Delivery Report for

MeBeSafe

Measures for behaving safely in traffic

Deliverable Title	Integrated Framework
Deliverable	D1.1
WP	WP1 Integrated Framework
Task	Task 1.1. Integrated framework Task 1.2. User profiling Task 1.3. Refinement of measures

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Abstract
The MeBeSafe project intends to develop, implement and validate interventions that direct road users (drivers and cyclists) towards safer behaviour in common traffic situations which carry an elevated risk. More specifically, the aim is to change habitual traffic behaviour using different nudging interventions, i.e. subconsciously pushing road users in a desired direction without being prohibitive against alternative choices of action. The project will also compare different ways of coaching and evaluate the effect of a combination of nudging and coaching. This deliverable, D1.1 Integrated Framework, describes the work completed within WP1 of the MeBeSafe project. Based on literature reviews, interviews with academic and non-academic experts, discussions and workshops, the deliverable: (i) describes the key characteristics of nudging and coaching respectively; (ii) presents a framework that integrates the two, taking into consideration (in particular) time and frequency; (iii) describes underlying theories and models of relevance for understanding road user behaviour; (iii) explains road user profiles or characteristics of relevance to consider in the design of the interventions (i.e., in WP2, WP3, and WP4), as well as the design and interpretation of the outcome of the field trials (in WP5); and (iv) presents design considerations, i.e. factors that should be observed when improving on the initial ideas and further develop the design of the nudging and coaching interventions. More detailed design guidelines must be developed as part of the work to be completed in WP2, WP3, and WP4.

Version	Date	Comment
1	12.07.2017	Creation of structure & assignment of tasks
2	07.08.2017	Creation of template
3	01.09.2017	Draft 1
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9	29.10.2017	Review comments received and minor changes made.
10	30.10.2017	Draft 6 submitted to coordinator (ika)

table of document history

Table of Contents

List of Figures

List of Tables

Acronyms

Acronym	Explanation
ACC	Adaptive Cruise Control
CBT	Cognitive Behavioural Therapy
GEMS	Generic Error Modelling System
GIDAS	German In-Depth Accident Study
EU	European Union
HGV	Heavy goods vehicles
IVMS	In-Vehicle Monitoring System
MeBeSafe	Measures for Behaving Safely in Traffic
SCT	Social Cognitive Therapy
TEC	Theory of Event Coding
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
WP	Work Package

Glossary

Term	Definition/explanation
Coaching	A collaborative solution-focused, results-orientated systematic process, used with normal, non-clinical populations, in which a coach facilitates the enhancement of work performance and the self-directed learning and personal growth of a coachee.
Design considerations	An aspect that has to be considered at a certain stage of the design process so that decisions regarding the design of an intervention can be taken.
Intervention	The act or process of intervening to bring about behaviour change or to improve a situation; the combination of particular intervention strategies that are applied in a certain way to address a specific behaviour with the aim to produce a defined target behaviour or target outcome.
Intervention approach	A distinct theoretical perspective for how to address behaviour change.
Integrated framework	A conceptual structure that combines one or more frameworks/models consisting of a set of ideas, conditions, or assumptions that describe how something can be perceived, understood, or approached.
Intervention strategy	A way to stimulate a particular behaviour or produce particular outcomes.
Nudge	Any aspect of car interiors or of road infrastructure that will mindlessly influence an individual's choosing a certain behaviour.

