher response times.

Most relationships that are described between TH and safety only concern a critical (threshold) value (e.g., $TH < 1s$ is unsafe). An exception to this is the model reported by Farber (1993, 1994) who uses a set of car-following data measured in actual traffic to assess the impact of a collision avoidance system that would effectively reduce the driver's response time to a sudden braking action by the preceding vehicle. This can be generalized to calculate the risk attached to a given following situation per se. The algorithm has the following steps (Janssen, 2000):

(1) For a given headway it is calculated whether, for a given range of response times, a collision would follow if the preceding vehicle were to brake sharply, i.e., at full braking power.

- (2) The total probability of a collision is then computed by integrating driver response times over a log-normal distribution (which has a tail towards the longer reaction times).
- (3) The mean and the standard deviation of the distribution are, moreover, adapted to the headway itself: this procedure was introduced by Farber so as to incorporate the fact that drivers follow more attentively at shorter headways.
- (4) In the case of a rear-end collision the speed difference at the moment of impact is computed.
- (5) The overall risk of the car-following situation is then computed by multiplying accident probability by the squared speed difference at impact.

Figure 4 shows the results for a few everyday car-following situations. As has been observed by other authors, the ‘worst’ headway at which to follow is not the shortest. This is intuitively clear when it is realized that although the probability of the collision happening becomes higher at shorter headways, its severity will be less because at a short headway the speed difference between the two vehicles at the moment of impact will be lower.

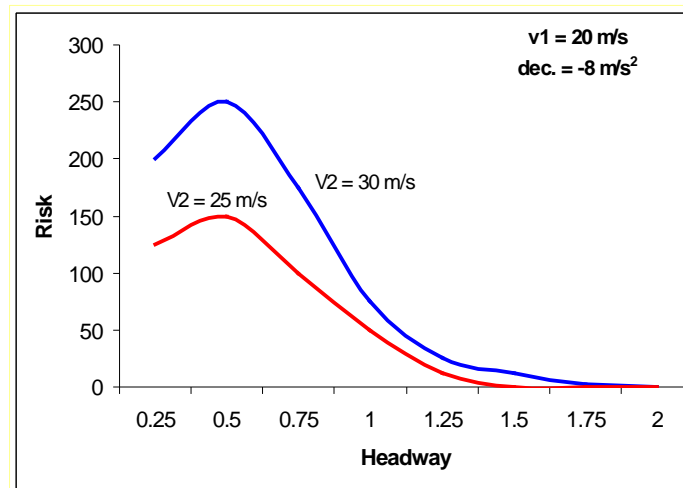


Figure 4: Rear-end collision risk in a car following situation with 1 vehicle driving at 20m/s and the other one driving at 25 or 30m/s. The lead vehicle suddenly brakes at $-8/m^2$. Risk units are arbitrary, i.e. defined as 100 at one of the configurations.

Although this risk function does not provide a cut-off value for what is safe and what is not, it shows that there is a steep rise in risk below a TH of 1.5. Figure 4 also shows that the slope of the function also depends on the speed and speed difference of the two following cars. Again this illustrates that TH is not a value that can be a single safety indicator, but is should be considered together with other values. Also, a high TH does not necessarily indicate a safe situation, since it is only related to one aspect of the driving task, and that is the car-following situation??

Time to Collision

TTC refers to the time span left before two vehicles collide, provided that they continue on the same course and at the same speed (Hayward, 1972). TTC can thus only be defined if the speed of the following vehicle is higher than the speed of the lead vehicle.

Compared to TH the calculation of TTC requires more known variables. Besides the time gap, the speed of the two vehicles has to be known. In practice, a short TH does not imply a short TTC whereas the opposite is true; a short TTC is impossible for vehicles with long THs. This difference has implications for the value of these two measurements when assessing safety. Under stable circumstances a short TH can be maintained for a long period of time, without resulting in a safety critical situation. On the other hand, in the case of a short TTC something has to be done in order to avoid a crash. Therefore, Vogel (2003) states that the measurement of THs should be used for enforcement purposes, in order to prevent potentially dangerous situations. When traffic situations have to be assessed in terms of safety TTCs should be used, because they actually indicate the occurrence of dangerous situations.

As with TH there is no real consensus on a critical value of TTC. In a study in which TTC values were computed from video recordings of traffic scenes, Van der Horst and Godthelp (1989) propose that only TTC values below 1.5s should be considered critical. Also Svensson (1992) proposes a value of 1.5 s in urban areas, whereas 5 s is mentioned by Maretzke and Jacob (1992). The difference may also be explained by a difference in purpose of calculating TTC. In the case of studying TTCs, 5 seconds may be used as a maximum limit. Including TTCs higher than 5 seconds is not very feasible for traffic safety research, whereas 1.5 seconds may be suitable as a cut-off value.

