

Safe driving and the training of calibration

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Literature review

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Summary

Over the years, much research has been done to optimize instructional methods in driver training. A number of issues, however, remain unresolved. In the literature we find that there are two main areas of critical factors in safe driving; namely the ability to detect hazards and risks, and the role of self-assessment in driving performance. This paper describes some of the main findings with respect to these two areas.

The main focus in this paper, however, is on the relation between the above mentioned critical safety factors. It is assumed here that the essential issue in safe driving is not so much the development of specific skills, but the ability to balance task demands and skills accurately. Drivers have an ongoing dynamic control over several of the determinants of task difficulty. This balancing of demands and capabilities is also known as 'calibration'.

The assumption underlying this paper is that calibration is a core issue in driving. The relevant literature was studied to substantiate this claim. This paper explores theories relating to calibration and investigates whether, and how, to incorporate the issue of calibration in formal driving instruction.

The literature thus far supports the thesis that calibration is a core issue in safe driving. Inexperienced drivers show less awareness than experienced drivers of the actual realities of road system operation, and less awareness of their own role. Calibration is conceptualised as not just momentary demand regulation, but also as behavioural regulation on the basis of anticipated events (hazards). It is theorized that the problem with young drivers lies both in the anticipatory realm as well as in momentary demand regulation. Miscalibration can lead for instance to: small safety margins, excessive speed, aggressive driving, short following distances, and the performance of risky manoeuvres etc.

Current driver training does not prevent miscalibration, and may even stimulate miscalibration. This is related to the fact that the training does not incorporate enhancing learning conditions for the driver after qualification. For instance, drivers are not taught how to assess the degree to which they have actually mastered certain skills and which skills they still need to develop to what degree. The inherent caution with which novice drivers operate, will partly diminish on account of the fact that they have received formal training. This allows them to think they have acquired all necessary skills, while in fact they have not.

A correct calibration of task demands and coping abilities largely depends on the amount of practice and the amount and quality of feedback that a driver receives. It is suggested that driver training should incorporate methods to match self-assessed ability to actual ability. Drivers should learn to actively search for, and use, the feedback that the driving environment provides them with.

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1. Introduction

Driving involves responding to real objects in the spatial world. It requires domain specific knowledge, motor skills and high perceptual and cognitive skills. Formal driving instruction is generally assumed to be the most important method by which drivers acquire the basic skills and knowledge that govern behaviour in traffic. Results of instruction are however somewhat disappointing. Compared to more experienced drivers, novice drivers have a relatively high accident involvement. Over the years, much research has been done to optimize instructional methods. A number of issues, however, remain unresolved. In the literature we find that there are two main areas of critical factors in safe driving. One concerns the ability to detect hazards; the other looks at the role of self-assessment in driving performance.

Accident studies suggest that misperceiving and misjudging traffic hazards is a relatively serious problem in the field of road safety. Insufficient skill in this area has also frequently been mentioned as one of the critical behaviours of inexperienced drivers. Other authors emphasize the role of self-assessment in safe driving. In several studies it is suggested that drivers have an unrealistic view of their own driving ability, which may seriously impair safe driving. It appears for instance that the majority of drivers believe themselves to be more skilful than the average driver (Brown & Groeger, 1988; for a review see also Kuiken, 1996, Gregersen, 1996).

This paper describes some of the main findings with respect to these two areas of performance. The main focus in this paper, however, is on the relation between the above mentioned critical safety factors (i.e. hazard perception, risk perception and self-assessment). It is assumed here that the essential issue in safe driving is not so much the development of specific skills, but the ability to be able to balance task demands and skills accurately. When addressing the question how to train safe driving, Brown, for instance, argued that it is essential that drivers acquire knowledge of their ability to deal with traffic hazards (1989, 1990). It was argued that drivers decide upon their actions on the basis of two inputs: on the one hand the detection, identification and evaluation of hazards, and on the other hand, the assessment of their own ability to cope with engagement in manoeuvres potentially involving such hazards, and recovery from any errors they might make. Dangerous situations may occur when drivers overestimate their own abilities and underestimate the risks. Also relevant is the model proposed by Deery (1999) in which the relation between hazard perception, risk perception, self-assessment and risk acceptance is made explicit. Recently, Fuller (2000) presented the Task-Capability Interface model. The model conceptualises on the one hand task demands and task difficulty, and on the other hand what the driver contributes to the problem of managing task difficulty. It is assumed here that drivers have an ongoing dynamic control over several of the determinants of task difficulty. This balancing of demands and capabilities is also known as 'calibration'.

The assumption underlying this paper is that calibration is a core issue in driving. The relevant literature was studied to substantiate this claim. The paper explores theories relating to calibration and investigates whether, and

how, to incorporate the issue of calibration in formal driving instruction. This is all the more important because there is evidence that driver training and safety training courses (like skid training) may have adverse effects on calibration.

The theoretical exploration in this paper is an initial part of a larger experimental programme on calibration. Goals of this programme are:

- (a) building the theoretical framework with respect to the calibration process in novice drivers;
- (b) designing a training intervention to improve calibration;
- (c) evaluating the intervention to ascertain the possibilities and benefits of training aimed at calibration.

Chapter 2 presents the theoretical background of calibration. Several views and literature findings are presented concerning critical factors of safe driving and the process of balancing task demands and capabilities. Chapter 3 explores whether, and how, driver training may improve calibration in young drivers. Learning objectives are identified and a number of instructional methods are described.

Chapter 4 describes the main results and conclusions from the literature survey.