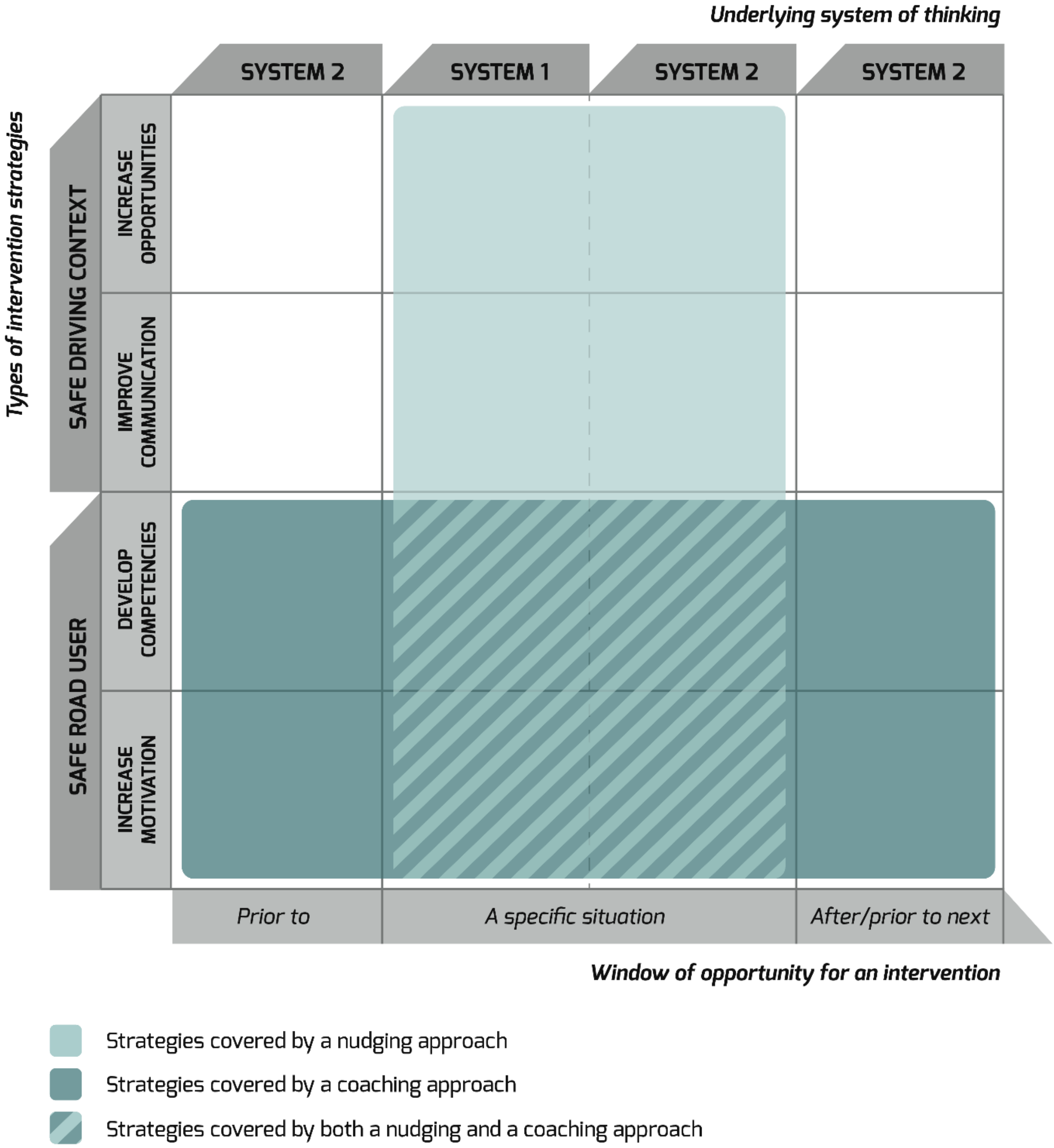
Executive Summary

The **MeBeSafe project** is to develop, implement and validate interventions that direct road users (drivers and cyclists) towards safer behaviour in common traffic situations which carry an elevated risk. More specifically, the project aims at changing habitual traffic behaviour using different nudging interventions, i.e. subconsciously pushing road users in a desired direction without being prohibitive against alternative choices of action. The project will also compare different ways of coaching and evaluate the effect of a combination of nudging and coaching.

MeBeSafe is organised in altogether six work packages (WPs). This deliverable is the result of WP1 **Integrated Framework**. The main purposes of WP1 were to (i) develop a framework which combines theoretical behavioural change models with the concepts of nudging and coaching; (ii) identify relevant road user profiles or characteristics that need to be considered in the project, and (iii) propose design guidelines to help refine the initial ideas for interventions. The overall aim is to support work in WP2, WP3 and WP4 in which the detailed design of the respective nudging and coaching interventions will be developed.

The work has been accomplished based on literature reviews (to ensure state-of-the-art), interviews with academic and non-academic (in-house) experts to exhort their thoughts on nudging, coaching, and road user profiles, as well as workshops and discussions in which participated WP1 project partners.

The types of interventions to be developed and implemented in MeBeSafe include nudging, coaching (and combinations of nudging and coaching). Part of developing the **framework** (task 1.1) has been to typify the two approaches. On the basis of this typification, the assumed underlying system of thinking, i.e. System 1 or System 2, and types of intervention strategies, an integrated model is proposed. System 1 is fast and operates automatically, with little or no effort and no sense of voluntary control. System 2, on the other hand, is slow and allocates attention to the effortful mental activities that demand it.



In addition to a literature review on state-of-the-art re nudging and coaching, further literature studies have contributed to identifying **underlying, fundamental theories and models** of relevance for further understanding road user behaviour. Three main groups of theories and models have been distinguished: on road user competencies, on road user states, and on motivations and decisions. The models on road user competencies deal with questions as; Which skills does a road user need to perform the traffic task? Which underlying processes play a role, such as information processing, visual perception and attention? The road user states models address how risk factors (fatigue, poor vision, alcohol and drugs, etc.) influence behaviour in traffic. Models on motivation and decisions, finally, refer to factors which motivate road users to make decisions that might impede their own safety and that of others. The three types of models fall into one of two categories. The first category is based on the assumption that the underlying processes are basically conscious and that road users engage in mental processes such as weighing the pros and cons, developing opinions and beliefs, and assessing barriers and opportunities (i.e. System 2 thinking). In contrast, the second category assumes that most decisions are automatic, and more importantly that they are heavily biased and substantially less rational than most people believe (i.e. System 1 thinking). Based on these, implications for coaching and nudging interventions have been formulated.

The work in WP1 has also included identifying and taking into consideration **road user profiles** or road user characteristics of relevance (task 1.2). General characteristics include, for example age (younger and elderly road users are identified as risk groups), gender (gender differences exist) and experience but also personality traits, attitudes and intentions should be considered in the further work of MeBeSafe. In designing the field trials (in WP5) it is recommended that demographical factors such as age and gender but also experience are controlled for. In relation to nudging and coaching there is limited knowledge as to the influence of profiles but there are implications that there are cultural differences regarding who is open to nudging or not.

The design of the interventions will require a process consisting of several, iterative steps and decision points. To support the initial stages of the design process, WP1 (task 1.3) has resulted in the formulation of some **design considerations** which have been educed from the literature reviews, the accomplished interviews, and the workshops. The considerations have taken the shape of questions to be addressed when moving from a conceptual level to more detailed designs. The work has also resulted in some generic design guidelines. When designing nudging interventions, for example, it is essential that the nudges do not interfere with 'good' automatic routines and that they do not increase the mental workload of the road user in critical situations. When designing coaching interventions, the recommendations are, for example that professional drivers should be coached by a peer; advice should be presented before a trip and informative feedback be presented after each trip; and that feedback on individual behaviour should only be made available to the coaching pair (coach and coachee).

Contribution by Each Partner

BMW has contributed to the completion of the work in WP1 by taking part in the discussion on the framework, participating in telephone conferences and one of the two workshops, and by reviewing the deliverable D1.1 as well as adding references.

Cranfield University has been responsible for the chapter on coaching in cooperation with Shell. Cranfield has also participated in the second of the two WP1 workshops.