Lateral Behavioral Indicators

Lane keeping indicators are the most frequently used lateral control performance measures. The most common lane keeping indicators are mean lane position, standard deviation of lane position, lane exceedance and Time-To-Line-Crossing. The rationale behind these metrics is that increased lane swerving and/or lane exceedances indicates reduced vehicle control and hence a higher accident risk. A relationship like that described by Nilsson for speed does not exist for lateral parameters.

O'Hanlon et al. (1982) extrapolated distributions of observed lane positions from an instrumented vehicle study to estimate the probability of the vehicle leaving its lane. Today, the standard deviation of lateral position (SDLP) is one of the most common performance metrics used. A higher SDLP indicates stronger swerving within a lane and thus an assumed adverse impact on traffic safety.

The number of times the vehicle crosses the lane boundary (Wierwille et al., 1996) or a proportion of time any part of the vehicle is outside the lane boundary (Östlund et al., 2004) can also be used as a risk estimation. An alternative is to measure major lane deviations, which are defined by Liu et al. (1999) as a situation in which part of the vehicle exceeds the lane by more than half the vehicle width. Of course, lane deviations cannot discriminate risk levels that precede the situation of the vehicle actually moving outside the lane. One solution to differentiating lateral risk level early is the Time-To-Line-Crossing parameter (Godthelp et al, 1984), a time-based parameter first developed by Godthelp and Konings (1981). TLC is defined as the time it takes to reach the lane marking, assuming fixed steering angle and a constant speed. TLC measurements that are too short indicate reduced lateral control. A rule of thumb is that a TLC of less than 1 s implies an increased safety risk. TLC indicates that a lane exceedance is likely to occur within a short time frame and therefore detects a possible risk before the lane exceedance actually occurs.

Other Metrics

Even though there are numerous other indicators that may be used in trying to define levels of safety for individual drivers, most of these cannot be treated as a direct safety indicator. The literature cites steering wheel metrics as the most common way of assessing the effect of a secondary task, such as the use of an In Vehicle Information System (IVIS) or Advanced Driver Assistance System (ADAS). The rationale behind the use of this metric is the fact that when attention is diverted, heading errors are made, which are corrected by relatively large steering wheel movements, indicating reduced lateral control. However, increased steering activity can be associated with both higher and lower lane-keeping performance. Also, steering metrics are especially useful with respect to their effects on lateral performance, making it an indirect safety measure.

Various other metrics are intuitively related to safety but this relationship has not yet been quantified. High workload is often associated with a higher accident risk as is a low alertness level. However, these relationships are still descriptive and indirect, since these are more or less input rather than output measures. There are not considered to be behavioral indicators.

Combining Behavioral Indicators

Within the European AIDE (adaptive integrated driver-vehicle interface) project the different variables mentioned above were integrated in a single estimate to assess a change in risk (see Janssen et al, 2008). These variables were:

- Average speed
- Speed variability
- Lane-keeping performance
- Car-following headway
- Driver workload level
- Driver visual distraction level
- Driver alertness level

The only way to obtain a single estimate was to assume independent measurements so that changes in different parameters could be multiplied. A simplified example based on Janssen et al is:

1) Average speed increases by 3%. Using the Nilsson functions, fatalities would increase by 17 % (factor 1.17).

2) Speed variability decreases by 3 km/h. Using the Salusjarvi function, a risk reduction of 5% is found (factor 0.95).

Based on these two findings the risk would increase by 11% ($1.17 \times 0.95 = 1.11$).

The approach obtained in AIDE is attractive for its simplicity. However, whether the assumption of independence can be maintained between all factors is, of course, questionable.

EARLIER STUDIES LINKING BEHAVIOR TO TRAFFIC SAFETY

Clearly, different behavioral indicators relate to risk. The obvious question is what this exact relationship is and what a good cut-off value would be to indicate unsafe driving. To define whether it is acceptable in terms of traffic safety to drive having taken a specific medicinal drug, some definition of unsafe driving is needed. In developing ADAS (Advanced Driver

Assistance Systems), a cut-off value is needed for system activation at which the system will support the driver.

Brookhuis and colleagues (Brookhuis et al., 2003; Brookhuis, 1995a) reported absolute and relative behavioral criteria for identifying driver impairment. The relative criteria (or relative change as described by Brookhuis et al.) indicate “a significant change in individual driver performance”, while absolute criteria indicate “the cut-off point which defines impaired driving” (Brookhuis et al., 2003). These absolute and relative criteria can be seen as cut-off values beyond which driving becomes unsafe. The relative criteria take individual differences into account whereas the absolute criteria are completely independent and apply to all drivers. The criteria of Brookhuis are based on work on the effects of illegal levels of alcohol intoxication, visual occlusion data (e.g. Godthelp, 1988), driver inattention and prolonged journey time on driving behavior. Although there were some slight differences between the studies, the criteria are relatively similar.