2. Safe driving and calibration: a review of the literature

Important questions guiding the literature review concern the role of critical safety factors in the driving process and the role of calibration. Specific attention is given to the situation of novice or inexperienced drivers and to the question whether calibration should be incorporated in driver training.

2.1. Critical factors in safe driving

In order to drive safely, drivers need to be able to assess the difficulty of the driving task on the road at any moment in time. This requires them to look at the right place at the right time, in order to detect any critical changes in traffic circumstances and identify imminent hazards. Often, this task needs to be performed under pressure of time. Several authors argue that the perception of and response to hazards is a particularly critical part of the decision process for novice and inexperienced drivers. The over-representation of young inexperienced drivers in accidents has partly been attributed to poorly developed skills in this area.

Although the relation of hazard perception to accident involvement has proved to be difficult to investigate, in laboratory studies some indications have been given. McKenna reports results in which drivers involved in an accident in the previous three years had significantly worse hazard perception scores than drivers who had remained accident-free over the previous three years. This has also been found in other studies (Quimby & Watts, 1981, Quimby et al, 1986). Therefore, we will primarily focus here on hazard perception as one of the primary aspects in the assessment of task demands.

2.1.1. Hazard perception

Hazard perception is described as the ability to anticipate potentially dangerous road situations. It can be seen as “the ability to read the road” (e.g. McKenna, 2000). Since misperceiving or misjudging hazards seriously impairs road safety, a range of methods has been developed for measuring hazard perception ability (see McKenna & Horswill, 1999), for example:

- In assessments of McKenna & Crick (1991) drivers respond discretely the moment they detect a hazard.
- Kruysse. & Wijnhuizen (1992) used a range of rating scales in which drivers are asked to rate the degree of danger in a scene.
- Groeger & Chapman (1996) used a short questionnaire with each scene which required drivers to make judgments about the level of risk etc.

2.1.2. Hazard perception and experience

Hazard perception has frequently been mentioned as one of the critical behaviours of inexperienced drivers. Several studies show effects of experience on a hazard perception task (Crick & McKenna, 1992; Mills et al, 1996), or on reaction time to a potential hazard (Quimby & Watts, 1981; McKenna & Crick, 1991). McKenna & Crick found, for instance, that mean hazard perception scores in milliseconds were significantly lower for expert drivers than for novice drivers. They concluded that expert drivers detect hazards faster than novice drivers. When the time taken to detect hazards

was plotted against an estimate of the total mileage of the driver, a linear decrease in hazard perception latencies was found up to 100.000 miles. It was also found that expert drivers detected more hazards than new drivers (McKenna & Crick, 1991; Renge, 1998; McKenna & Horswill, 1999). From these findings one may conclude that hazard perception naturally improves with practice. This immediately raises the question whether the improvement of hazard perception can be accelerated through training.

2.1.3. *Training of hazard perception*

A number of studies have been performed to investigate whether improvement in hazard perception can be accomplished by training. Results of safety related advanced driver training indicate that this is indeed the case. Mills et al. (1996) investigated the effects of training on hazard perception and found that both video and on-road hazard perception training, significantly improved the hazard perception scores of the trainees. Horswill & McKenna (1996) demonstrated that for inexperienced drivers, video simulation training methods are particularly valuable, because they allow newly licensed drivers to be exposed to dangerous scenarios. Another advantage of video scenarios is that it allows a controlled exposure to infrequent driving situations. Other research has also indicated that hazard perception skills of new drivers can be significantly improved using video-based training methods. (McKenna & Crick, 1994). In another study, McKenna and Horswill (1998) conclude that:

"Trained drivers decrease their risk taking only for hazardous situations, indicating that they were perceiving the hazards rather than simply demonstrating that they had been sensitized to safety issues. Hazard perception training appears, therefore, to have the dual benefit of improving hazard perception skill, while decreasing risk-taking propensity."

There are also problems associated with the video scenarios. Young people tend to see them as games, and the occurrence of hazards on the video is sometimes quite predictable, thereby losing impact.

Underwood (2000) performed an experiment in which pupils watched hazard perception films. Although he found no evidence that it improved their ability to detect hazards, he did find an effect of hazard awareness training upon visual search, while novices were watching video clips showing hazardous events. He also found that eye movements in dangerous situations are quite unlike those in normal driving. The driver spends more time processing each thing they look at, and less time scanning the rest of the environment. Such changes are particularly pronounced in novice drivers, suggesting that they have problems taking in sufficient information in dangerous situations. Underwood indicates that it is extremely difficult to provide realistic representations of the information in mirrors, blind spots and peripheral vision on a television screen.

An alternative way to look at hazard perception is to address hazard perception skills not separately, but in relation to other processes and skills, which also involve capabilities and skills of the driver in the road system. Some time ago Brown and Groeger already theorized that the cognitive process that underlies hazard perception is: "the ability to construct and use effectively a continuously changing predictive appreciation of a complex system." In this definition they stress that next to the perception, the evaluation of a hazard is also a key element that needs separate attention.

It is clear that hazard perception needs further elaboration. If young drivers do not sufficiently *adapt their behaviour to (anticipated) hazards*, there are several explanations that can be put forward. Amongst these are:

- lack of detection (e.g. due to inappropriate visual search) and
- lack of recognition (situation detected but not recognised as potentially hazardous).

However, other explanations are that the driver:

- made an error in the anticipation of the task demand required to negotiate hazard, or
- made an error in the anticipation of his own task capability to negotiate the hazard.

Note also that young drivers may differ in their *evaluation of the outcome* of hazard adaptation. Again, two aspects are relevant. First, they may perceive the outcome accurately, but have different acceptance criteria (e.g. in terms of acceptable margins). Second, they may not have the capability to perceive the outcome accurately. On the basis of the general literature, both are likely.