FCA Italy (Fiat Chrysler Automobiles Italy) has contributed to the work in WP1 by carrying out interviews with different experts, hereby providing input to the chapter on user profiling. By participating in one of the two workshops, FCA Italy has contributed to the definition of the integrated framework.

ika (Institute for Automotive Engineering, RWTH Aachen University) has been responsible for writing the chapter on user profiling and integrating textual contributions from other partners in this chapter. ika has also contributed to the sections on behavioural models, problems to be addressed and design considerations. ika participated actively in two WP1 workshops and attended and actively contributed to WP1 telephone conferences.

TNO has been responsible for writing the section on nudging. TNO has further contributed to the sections on intervention strategies, problems to be addressed, integrated framework and design considerations. TNO participated actively in the two WP1 workshops.

SAFER/ Chalmers has been the leader of WP1 with overall responsibility for organising the work, including workshops, telephone conferences, and communication with the internal reviewer of the deliverable, etc. SAFER/Chalmers has provided the interview template used for collecting information from in-house and external experts on the topics of nudging, coaching, and the relevance of user profiles. In addition to proposing the structure for the deliverable and writing the Executive Summary, Conclusions etc., SAFER/Chalmers has had main responsibility for the sections on intervention strategies and the integrated framework. SAFER/Chalmers has also developed the content of the chapter on design considerations, for example linking it to the integrated framework.

Shell has in collaboration with Cranfield contributed to the chapter on coaching, with specific responsibility for information from hauliers. Shell has contributed to the work in WP1 by conducting interviews with stakeholders, and by participating in WP1 workshops.

SWOV (Institute for Road Safety Research) has been responsible for writing the chapter on behavioural models and contributed to the chapter user profiling. In addition, SWOV participated in both workshops, aiding to the clarifications and the consistency of the concepts used in the framework.

VCC (Volvo Car Corporation) has written the problem formulating sections for the nudges that will be developed by VCC, as well as through interviews gauged the readiness for, and previous experience of, working with nudging as a means for drivers' behavioural change at VCC. VCC has also participated in one of the two WP1 workshops as well as in telephone conferences.

VUFO (Institute for Traffic Accident Research at Dresden University of Technology) has contributed to the chapter on user profiling with expertise in analyses of national and international road traffic accident data. VUFO was able to determine the user profiles more directly by using an in-depth database for road traffic accidents (GIDAS). VUFO participated actively in one of the two WP1 workshops and attended all WP1 telephone conferences.

1 The MeBeSafe Project

In 2014, almost 26,000 people were killed and 300,000 seriously injured on EU roads. The major cause in most road accidents is argued to be road user behaviour that is inappropriate to the risk posed by the situation. Road accident statistics identify several factors including lack of attention, excessive speed for the circumstances leading to loss of control and failure to timely spot hazards, and impeded mental and/or physical condition due to, for example, fatigue.

The MeBeSafe project will develop, implement and validate measures that direct road users (vehicle drivers and cyclists) towards safer behaviour in common traffic situations which carry an elevated risk, making road users preserve larger safety margins. The project takes the approach to change habitual traffic behaviour directly using nudging, a concept adapted from behavioural economics that relates to subconsciously pushing humans in a desired direction without being prohibitive against alternative choices of action. Predisposing humans to making a desired choice makes nudging measures less invasive and applicable early in a given chain of events that might lead to a critical/accident-prone situation. This is a major benefit. The project will also compare different ways of coaching and evaluate the effect of a combination of nudging and coaching.

MeBeSafe is organised in altogether six work packages (WPs) (Figure 1.1).

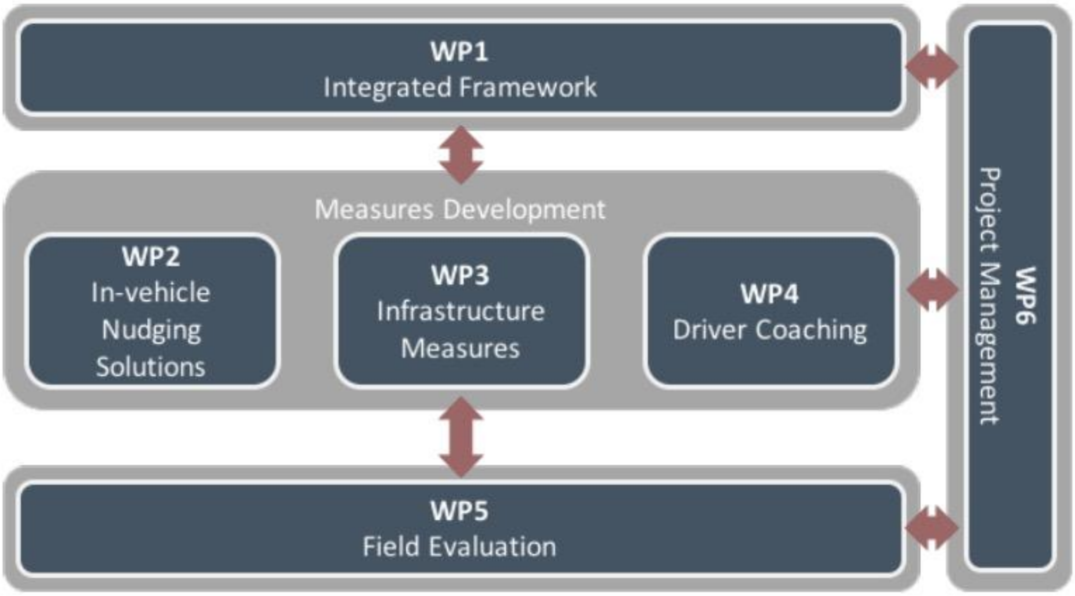


Figure 1.1: MeBeSafe is organised in six work packages.