Brouwer et al (2005) analyzed the results of an experiment that investigated drowsy driving and compared the absolute criteria of Brookhuis and colleagues for the standard deviation lateral position, the average speed and the time-to-line crossing for the left and right marking with scores for drowsy driving. The absolute criteria for these variables defined by Brookhuis et al. (2003) were:

- Standard deviation lateral position: > 0.25 m
- Vehicle speed: limit + 10%
- TLC left marking: < 1.7 s
- TLC right marking: < 1.3 s

A similar analysis was performed for the following relative criteria:

- Average speed: $\pm 20\%$
- Minimum TLC left marking: -0.2 s
- Minimum TLC right marking: -0.3 s
- SDLP: $+ 0.04$ m

The analyses of both absolute and relative criteria showed that there impaired driving (drowsy driving) could not be adequately identified on the basis of these criteria. Brouwer et al (2005) showed furthermore that for different drivers certain driving variables are better predictors for ‘unsafe’ driving for than others. They investigated this possibility for individual predictors with a linear correlation analysis between different driving variables and time on task. The results of this analysis indeed show that for different drivers different variables are sensitive to time on task. Therefore, for the detection of impaired (‘unsafe) driving, different variables are needed for different drivers and most likely different variables need to be combined even for a single driver. This is in line with the findings of de Waard, Brookhuis and Hernandez-Gress (2001) who found good detection of impaired driving only after a detection system was trained with control data and impaired data per individual.

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE WORK

This article has discussed the need to identify the link between behavioral indicators and traffic safety but in order to derive international standards for cut-off values for safe and unsafe driving, more data and research are needed. However, despite the numerous amount of work done in this field, no international standards have yet emerged. The reason for this lies in the fact that there are still some limitations to behavioral indicators:

- 1) No one-to-one relationship to safety exists so the safety measurement will always be indirect.
- 2) Many indicators are by nature not linked to the infrastructure, e.g. in the case of speed, speed variability and SDLP, this is calculated irrespective of the type of road on which one is driving.
- 3) Safety cannot be based on a single parameter only, so a combination of various measurements needs to be calculated into one risk factor.
- 4) There are no clear and general cut-off values (yet).
- 5) It is important to set clear criteria for time and frequency.

A few examples illustrate the need for more research on:

The combination of behavioral indicators:

- If two cars drive at the same speed, a TTC will be infinite, while the distance between cars can only be 1 cm. Therefore, TTC alone is not sufficient.
- How do a decrease in SDLP (indication of increase in safety) and a higher SD speed (indication of decrease in safety) relate and what does this mean for safety?

Behavioral indicators in the context of the surroundings:

- A low SDLP within a narrow lane may be less safe than a higher SDLP in a wide lane.
- Low speed in fog is not safer than high speed with good visibility.
- A sudden change in lateral position may be the result of making room for an approaching truck on a narrow road rather than being attributable to swerving.

Time and frequency related indicators:

- Assuming the cut-off value for SDLP in combination with a specific road width is $>0.25\text{cm}$, do we then claim that a 200 m/sec exceedance of this value is unsafe?

Therefore, the ultimate goal is to develop individual (and therefore relative) criteria for what is 'acceptable' or 'unacceptable' in terms of traffic safety, integrating different behavioral measurements and linking them to their surroundings. Because the ultimate goal is to define cut-off values of behavioral indicators that actually relate to accident risk, it is important to start defining more research in which there is a link between these indicators and safety and accidents.

A feasible option would therefore be to relate cut-off criteria to generally acceptable cut-off values. Using the behavior found with illegal BAC levels as cut-off values would be a feasible option because of the established and accepted link between BAC and accidents. This line of reasoning has been used before for single parameters. Another good and additional line of reasoning would be to link the behavior found with 'eyes-off the road' as cut-off values. The link between the time that the eyes are off the road and accidents (and even conflicts) has been established in the 100 car study (Klauer, Dingus, Neale, Sudweeks and Ramsey, 2006). This calculated the odds ratios associated with eyes off the forward roadway in a naturalistic

driving study, since odds ratios are appropriate approximations of relative near-crash/crash risk for rare events (Greenberg et al., 2001). The odds ratios were calculated for all instances of eyes off the forward roadway as well as for different ranges of time that the drivers' eyes were off the forward roadway. They found that eye glances away from the forward roadway greater than 2 seconds, regardless of location of eye glance, are clearly not safe glances as the relative near-crash/crash risk sharply increases to over two times the risk of normal baseline driving. So it is an interesting concept to occlude drivers from the forward roadway for 2 seconds or more and register the associated behavioral indicators and how they relate to each other as cut-off values. This way we can link individual changes in behavior to accident risk.

Future studies (the first studies are planned in 2012) need to be performed in a driving simulator or on the road in an experimental setting in order to log all possible behavioral indicators in their surroundings. Through international cooperation, data from naturalistic driving studies, driving simulator studies and field studies (e.g. in the area of driver drowsiness) can be exchanged in order to set the first international standard for cut-off values for the combination of behavioral indicators linked to the infrastructure. Only by joining forces can the issue of behavior as the key to predicting traffic safety be tackled and, hopefully, lead to international standards within a few years.

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