2.1.4. Self-assessment

From research it is clear that drivers produce different ratings of risk when confronted with similar hazards. One of the components that may negatively affect the perception, as well as the response to hazards, is the driver's view of his own skills and abilities.

There is growing evidence that drivers tend to overestimate their skills (Wills, 1981; see literature reviews in Kuiken, 1996; Gregersen, 1996; Lajunen et al, 1998; Walton, 1999). Some authors conclude that it appears that the reported tendency of drivers to overestimate their skills and safety is largely an experimental artefact. For instance, Brown & Groeger (1988) concluded that the overrating was a result of experimenter bias, in the sense that subjects liked to present themselves in a favourable light to the experimenter. Others (e.g. McKenna, 1982) conclude that we are not dealing with an experimental artefact, but that particularly young inexperienced drivers actually think they are better drivers than other or average drivers. After reviewing a large number of studies on assessment and safety, also Gregersen (1996) draws the conclusion that drivers' lack of understanding their own limitations may be an important critical safety factor in driving.

Understanding the self-enhancement bias. A more positive evaluation of one's own skills and abilities can always be interpreted in two ways: a 'positive self' or 'negative others'. A positive self indicates that the person judges his own skill as more positive than the skill of another person or of an average person. When the bias stems from negative others, this would indicate that the person judges the performance of others as worse than is actually the case. Findings mainly support the common idea that the reported tendency of drivers to overestimate their skills is due to a 'positive self' rather than 'negative others'. While McKenna, Stanier & Lewis (1991) draw the conclusion that the bias is a 'positive self' phenomenon, Groeger and Grande (1996) criticised the conclusion. Walton (1999) recently performed an experiment on the self-enhancement bias of professional truck drivers. He found a highly significant bias, with 78% of the drivers claiming to drive safer than the average truck driver. Other findings in his study were that drivers are extremely accurate in the assessment of their own driving speeds, but that they produce inflated accounts of the speeds of

others. Walton concludes that the findings support the conclusion that the self-enhancement bias is caused by exaggeration of the negative conduct of others, and not so much by exaggeration of the positive conduct of the interviewees themselves. The issue is not yet resolved and will require further study.

Also, it was tested experimentally, whether the personal underestimation of probability of encountered negative events was due to illusion of control versus unrealistic optimism (DeJoy, 1989). Illusion of control refers to the idea that people wrongly think that they are sufficiently equipped and able to control a situation. This illusion is likely to affect risk acceptance. Unrealistic optimism refers to a situation where people mistakenly think that nothing will go wrong. This bias will more likely influence hazard perception. From the literature it is concluded that there is clear support for the bias being caused by illusion of control and little support for its being caused by unrealistic optimism.

Measuring self-assessment. Lajunen & Summala (1995) have developed a questionnaire (the Driving Skill Inventory (DSI)) for measuring a driver's perceptual motor skills and safety skills. In the DSI, drivers are asked to assess their skills in relation to an internal reference, i.e. drivers are asked to identify the weak and strong elements in their driving. Safety skills included for instance issues like: paying attention to pedestrians and cyclists, avoiding competition in traffic, conforming to speed limits, and carefully obeying the traffic lights. The questions on perceptual motor skills included for instance: fluent driving, performance in a critical situation, driving in a strange city, driving on a slippery road, predictions of traffic situations ahead etc. Results from various studies suggest that DSI is a viable instrument for measuring drivers' self-assessment of their perceptual motor and safety skills (Lajunen et al, 1998). The study also shows that perceptual motor skills improve rapidly with experience (as measured by DSI), whereas the reported safety skills deteriorate drastically. Lajunen et al theorize that, whilst novice drivers initially emphasize a concern for safety, they soon forget this safety orientation.

Self-assessment and behaviour. A few studies have looked at the relationship between the assessment of one's skills and actual behaviour. The question, whether a driver's view of his motor and safety skills is directly related to risk-taking and hazardous behaviour, is not simple to answer. In one study a subject was asked to assess his performance in a simple reaction time task and in real driving (Quimby and Watts, 1981). The study showed that young drivers performed better than the older experienced drivers in the simple reaction time task, but had longer reaction times in the driving situation. While driving, young drivers generally took shorter headways and smaller safety margins than the experienced drivers. This indicates that they did not adequately balance their ability to react (fastness of response) and the actual task demand (to stop in time for an obstacle). Gregersen (1996) concludes from a review that research data suggests that drivers' overestimation of their own skill, actually contributes to higher accident involvement. He then argues that: "An important method of improving safety among young drivers may therefore be to find ways of making them realize their own limitations, and understand that situations that they cannot handle may very well occur."

2.2. **Balancing demands and skills: situation awareness and calibration**

Some authors address the relation between hazard perception and self-assessment. It is claimed that the driver's *view* of his motor and safety skills is directly related to risk-taking and hazardous driving. The task to continuously compare task demands with capabilities and skills plays an essential role. Brown (1989), for instance, has presented a model of subjective safety, in which he shows that the perception of risk is, on the one hand, dependent on the detection, identification and evaluation of road and traffic hazards and, on the other hand, dependent on the self-assessment of coping ability during engagement in manoeuvres and recovery from error. He claims that the perception of risk cannot be studied in isolation of both these elements. In a way the driver acts as a comparator. This generates the question: how do drivers acquire a realistic insight into or understanding of the degree to which they have mastered certain skills?