- WP1 - *Integrated Framework* - is to provide a theoretical framework which combines theoretical behavioural change models with the concepts of nudging and coaching, and identify relevant factors to support to the design of the specific measures in WP2, WP3, and W4.
- WP2 - *In-vehicle nudging solutions* - focuses on the design, development and preliminary tests of in-vehicle nudging solutions. This WP will also develop interfaces for in-vehicle coaching systems.
- WP3 - *Infrastructure measures* - is to develop and test nudging infrastructure measures directed towards drivers and cyclists respectively, hereby increasing safe behaviour in specific situations and sections of roads/streets.
- WP4 - *Driver coaching* - involves the development of driver coaching schemes, both on- and off-line, directed towards professional as well as non-professional road users.
- In WP5 - *Field Evaluation* - the in-vehicle, infrastructure, and coaching measures developed in WP2, WP3 and WP4 will be implemented and tested in actual traffic environments and their effects evaluated.
- Finally, WP6 - *Project Management* - is concerned with administering the project as well as coordinating communication and dissemination.

2 Scope and Structure of Deliverable

2.1 Scope

The scope of the deliverable, D.1.1 Integrated Framework, is to describe the outcome of the work accomplished in WP1. More specifically the scope of the deliverable is to:

- describe the key characteristics of nudging and coaching and present a framework that integrates the two, taking into consideration (in particular) time and frequency;
- describe underlying, fundamental theories and models of relevance for understanding more in-depth road user behaviour;
- explain road user profiles or road user characteristics of relevance to consider in the design of the interventions (in WP2, WP3, and WP4), as well as in the design and interpretation of the outcome of the field trials (in WP5);
- present design considerations, i.e. factors that should be observed in improving on the initial ideas when further developing the designs of the nudging and coaching interventions in WP2, WP3, and WP4.

2.2 Structure

The deliverable is structured as follows:

- *Chapter 1* introduces the aim and overall organisation of the MeBeSafe project.
- In this chapter, *Chapter 2*, an overview of the scope and structure of D.1.1 is provided, as well as a description of the main activities undertaken to accomplish the work.
- In *Chapter 3*, the six traffic safety problems to be addressed in MeBeSafe are briefly described.
- *Chapter 4* provides an introduction to different behavioural change strategies. The concepts of nudging and coaching are described and a framework integrating the two concepts is presented.
- *Chapter 5* presents an overview of different fundamental theories and models of relevance to the problems to be addressed in the project.

- *Chapter 6* provides a summary of findings related to user profiling.
- In *Chapter 7*, the information extracted from the former chapters has been brought together and translated into design considerations.
- *Chapter 8*, finally, summarise the main conclusions.

2.3 Accomplishment

The work in WP1 and the completion of D1.1 were accomplished as follows:

- The MeBeSafe project builds on existing knowledge. Nevertheless, further literature studies were undertaken to ensure that the project had access to state-of-the-art on nudging and coaching, as well as fundamental theories and models of relevance to road user behaviour.
- Furthermore, a literature study was accomplished to address the influence of road user profiles or characteristics on traffic accidents and incidents. In addition, the German database GIDAS for further analyses order to provide more detailed input.
- In order to gain further input on nudging and coaching schemes directed towards professional and non-professional drivers and other road users, a series of interviews were completed. The interviews have been carried out with individuals from within the partner organisations (FCA Italy, Shell, and VCC) as well as with, for example, academics from different disciplines.
- Telephone conferences have been organised with project partners to discuss and plan the work.
- Workshops have been arranged with project partners to discuss the key concepts (i.e. nudging and coaching), the outcome of the in-depth literature studies and, further, to compare these with the knowledge and experience within the group. The two workshops have been completed, one in Aachen in connection to the kick-off meeting (June, 2017) and one in The Hague (Sept, 2017).

3 Problems Addressed

The MeBeSafe project will address altogether six traffic safety problems - or use cases - by developing nudging or coaching or a combination of nudging and coaching interventions. These problems as well as the proposed interventions have been specified in the MeBeSafe project plan.

3.1 Inappropriate speed

3.1.1 Driving

Drivers should adopt appropriate speed!

Speed limits on inter-urban 2-lane roads (single carriageways) vary between 80 km/h and 100 km/h in most EU countries. However, unlike motorways (where the road layout supports continuous high speeds) these inter-urban 2-lane roads have segments where the safe speed is much lower than the general speed limit due to, for example tight bends, hidden dips and sudden road narrowing. They mix extra-urban stretches with urban segments when passing through built-up areas and they have level crossings. Over 50% of all accidents take place on inter-urban roads. The problem is that drivers often choose a speed that is inappropriate for the stretch of road they are driving on.

Drivers may not be aware of the fact that they drive at an inappropriate speed on a certain stretch of the road, unaware of possible risks that are still out of their sight, for example, if a congestion happens after a curve at a motorway exit or after a narrow part of the motorway.

Within the MeBeSafe proposal, infrastructure nudging measures have been proposed as solution for this problem. Refining these ideas is part of WP3. MeBeSafe aims at detecting if a road user is approaching a section at an inappropriate speed for the specific situation at the specific moment. By implementing infrastructure nudging, MeBeSafe aims to slow them down without them necessarily being aware of the reason why they are slowing down. MeBeSafe will use the input from a network of roadside sensors feeding into a machine learning system to develop triggering conditions that will decide whether to deploy nudging interventions. In doing so, nudging measures addressing inappropriate speed will be directed only at road users and in situations where this is necessary.

3.1.2 Cycling

Bicyclists should adopt appropriate speed!

Cycling is getting more and more popular and the number of bicyclists has been significantly increasing over the last decades. Even though there are a number of benefits associated with cycling, it also results in a number of injuries and deaths every year. With an increasing number of bicyclists, an increase in injuries and deaths can be expected.

A large part of bicycle accidents happens on bicycle lanes, where bicyclists may be in conflict with other bicyclists or pedestrians, or where bicycle lanes intersect with other type of roads, i.e. where bicyclists conflict with, for example motorised vehicles.

There are several contributing factors, one of which is speed. Higher cycling speeds have been found to be related to injury severity (Schepers et al., 2014) whereas low cycling speeds have been suggested as an explanation for lower injury rates (e.g., Woodcock et al., 2014). Keeping an appropriate speed is of importance overall but in particular when approaching intersections. Low cycling speeds increase the time that the bicyclist has to pay attention to other road users and in longer reaction times to take action to avoid collisions. It also allows car drivers more time to respond to cyclists (Summala et al., 1996).

Speed reducing interventions have most often focused on the drivers of motorised vehicles, from simple infrastructure measures, to in-vehicle ICT-based systems that convey messages to warn the driver and, further, to cooperative technologies that gather information from infrastructure and/or other vehicles and convey information to the driver (e.g., Schramm & Rakotonirainy, 2008). MeBeSafe will instead focus on the bicyclist per se. MeBeSafe intends to evaluate and compare the efficiency of non-intrusive and cost-efficient nudging strategies to reduce the speed of bicyclists when approaching critical intersections and hereby increase the possibility for the bicyclists to observe other road users as well as the possibility for the bicyclist to manoeuvre the bicycle in a safe way.

3.2 Inappropriate trajectory

Road users should follow an appropriate trajectory!

Similar to speed, driving at an inappropriate trajectory can pose a risk in some traffic situations. If, for example, a driver encounters a highway exit with a tight bent curve in which (s)he has to correct his steering to get through, choosing the correct trajectory according to his/her own speed is crucial. The middle of the road is neither the subjective preference of the driver as they tend to cut curves to avoid a high lateral acceleration (see Bellem et al., 2017), nor is the chosen trajectory always the safest at a certain speed. Some situations are difficult to forecast for drivers, especially if curves, trees, traffic or other environmental conditions make assumptions about potential dangers almost impossible.

Within the MeBeSafe proposal, infrastructure nudging measures have been proposed as solution for this problem. MeBeSafe aims to nudge drivers to choose a trajectory taking into account also the maximum allowable speed (see section 3.1.1) with regards to the specific situation. This can be, for example, a curve with a tight bend that the drivers cannot foresee and where they need to be nudged to adjust their driving behaviour beforehand, as it is usually too late to adapt to such a situation once one realizes that something is going wrong.

MeBeSafe will use the input from a network of roadside sensors feeding into a machine learning system to develop triggering conditions that will decide whether to deploy nudging interventions for guiding road user along a preferred risk-minimizing trajectory. In doing so, nudging measures addressing inappropriate trajectory for a certain speed will be directed only at road users and in situations where this is necessary.

3.3 Inattention to possible risk

Road users should direct attention to possible risks!

"Failure to look properly" has been shown to be a major causation factor in 30% of all accidents. The problem is to define what "properly" means. The mental workload put on a driver to keep full situational awareness in modern traffic is extremely high. In most routine driving situations, full awareness might not be required, but the exposure to potential hazards can fluctuate wildly on each trip. Most drivers subconsciously change their direction of attention to suit this fluctuating risk. For example, they interact with their radio while queued up at a traffic light but not while negotiating a busy roundabout; they will converse with passengers while driving on the motorway but stop this conversation when they have to negotiate a busy exit.

The problem is that particularly in urban traffic (where hazards can come from every possible direction) drivers have difficulties in predicting episodes of increased risk. Therefore, MeBeSafe is going to develop an in-vehicle nudging intervention that provides information to drivers in such a way that it heightens their level of attention to the potential hazards. The in-vehicle nudging intervention will increase drivers' level of attention to potential hazards in pre-conflict situations (i.e. situations that occur quite frequently in everyday driving). The in-vehicle nudging intervention directs a driver's attention towards forecasted and detected hazards before these actually pose a critical risk.

3.4 Non-usage of Adaptive Cruise Control (ACC)

Car drivers should increase their use of ACC!

In order to crash into a lead vehicle (i.e., a rear-end collision), accident causation research shows that generally two things are required: (i) a distracted driver and (ii) a lead vehicle. It may seem ludicrous to bring up the second condition, but this is in fact very important. The reason is that many proposed solutions to the problem only focus on the first issue (the distracted driver), and do not address the second one (close following). However, research on this type of conflict clearly shows that the risk of a crash is highly influenced by how far behind one is when the unexpected happens. If you're not following a lead vehicle very close, you're much more able to resolve the conflict once it arises. Rear-end crashes should therefore be possible to address just as well by avoiding close following as by avoiding distracted drivers.

Given that this assumption holds, the next question is how to make drivers avoid close following? Given that driving is largely automatized and habitual, changing how a particular individual is managing his/her distance keeping is challenging. However, there is a simpler way, further illustrated in Figure 3.1. With the merits of ACC usage clearly illustrated, the question to resolve is: How make drivers use ACC more in their everyday driving?

MeBeSafe will design nudging interventions targeted to get drivers to use their ACC system more than they have previously. The nudges may be tailored to driver's driving support preferences (i.e. one type of nudging for those who already use the system, but in a limited way, and another for those who do not use it at all). The nudges may also be tuned to context, i.e. an opt-out implementation where the system automatically turns on unless you actively block it may be restricted to a highway/interurban context where the expected uptime of the function once activated could be expected to be fairly long.