2.2.1. *Situation awareness and the development of meta-cognitive strategies*

A promising approach is put forward in theories on situation awareness. Essential in the approach is that the traffic system is seen as a complex dynamic system which requires situation awareness of the driver. Situation awareness is defined as (Endsley, 1995): "The perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future." Endsley describes how situation awareness involves far more than merely being aware of numerous data. It requires an advanced level of situation understanding and a projection of future system states. In aircraft it has long been recognized as a crucial commodity for crews of military aircraft. In dynamic environments, like driving, many decisions are required within a minimum amount of time, and tasks are dependent upon an ongoing up-to-date analysis of the environment. Clearly, drivers have to do more than simply perceive the state of the environment. Endsley (1995), for example, indicates that a person must understand "the integrated meaning of what they are perceiving in light of their goals". Endsley further indicates that there is evidence that an integrated picture of the current situation may be matched to prototypical situations in memory, and quotes Klein's study of ground commanders, where it was found that conscious deliberation of solution alternatives was rare. Rather, most of the time, experts focussed on classifying the situation, in order to immediately recall the appropriate solution from memory. Such meta-cognitive strategies become more important, when assessment of the situation becomes more challenging.

2.2.2. *Training situation awareness*

The following key features are hypothesized to affect situation awareness:

- (1) The way in which attention is directed across available information.
Three levels can be distinguished here, namely:
 - the actual directing of the attention of a person;
 - integrating and comprehending the perceived information (the current situation);
 - projecting the future states of the environment.
- (2) Knowledge of critical cues in the environment. Such knowledge is highly important for:
 - the selection of active goals (mental mode selection);

- pattern matching with schemata of prototypical situations according to the current model.

In this process, feedback that is related to the performance of the novice driver, is essential. Errors can only be detected when the performance of a task generates feedback. Feedback generally results from performance which is closely monitored in such a way that an 'error message' is generated, when a deviation from plan occurs. Feedback may be the result of signals intrinsic to the task (e.g. crunching of gears) or signals extrinsic to the task (e.g. other drivers' reactions) (Groeger, 1989).

Situation awareness appears to be an essential factor in assessing the demands of particular traffic situations, and is therefore an important element to consider in calibration.

2.2.3. Calibration

Calibration is seen to be an essential element in safe driving. It refers here to the ability of drivers to recognise the relationship between the demands of the driving task and their own abilities, including error recovery. At any moment in time, a driver needs to be actively engaged in assessing what the driving task requires in terms of actions or the avoidance of actions, and the potential difficulties involved.

Although hazard perception and evaluation are part of this assessment, the driver needs to be aware that he is not a passive factor in the traffic environment. He brings to the driving task a level of capability, skill and knowledge, and has an ongoing dynamic control over several of the determinants of task difficulty. The difficulty of the driving task is not only the result of a combination of features of the environment, the behaviour of other road users and performance characteristics of the vehicle, but is also determined by the driver's own speed, road position and trajectory (see also Fuller, 2000). Especially the speed and following distances maintained by the driver may contribute significantly to task difficulty. Decisions concerning speed and position are in turn influenced by a number of factors, in particular the perceived level of one's specific competence. Also motivational factors may play a role. So, there is a strong argument here, that safe driving requires that a driver is able to accurately assess not only the task demands (including hazards), but also his own level of skill to safely deal with specific traffic situations, and to recover from his own errors or the errors of others. This process to assess and balance task demands and capabilities is called calibration. Other terms, referring to similar processes, may be found in Brown (1989): model of Subjective Safety, and Fuller (2000): Managing task difficulty in The Task-Capability Interface model.

The process of calibration may be characterised as the weighing or balancing of the results of the assessment of driving demands and the assessment of one's own skills, resulting in the recognition of balance or imbalance. When a person perceives that specific task demands are higher than what is available to deal with those demands (own capabilities), he may respond in two ways:

- a) reducing task demands, by reducing task difficulty;
- b) improving own capabilities to deal with the task.

These strategies may be followed at different levels and in different time spans.

Most importantly, it may concern momentary demand regulation and a more strategic behavioural regulation on the basis of anticipated events (hazards).

When driving is conceptualised as a process in which task demand and task capabilities are dynamically matched (i.e. calibration), this match may also be based on the match of momentary demand and the capability of meeting that demand. It is not (necessarily) based on anticipated demand as the term hazard implies. Hence, if self-assessment is conceptualised as a dynamic evaluation of the momentary performance (i.e. the capability to meet demand), then it may play a role in the calibration process.

Momentary demand regulation. Most obviously, the calibration may result in the lowering of speed or repositioning of the car on the road (decrease of task demand), or by increasing and/or focussing attention to the task (increase of coping ability). At a tactical level drivers may choose to avoid certain manoeuvres, for instance overtaking (decrease of task demand), or again, increase their alertness.

Strategic behavioural regulation. Calibration may result for instance in selecting a different route and time, or adapting the style of driving (strategically reducing speed). Coping abilities may be increased by the adoption of standards concerning general fitness (no alcohol, not driving while tired), or by additional training (e.g. skidding techniques).

The matching process between task demands and skills continuously plays a role in driving. Errors in the assessment of the driving demands and/or one's own skills may result in a mismatch. A mismatch may lead to an ineffective driving strategy, which would gain the appearance of risky behaviour.

2.2.4. Calibration errors

The literature thus far supports the thesis that calibration is a core issue in safe driving. Calibration is conceptualised as not just momentary demand regulation, but also as a behavioural regulation on the basis of anticipated events (hazards). It is theorized that the problem with young drivers lies both in the anticipatory realm, as well as in the momentary demand regulation. Miscalibration may for instance lead to: small safety margins, excessive speed, aggressive driving, short following distances, risky manoeuvres etc. The most important underlying factors are:

1. Failing to anticipate risk and danger. The following aspects are relevant:
 - lack of detection (e.g. due to inappropriate visual search);
 - lack of recognition (situation detected, but not recognised as potentially hazardous);
 - error in anticipation of *task demand* required to negotiate hazard;
 - error in anticipation of *task capability* to negotiate hazard.