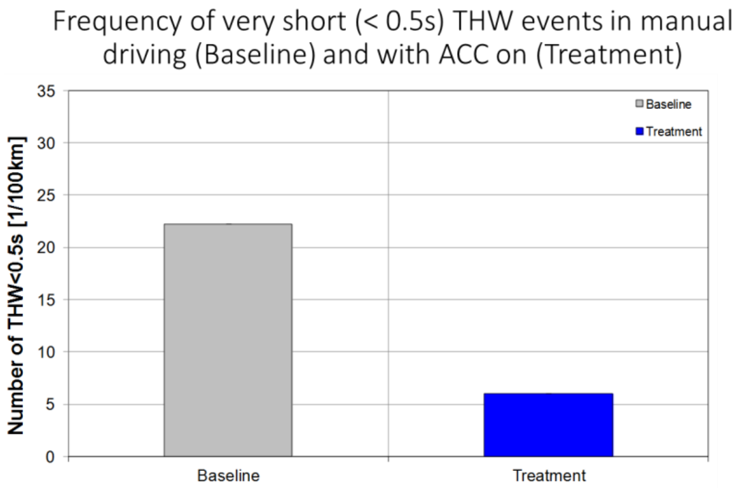


Figure 3.1: Frequency of short time headway events per 100 km of driving where driving with and without ACC on in lead vehicle following situations was compared. (Source: EuroFOT).

3.5 Unwillingness to take a break when tired

Car drivers should take a break from driving when really drowsy!

Drowsiness is a large traffic safety problem, but it does not receive the same level of attention as other crash contributing factors. This is likely due to the fact that it is difficult to detect and assert in retrospect, which is when most traffic accident reporting is done. However, it is safe to say that if drowsy driving could be addressed properly, traffic safety would be significantly increased.

When it comes to technically detecting that a driver is driving drowsy, this problem has been solved to a large extent. For example, Volvo Cars' Driver Alert system has close to 100% detection rate of when drivers are about to have a long enough micro sleep to leave the lane completely. The problem is, thus, not a technical one but rather a behavioural; few drivers actually take the break they need when drowsiness has been detected. From interviews with tired drivers, it is clear that the reasons for not taking that break are many and varied: you want to get home, there is nowhere to stop, you only have a few minutes left to drive, etc. All these reasons have one thing in common, and that is an unwillingness to change the current course of action before it is completed. In other words, when you are really tired, you don't want to exchange your current plan of action for something else. Drowsy people are neither flexible, nor willing to re-prioritize.

For vehicles equipped with Driver Alert, the default setting means that it is always on, and difficult (if not impossible) to switch off. The driver does not have to do anything to get the feedback from the system on whether s/he is drowsy or not. Given that this analysis on why drivers do not stop is correct, the challenge that MeBeSafe will take on is designing ways to nudge drivers to actually take that break when the Driver Alert function indicates a high level of drowsiness, despite their inherent unwillingness to do so.

3.6 Harsh braking

Truck drivers should put their safe driving skills into practice and change the habit of harsh braking!

In traffic safety, harsh braking is often used as an indicator of crash risk (e.g. Händel et al., 2014; Takenaka et al., 2012; Tselentis et al., 2016) usually as a measure of individual differences (e.g. Kay et al., 2008).

Harsh braking is a fairly common behaviour amongst drivers (e.g. Tapp et al., 2013). Although no studies have investigated how the frequency of harsh braking is related to (individual differences in) crash involvement, other research has linked the habitual levels of acceleration/deceleration of drivers to their crash record, and found weak to very strong effects (e.g., Jun et al., 2007; Lajunen et al., 1997; Musicant et al., 2007; Toledo et al., 2008; af Wåhlberg 2007a; 2007b), the differences a consequence of different methods being used (af Wåhlberg, 2009).

As driver acceleration/deceleration behaviours are habitual (af Wåhlberg, 2003; 2004; 2007b) and as strong braking must add to any measure of an overall acceleration/deceleration behaviour, harsh braking must correlate with other measures of such behaviours which have been shown to be associated with crash involvement. Hence, reducing harsh braking could be expected to have an effect on overall safety.

MeBeSafe will develop different coaching schemes to stimulate truck drivers to put their safe driving skills into practice and hereby reduce, for example unnecessary harsh braking.

4 Intervention Strategies, Approaches and Integrated Framework

This chapter discusses how the problems described in the previous chapter can be addressed. In this deliverable is distinguished between *behaviour intervention strategies* and *approaches to behaviour change* as they present different input, valuable for MeBeSafe when addressing the identified problems.

Literature describes intervention strategies as specific ways to stimulate a particular behaviour or to produce particular outcomes. By contrast, broader approaches are also discussed, which can be described as distinct theoretical perspectives for how to address behaviour change. Both can provide insight into how to develop and implement interventions for changing behaviours or encourage the adoption of new behaviours.

The chapter will first provide an overview of intervention strategies and highlight categories of strategies that can be of importance to MeBeSafe. The following sections address two specific approaches that are at the core of MeBeSafe: a nudging approach to behaviour change and a coaching approach to behaviour change. A comparison between the approaches and their relation to the intervention strategies are provided in the final section, which introduces the integrated framework.

4.1 Intervention strategies

A plethora of intervention strategies are discussed in literature which can be used in different ways to enable, facilitate, encourage or even force behaviour change. Due to the large number of strategies available, a number of categorisations and taxonomies have been suggested to provide a better overview of the different strategies and how they can be used to contribute to behaviour change. These categorisations chunk the strategies differently depending on their intended purpose. Some (Geller et al., 1990; Gifford et al., 2011; Michie et al., 2011) categorise the strategies in regard to *what* the strategies consist of (e.g. education and control systems). Others (Fogg, 2013; French, 2010; Geller, 2002; Lidman & Renström, 2011) discuss *how* the strategies influence behaviour (e.g. educates or spurs) or *when* the strategies are to be applied (Bamberg et al., 2011; Dwyer et al., 1993; Ohnmacht et al., 2017). Even though these categorisations may be appropriate for their respective purposes, a number of disadvantages can be highlighted when discussing their usefulness for MeBeSafe. For example, many of them do not offer enough detail to provide a basis for developing interventions as they make use of overarching strategies (such as enable, encourage, and engage) without providing more specific strategies, nor do they explicitly describe how an intervention could be designed based on a particular strategy. The more detailed taxonomies, on the other hand, are not easily grasped and often formulate strategies using a mixture of, for instance, mechanisms, attributes or psychological constructs (Michie et al., 2011) which makes it more difficult to compare and apply the strategies. Additionally, the majority of categorisations are formulated to aid policy interventions or large scale social marketing programs, but few are presented in a way that is suitable for designing interventions from the perspective of different market players such as car manufacturers, app developers or infrastructure builders etc.