The discrepancies between task demand and task capability point to a lack of knowledge concerning the limit of one's own skills, the characteristics of the vehicle (speed, braking distance, steering characteristics) and the dynamics of the traffic situation.

2. An incorrect evaluation of the outcome of demand regulation and hazard adaptation. Two aspects are relevant:
 - drivers may perceive the outcome accurately, but have different acceptance criteria (e.g. in terms of acceptable margins);
 - drivers may not have the capability to perceive the outcome accurately

2.3. **Other factors: risk taking behaviour and feedback**

In 'driver adaptation theories', the driver's motivation plays a central role. A traffic safety intervention does, in many situations, not yield the net result in safety as might have been expected from the technical characteristics of the innovation. These disappointing results are believed to be caused by the 'reaction' of the traffic participants to the perceived safety gains. Drivers often use the safety gain to attain another 'extra' goal. With respect to driver training, it is theorized that advantages gained in driver training, such as improved skill, are often used not to improve safety, but rather to achieve goals such as mobility, pleasure, adventurousness, fulfilling role expectations and living up to social expectations etc. As these additional motives lead to immediate rewards, they are therefore easily reinforced, and thus become stronger than the safety motive. Safety goals are less rewarding. Drivers would normally avoid behaviour that evokes fear or anticipation of fear. Yet, these fearful conditions only seldom occur in traffic. Therefore the safety-oriented response is weakened and gives way to the competing and more rewarding goals.

So taking Brown's model, the fact that novice drivers seldom experience fright, leads them to believe that the balance between task demands and self-assessment is rather accurate.

Skill training leads them to believe that skills have improved. As they felt confident with the quality of their driving before the training, they now believe that they can use this improvement to gratify their ulterior needs. The driver's belief in his improved skills is not tested in actual driving tasks.

In this chapter the literature concerning the role of calibration in safe driving has been reviewed. Our main goal was to identify critical factors which contribute to safe driving, and to explore whether the findings support the notion of calibration as a key ability in safe driving. In the next chapter principles of current driver training are reviewed. This is followed by a closer look at instructional methods and the role of feedback in the learning process. Chapter 4 presents overall conclusions and discusses the main results of both chapters.

3. How to train safe driving?

In this chapter we address the question how to train safe driving. First of all we look into current driver training. Next we focus on learning opportunities for calibration and on the instructional method towards this end. Finally, some consideration is given to individual differences in driver training.

3.1. Driver training

The development of strategies for the training of drivers is largely dependent upon our understanding of the task and on the limitations of training opportunity. In the previous chapter a number of factors have been described that are critical for safe driving. It has been argued that especially the balancing of the assessment of the task demands and the driver's own capabilities plays a crucial role in the learning process of novice drivers.

Until now, driver training primarily addresses operational task elements. It is particularly focussed on the acquisition of skills, especially those skills that are necessary to pass the driving test. The emphasis lies on perception skills, motor control skills, and decision making (Vlakveld, 2000). Also additional training courses are organised, which emphasize the acquisition of more advanced driving skills, such as skid training, and driving in adverse weather conditions. These training courses generally take place in a car on a test site. It is common knowledge now, that this type of training is not without problems. It has been shown that the training itself may lead to an overestimation of own's own skills. The problem is that: "A skilled driver is not necessarily a safe driver (Drummond, 1995; Gregersen, 1999)". Detrimental effects of overestimation threaten to counterbalance the beneficial effects of training. Driving pupils tend to overestimate the safety effects of the training programme, and believe they have already acquired the necessary skills. For instance, Gregersen (1996) demonstrated that learner drivers who were trained in practical skills (the training group) were found to overestimate their ability more than learner drivers who were trained to be aware of their limitations in the same situations (the insight group). After a skid training (30 minutes), the training group demonstrated a higher estimated skill than the insight group, while both groups did not differ in their actual skill. He concluded that the skill training produces more overestimation than the insight training. This may also explain the negative effect of skid training on accidents on icy roads. Gregersen reports that the introduction of a compulsory skid course as part of a basic driver training course in Norway, resulted in an accident increase on slippery roads. He postulated that the skid course had made youngsters believe that they could handle slippery conditions. Would they in the past have refrained from driving in these conditions, after the course they chose to drive under these conditions (increased task demands). The benefits of a change towards more risk awareness, insight into one's own limitations etc. have been shown in several studies.

So, the preliminary conclusion is that the essential element that drivers need to acquire, is not training of skills, but knowledge of their ability to deal with traffic hazards.

Novice drivers need to understand that driving involves much more than control skills. If this is not given proper attention, the provision of additional training will only further improve their skills and sense of accomplishment, but will not lead to safer behaviour.

A powerful way to reduce this effect is, to have the instructor make the driver realize that, in spite of his skill training, in specific traffic situations he may not be as skilled as he thinks. Driver training should not only focus on improving skill, but also on making the driver aware that he cannot (yet) rely on his own skill in handling all critical situations (see also Gregersen, 1996, 1999). The explicit aim of such training is to calibrate the driver's self-assessment and to encourage him to drive with larger safety margins. Gregersen points out that, in order to achieve such insight, it is probably insufficient to tell the driver that his skills are limited: he must realize this in practice.

Current driver training does not prevent miscalibration, and may even stimulate miscalibration. This is related to the fact that the training does not incorporate enhancing learning conditions for the driver after he has been qualified. For instance, drivers are not taught how to assess the degree to which they have actually mastered certain skills, and what skills they still need to develop to what degree. The inherent caution with which novice drivers operate, will partly diminish on account of the fact that they have received formal training. This allows them to think they have acquired all necessary skills, while in fact they have not.

Instead, driver training should incorporate methods to match self-assessed ability to actual ability. Errors and the appearance of lack of skills are important elements of instruction. It is important that drivers learn to actively search for and use the feedback that the driving environment provides them with. The main goal should be to prevent hazards from developing. This is an element that can be taken up in driver training.

The rule should be: when providing drivers with training, it is essential that these drivers also receive adequate feedback on the level of their skill. This is the reason why in the Netherlands, the emphasis on skid training shifted from training of skidding skills, toward focussing on the prevention of a situation in which a person loses control of the vehicle.

Driver training may play an essential role in providing the necessary feedback to acquire accurate safety assessment and control. Lack of feedback is expected to lead to failure in the perception of safety and risks.

3.2. Instructional method and the role of feedback

It has been established that feedback on performance is essential for the learning of complex skills (e.g. Groeger & Brady, 1999). Skills are learned better and faster, if learners are given clear and immediate information of the effects of their actions. Without knowledge of the effect of one's actions on the environment, and knowledge of the criteria which one's performance should meet, a system cannot regulate itself. Without such knowledge a driver will have great difficulty in arriving at sensible conclusions about hazard occurrence and about his own ability to deal with the hazard. Initially the driving instructor is, or should be, one of the most important sources of feedback for the trainee driver. After qualification, feedback from the environment is limited to reactions from the traffic environment. Instead of

receiving verbal support, the novice drivers must now extract relevant information about the appropriateness of their behaviour from the effect it has on the traffic scene. A complication in this process is that “the highway system is notoriously ‘forgiving’, providing great scope for error recovery, while supplying road users with the minimum information on their levels of performance” (McKenna, 1982).

This means that a correct calibration of task demands and coping abilities largely depends on practice, and the amount and quality of feedback that a driver receives. The literature shows that calibration improves with feedback (Sharp, Cutler & Penrod, 1988). For calibration training this would mean that a method needs to be designed in which drivers encounter critical situations to which they are required to respond. This should be followed by performance feedback.

The term feedback is used here to refer to task and performance related information. Feedback can be provided actively, through a driver instructor, or a passenger (*extrinsic feedback*), or it can be generated as intentional and unintentional cues from the traffic environment in which the driver takes part (*intrinsic feedback*) (see Kuiken, 1996). Intrinsic feedback is also defined as information from the environment produced by the system as it responds

Next to the explicit direction of attention, performance feedback is also of crucial importance in the acquisition and maintenance of safe driving skills. One of the problems in driving is that, generally, driving provides only a limited amount of feedback. Errors are compensated for by the road design or other road users. Also, automated tasks may become an issue. Take the example of a person driving home from work who follows the same pre-determined path, stops at a traffic light, responds to brake lights and goes with the flow of traffic, yet can report almost no recollection of the trip. Here, it appears that a low-level attention is being allocated to the task, keying on critical environmental features that automatically evoke appropriate responses. Although automatism is an important mechanism for overcoming human information processing limitations, the primary hazard here is an increased risk of being less responsive to new stimuli, as automatic processes operate with limited use of feedback.

Feedback-based adjustments of behaviour may occur at different levels, e.g. adjustments of safety margins when following a car (manoeuvring level), momentary adjustments of steering and acceleration in response to slippery roads (control level), and changes in travel plans to avoid driving under certain conditions (strategical level).

The absence of intrinsic feedback concerning errors may weaken associations between actions and their consequences. This may lead to learning of inappropriate behaviour, and incorrect calibration. One implication may even be, that drivers are *unaware* of their inappropriate speed or positioning. Inadequate safety margins and unsafe speeds may develop *gradually* and *outside the driver's awareness*. In addition, practice does not always improve or help sustain performance. This is consistent with the results of a study performed by Groeger and Grande (1996), in which the relationship between self-assessed and objectively assessed driving behaviour (e.g. assessed by driving instructors) was investigated. The authors found that, although drivers' assessments of their own performance were quite consistent and stable over time, drivers' views of their own ability seemed only weakly related to the objective assessment (e.g. driving

instructor) of their skill. Without explicit feedback from the instructor while driving the test route, the drivers' self-assessment was not related to that of the instructor (it was more positive), whereas with feedback from the instructor, the assessments of drivers and instructors were related. From the few studies that have directly addressed calibration, we may tentatively conclude that driver training is risky, but it may also be effective if the right feedback is given.

3.3. Individual differences

Learners do not use knowledge of results in the same way. Personality may account for important differences. Young drivers who hold strong views about themselves as drivers, and are very reluctant to put their skills to a test (certainty-oriented learners), are expected to back off, or stop trying. They are unwilling to use additional feedback about their real performance. If they are forced to do so, they will, in accordance with attribution theory, devalue the results. It is important to recognize these drivers before the test, and to look for instructions that will accommodate their needs and motivate them to use the feedback provided.

Sex-differences

Most studies dealing with overestimation have focussed on young men. As a result not much is known about overestimation and calibration errors in young women. Spolander (1983) argues that 'miscalibration' in young men leads to a more aggressive driving style. Women of the same age also 'miscalibrate', but have a more inadequate driving style as a result of limited driving experience. They often underestimate their own potential and overestimate the traffic complications. This leads to a more defensive driving style. Within the framework of the study, sex differences need to be studied in order to assess the differential effects of calibration training on men and women.