Additionally, some of the categorisations are linked to, and often built upon, particular behaviour models or particular frameworks describing behaviour changes processes. These categorisations are primarily focused on presenting how the interventions are related to, and can target, socio-psychological determinants and/or a reflective decision-making process. This too, as will be further discussed in the chapter, limits the scope of the strategies that are included in the categorisations, which reduces the usefulness of the categorisations for MeBeSafe.

4.1.1 The importance of addressing both the individual and the context

Categorisations of intervention strategies that are based on behaviour models that focus on aspects related to the individual most often result in frameworks that primarily focus on strategies for targeting aspects related to the individual (e.g. Ohnmacht et al., 2017). However, human behaviour is in general the result of the interplay between the individual and the context, which is addressed in some models, for instance through facilitating conditions in the Theory of Interpersonal Behaviour

(Triandis, 1977), and overall and situational conditions in the Motivation-Ability-Opportunity Behaviour model (Ölander & Thøgersen, 1995). In order to explore the full scope of opportunities for interventions, it is thus essential to include strategies for targeting the context that influences the behaviour in addition to strategies that target the individual.

The importance of including strategies for addressing the context is acknowledged in some of the categorisations of interventions strategies (e.g. Dwyer et al., 1993; French, 2010; Gifford et al., 2011) but often without any level of detail and with a rather limited view on what contextual or structural strategies may comprise. Exceptions are found in the design literature, which presents a number of different categorisations that explicitly addresses a multitude of strategies for how to design products and the built environment to facilitate behaviour change (e.g. Lidman & Renström, 2011; Lilley, 2009; Wever et al., 2008). However, these categorisations do not in any detail cover strategies for targeting aspects related to the individual.

As MeBeSafe aims to develop and test in practice different innovative measures for increasing safe traffic behaviour (encompassing both coaching interventions aimed at the individual driver and nudges, i.e. small alterations to the traffic context that influence people's behaviour and choices), a categorisation of intervention strategies that explicitly targets aspects related to both the individual (subsequently referred to as the *road user*) and to the context (subsequently referred to as the *driving context* which includes the physical road environment, cars, and bicycles) is thus necessary in order for it to be relevant and useful for MeBeSafe.

4.1.2 The importance of addressing both the automatic and reflective system

To be able to design effective interventions, it is of importance to understand how behaviour is first formed. Kahneman explains in his book "Thinking, Fast and Slow" (2011) how human behaviour is guided by two underlying systems of thinking (see Figure 4.1). System 1 is fast and operates automatically, with little or no effort and no sense of voluntary control. System 2, on the other hand, is slow and allocates attention to the effortful mental activities that demand it. These two systems control behaviour independently of and parallel to each other.

SYSTEM 1 (AUTOMATIC)	SYSTEM 2 (REFLECTIVE)
Unconscious reasoning	*Conscious reasoning*
Implicit	*Explicit*
Automatic	*Controlled*
Low effort	*High effort*
Large capacity	*Small capacity*
Rapid	*Slow*
Default process	*Inhibitory*
Associative	*Rule-based*
Contextualised	*Abstract*
Domain specific	*Domain general*
Evolutionarily old	*Evolutionarily recent*
Nonverbal	*Linked to language*
Includes recognition, perception orientation	*Includes rule following, comparisons, weighing of options*
Modular cognition	*Fluid intelligence*
Independent of working memory	*Limited by working memory capacity*
Nonlogical	*Logical*
Parallel	*Serial*

Figure 4.1: A summary of the differences between System 1 and System 2.

System 1, also known as the *automatic* system or the *intuitive* system, guides behaviour based on implicit associations. These constitute quick, spontaneous, automatic processes eventually resulting in actions. System 1 requires very little cognitive capacity. Because it requires so little effort, the impulsive system is assumed always to function in the background. When cognitive capacity is limited (e.g., when many tasks compete over the same resources, or when people are tired), or when people are unmotivated to put effort into cognitive processes, the impulsive system will predominantly influence and guide people's behaviour.

System 2 is also referred to as the *reflective* system, the *explicit* system, the *rule-based* system, the *rational* system, or the *analytic* system and it relies on logic reasoning. This occurs when capacity and motivation are present, and often involves awareness. System 2 thinking is a rational process and requires cognitive capacity. Due to natural limitations on cognitive capacity, most information is not processed with full (if any) attention. However, when important issues arise, system 2 comes into play. Perceptual information that enters our brain is processed, checked with our existing beliefs, and evaluated as to whether they lead to the desired end-state. If that is the case, it leads to a behavioural decision and then to an execution of a behavioural schema.

The most commonly discussed intervention strategies in literature are those that target system 2, i.e. people's reflective decision-making processes. However, people's behaviour may vary from new (planned) behaviour to habitual behaviour. For instance, while road users encountering unfamiliar new situations need to use cognitive resources to decide how to act, road users encountering familiar conditions repeatedly rely heavily on situational cues and naturally perform in a certain way. Thus, by making use of types of strategies that address only system 2, the potential for supporting behaviour change through system 1 is lost. Depending on the nature of the road user behaviour and the profile of the driver, specific intervention strategies can also be more or less successful in supporting safe traffic behaviour. A categorisation of strategies relevant and useful for MeBeSafe should thus address not only reflective behaviour but also automatic behaviour so that it covers a wider scope of intervention opportunities.