4. Conclusions

This chapter presents the main results of the literature review and identifies consequences of these findings for driver training.

4.1. Improving hazard perception?

Hazard perception is generally regarded as a specific skill or set of skills which can, to a degree, be measured and trained. Empirical findings support the conclusion that inexperienced drivers show less awareness than more experienced drivers of the imminent hazards of the road system operation, or are slower to respond. It seems that, with practice, young drivers' expectancies of what might happen next, begin to correspond better with reality. One of the main problems with empirical research on hazard perception, is that it is not known whether different researchers use the same criterion for hazards (see also McKenna & Horswill, 1999). It is theorized, that this is partly caused by the fact that many different items and components of driving behaviour are included in hazard perception tests.

4.2. Improving self-assessment?

From the literature, it is also clear that a lack of understanding of drivers' own limitations can be an important critical safety factor in driving. A large part of the problem is, that drivers do not perceive traffic situations as hazardous because they overestimate their skills. From this standpoint, it is believed that an important method to improve safety awareness among young drivers, is to find ways of making them realize their own limitations and making them understand that situations may occur that they cannot handle.

4.3. Development of meta-skills?

There is an increasing interest in the relation between different skills. Authors have successfully argued that hazard perception, risk perception and self-assessment are not unrelated. Driver training should not so much focus on acquiring sufficient skills, but on learning to balance the task demands and one's own skills and abilities. As driving is partly a self-paced task, it is to some degree possible to increase or decrease the task difficulty, for instance by slowing down or speeding up, or maintaining a larger following distance to a preceding vehicle. This requires drivers to be accurate in their assessment of task demands, as well as in the assessment of their own abilities or lack of abilities. This is usually called 'calibration'. The process of calibration can be characterised as the weighing or balancing of the results of the assessment of driving demands and the assessment of one's own skills, resulting in the recognition of balance or imbalance.

How do drivers perform such tasks and how should they be trained?
The literature survey supported the following notions concerning the role of calibration in driver training:

Calibration is a core issue in safe driving

- Inexperienced drivers show less awareness than older drivers of the actual realities of road system operation, and less awareness of their own role.
- Unrealistic self-assessment and poor calibration may be the rule in traffic behaviour, rather than an exception.
- The lack of calibration seems largely to be the result of system characteristics rather than to driver characteristics.

Poor calibration may be caused by:

- Failure to anticipate risk and danger (caused by lack of detection (e.g. due to inappropriate visual search), lack of recognition (situation detected but not recognised as potentially hazardous), error in anticipation of task demand required to negotiate hazard, or error in anticipation of own task.
- Incorrect evaluation of the outcome of demand regulation and hazard adaptation (e.g. drivers may perceive the outcome accurately, but have different acceptance criteria; they may not be able to perceive the outcome accurately).

It is recommended that calibration is explicitly addressed in driver training

- It is essential that the process of calibration is seriously taken into account when developing driver training programmes.
- Beneficial effects are expected when novice drivers are explicitly trained in higher order (driving) skills. A key area in this, may be to focus on the acquisition of accurate situation awareness, and the calibration of task demands and skills.
- It is recommended to investigate the effects of such additional training, in particular, the training in developing accurate knowledge of one's own ability to deal with hazards.

Current driver training does not prevent miscalibration, and may even stimulate miscalibration. This is related to the fact that the training does not incorporate enhancing learning conditions for the driver after qualification. For instance, drivers are not taught how to assess the degree to which they have actually mastered certain skills, and which skills they still need to develop to what degree. The inherent caution with which a novice driver operates, will partly diminish on account of the fact that they have received formal training. This allows them to think they have acquired all skills, while in fact they have not.

Feedback plays a key role

Correct calibration of task demands and coping abilities largely depends on practice and the amount and quality of feedback that a driver receives.

The term feedback is used here to refer to task and performance related information. Feedback may be provided actively, through a driver instructor or a passenger (extrinsic feedback), or it may be generated as intentional and unintentional cues from the traffic environment in which the driver takes part (intrinsic feedback)

The absence of intrinsic feedback concerning errors may weaken associations between actions and their consequences. This may lead to learning of inappropriate behaviour, and incorrect calibration. One implication is, that drivers may even be *unaware* of their inappropriate speed or

positioning. Inadequate safety margins and unsafe speeds may develop *gradually and outside the driver's awareness*. In addition, practice does not always improve or help sustain performance.

Driver training can contribute to better calibration between task demands and skills. The essence of the training is that it should incorporate methods to match self-assessed ability to actual ability. Errors and the appearance of lack of skills are important elements of instruction. Also, it is essential that drivers learn to actively search for and use the feedback that the driving environment provides them with. The main goal should be to prevent hazards from developing. When learning to drive, it should be a golden rule that drivers receive adequate feedback on the actual level of their skill.

References

- Brown, I.D. (1989). *How to train safe driving?* Traffic Research Centre, University of Groningen, Haren.
- Brown, I.D. (1990). *Driver's margins of safety considered as a focus for research on error*. In: Ergonomics, No. 33, p. 1307-1314.
- Brown, I.D. & Groeger, J.A. (1988). *Risk perception and decision taking during the transition from novice to experienced driver status*. In: Ergonomics, No. 31, p. 585-598.
- Crick, J.L. & McKenna, F.P. (1992). *Hazard perception: can it be trained?* In: Grayson, G.B. (ed.), Behavioural research in road safety II. Transport Research Laboratory, Crowhorne, p. 100-107.
- Deery, H.A. (1999). *Hazard and risk perception among young novice drivers*. In: Journal of Safety Research, No. 30, p. 225-236.
- DeJoy, D.M. (1989). *The optimism bias and traffic accident risk perception*. In: Accident Analysis and Prevention, No. 21, p. 333-340.
- Drummond, A.E. (1995). *The role of experience in improving young driver safety*. In: New to the road: reducing the risks for young motorists, International symposium, UCLA Los Angeles, June 8-11, 1995.
- Endsley, M.R. (1995). *Toward a theory of situation awareness in dynamic systems*. In: Human Factors, No. 37 (1), p. 32-64.
- Fuller, R. (2000). *The Task-Capability Interface model of the driving process*. In: Recherche Transports Sécurité, No. 66, p. 47-59.
- Gregersen, N.P. (1996). *Young drivers' overestimation of their own skill - an experiment on the relation between training strategy and skill*. In: Accident Analysis and Prevention, No. 28, p. 243-250.
- Gregersen, N.P. (1999). *Driver training and licensing – current situation in Sweden*. In: IATTS Research, No. 23, p. 67-77.
- Groeger, J.A. (1989). *Conceptual bases of drivers' errors*. In: The Irish Journal of Psychology, No. 10, p. 276-290.
- Groeger, J.A. & Brady, S.J. (1999). *The relationship between training, practice and license requirements*. In: IATSS Research, No. 23, p. 58-66.
- Groeger, J.A. & Chapman, P.R. (1996). *Judgement of traffic scenes; The role of danger and difficulty*. In: Applied Cognitive Psychology, No. 10, p. 349-364.
- Groeger, J.A. & Grande, G.E. (1996). *Self-preserving assessment of skill?* In: British Journal of Psychology, No. 87, p. 61-79.

Horswill, M.S. & McKenna, F.P. (1996). *A video-based simulation for measuring speeding-behaviour*. In: Grayson, G.B (ed.), *Behavioural research in road safety VI*. Transport Research Laboratory, Crowthorne. p. 27-37.

Kruysse, H.W. & Wijnhuizen, G.J. (1992). *Why are experts not better in judging the danger of filmed traffic conflicts?* In: *Accident Analysis and Prevention*, No. 24, p. 227-235.

Kuiken, M.J. (1996). *Instructional support to drivers; The role of in-vehicle feedback in improving driving performance of qualified motorists*. Traffic Research Centre, University of Groningen, Haren.

Lajunen, T. & Summala, H. (1995). *Driving experience, personality and skill and safety-motive dimensions in drivers' self-assessments*. In: *Personality and Individual Differences*, No. 19, p. 307-318.

Lajunen et al. (1998). *Cross-cultural differences in drivers' self-assessments of their perceptual motor and safety skills: Australians and Finns*. In: *Personality and Individual Differences*, No.24, p.539-550.

McKenna, F.P. (1982) *The human factor in driving accidents, an overview of approaches and problems*. In: *Ergonomics* 25, p 867-877.

McKenna, F.P. (2000). *What is going wrong in the early part of the driving career*. In: *Proceedings Novice Drivers Conference*, Bristol, 1-2 June 2000. DETR.

McKenna, F.P. & Crick, J.L. (1991). *Hazard perception in drivers; A methodology for testing and training*. Transport and Road Research Laboratory, Crowthorne.

McKenna, F.P. & Crick, J.L. (1994). *Developments in hazard perception; Final report*. Department of Transport (UK).

McKenna, F.P. & Horswill, M.S. (1998). *The effect of skill acquisition on risk-taking*. Department of Psychology, University of Reading, Reading.

McKenna, F.P. & Horswill, M.S. (1999). *Hazard perception and its relevance for driver licensing*. In: *IATTS Research*, No. 23, p. 36-41.

McKenna, F.P., Stanier, R.A. & Lewis, C. (1991). *Factors underlying illusory self-assessment of driving skill in males and females*. In: *Accident Analysis & Prevention*, 23, 1, p. 45-52.

Mills, K.L. et al. (1996). *The effects of hazard perception training on the development of novice driver skills*. In: *Roadsafe '96*. Influences on road user behaviour. Conference report. Association of London Borough Road safety officers.

Quimby, A.R. & Watts, G.R. (1981). *Human factors and driving performance*. Laboratory report 1004. Transport and Road Research Laboratory, Crowthorne.

Quimby, A.R. et al. (1986). *Perceptual abilities of accident involved drivers*. Research Report 27. Transport Research Laboratory, Crowthorne.

Renge, K. (1998). *Drivers' hazard and risk perception, confidence in safe driving, and choice of speed*. In: IATTS Research, No. 22, p. 103-110.

Sharp, G.L., Cutler, B.L. & Penrod, S.D. (1988). *Performance feedback improves the resolution of confidence judgements*. In: Organizational Behaviour and Human Decision Processes, No. 42. p. 271-283.

Spolander, K. *Accident risks of drivers; A model tested on men and women*. National Swedish Road & Traffic Research Institute. Linköping, Sweden.

Underwood, G. *In-depth study of young novice drivers*. In: Proceedings Novice Drivers Conference, Bristol, 1-2 June 2000, DETR.

Vlakveld, W.P. (2000). *Leerdoelen voor het Rijbewijs B. Eindrapport*. Ministerie van Verkeer & Waterstaat, Adviesdienst Verkeer en Vervoer, Rotterdam.

Wills, T.A. (1981). *Downward comparison principles in social psychology*. In: Psychological Bulletin, No. 90, p. 245-271

Walton, D. (1999). *Examining the self-enhancement bias: professional truck drivers' perceptions of speed, safety, skill and consideration*. In: Transportation Research, Part F, No. 2. p. 91-113.