4.1.3 Overview of intervention strategies

In order for a categorisation of intervention strategies to be relevant and useful for MeBeSafe (i.e. to aid the further development of the interventions proposed in MeBeSafe project plan) it should present an easy-to-grasp overview of different types of strategies that are coherently formulated and organised in a way that allows sub-strategies and specific interventions to be added. Such an overview can provide a detailed account of the multitude of strategies that exist and provide a good basis for designing interventions. In line with the arguments, the categorisation must include strategies for targeting aspects related to both the driving context and the road user, as well as strategies for targeting both the automatic and the reflective system. Additionally, it should describe the strategies from a "design" point of view rather than a policy perspective.

Based on the reviewed taxonomies of intervention strategies, a new categorisation has been developed to better fit the MeBeSafe agenda. It comprises four main categories (i.e. types of intervention strategies) where the first two address the design of the driving context and the last two address the road user. Additionally, each category consists of two subcategories that address the automatic and reflective system respectively (as illustrated in Figure 4.2). Thus, each of the categories and their subcategories represent distinctly different ways to influence behaviour, all which can be relevant to address within MeBeSafe.

		SYSTEM 1 (AUTOMATIC)	SYSTEM 2 (REFLECTIVE)
SAFE DRIVING CONTEXT	INCREASE OPPORTUNITIES	*(Re)Design functions of the driving context so that it enables and facilitates safe driving by triggering automatic responses to situational cues*	*(Re)Design functions of the driving context so that it enables and facilitates conscious choices to drive safely*
	IMPROVE COMMUNICATION	*(Re)Design how and when the message is communicated so that it facilitates perception and interpretation*	*(Re)Design the content of the message so that opportunities for safe driving are made clear without contributing to a too high cognitive load*
SAFE ROAD USER	DEVELOP COMPETENCIES	*Support the road user to develop e.g. perception skills, driving skills and habits to increase the level of automatic responses that results in safe driving behaviours*	*Support the road user to develop e.g. analysing skills and knowledge of own behaviour to increase the adoption of safe driving behaviours*
	INCREASE MOTIVATION	*Increase the road user's unconscious motivation for safe driving by e.g. providing a social reference point, endorsing behaviour and arousing emotions*	*Increase the road user's conscious motivation for safe driving by e.g. increasing awareness, supporting conscious goal-setting and providing incentives*

Figure 4.2: Overview of types of intervention strategies relevant for MeBeSafe

The first category comprises strategies for increasing opportunities to drive safely by (re)designing the driving context (i.e., the road infrastructure, vehicles etc.) and its functions. This includes either triggering automatic responses <u>or</u> supporting conscious choices to drive safely. The second strategy entails improving the communication of safe driving opportunities by (re)designing the message conveyed by the driving context (through colours, shapes, symbols etc.). Defining how and when the message is communicated can aid perception and interpretation to facilitate automatic thinking, while defining the content of the message can make available opportunities clearer. The third category includes strategies for developing the road user's competencies (knowledge, skills etc.) for safe driving. Developing, for instance, skills related to driving and perception can increase the level of automatic responses that result in safe driving behaviours and developing. Analysing skills and knowledge of one's own behaviour can increase the adoption of safe driving behaviours. These types of strategies may also give rise to risk compensation, i.e. road users behaving less carefully when the perceived level of risk is lower, which needs to be considered when designing the intervention. The last category is about increasing the road user's motivation for safe driving, including both unconscious and conscious motivation.

Even though the categories address either the design of the driving context or the road user, there is an overlap between the categories. For instance, many strategies that are discussed in literature for developing skills or increasing knowledge make use of technology or in-vehicle functions that are (or become) part of the driving context. Nevertheless, the main aim of the strategies is to influence the road user's competencies or motivation to drive safely, rather than designing a safe driving context.

For each to the four main types of strategies, a number of sub-strategies can be found in literature that, in more detail, describe how safe driving can be supported. An overview of different examples of intervention strategies that can be relevant for MeBeSafe to explore in relation to each category is provided in Appendix A.

4.2 Nudging

This section introduces the nudging approach to behaviour change. Initially, key characteristics are highlighted and a definition of a nudge is provided. The theoretical basis of nudging is discussed, and an overview of empirical evidence is provided on practical applications of nudges to increase traffic safety. The section is concluded with design implications for in-vehicle and infrastructure nudges.

4.2.1 Definitions and key characteristics

A decade ago, Thaler and Sunstein (2008) wrote their influential book 'Nudge - Improving decisions about health, wealth and happiness'. Central concepts in their book are: choice architect, libertarian paternalism, humans and econs and the nudge approach. These concepts are discussed below and related MeBeSafe.

4.2.1.1 Choice architect

A choice architect is a person who has the responsibility for organising the context in which people make decisions. Many people are choice architects, often without them realising it. Example include doctors describing alternative treatments to a patient, salespersons offering certain products, road planners thinking about road layouts, and car manufacturers designing cars with pre-set functions. A choice architect, just like a traditional architect, must make design choices (for example choosing a particular arrangement of food options in a canteen) that, as a result, influence people's choices and behaviour. Seemingly trivial or irrelevant aspects of these decision contexts designed by choice architects can have large effects on people's choices and behaviour. So, when road planners use seemingly trivial or irrelevant aspects of the road infrastructure to softly steer road users' choices and behaviour towards safety, they are nudging. When car designers build simple and unobtrusive cues in the vehicle interior to gently move car drivers' choices and behaviour towards safety, they are nudging. These nudges can be derived from the biases and heuristics people's thinking is subjected to. In MeBeSafe choice architects will use this knowledge about predictable biases in human decision making - especially related to risk taking and compliance - to develop effective measures.

4.2.1.2 Libertarian paternalism

Libertarian paternalism can be seen as the merger of two political notions: libertarianism and paternalism. Thaler and Sunstein (2008) mention that "… *people should be free to do what they like - and to opt out of undesirable arrangements if they want to do so."* (p.5). Nudges are measures or interventions that "*maintain or increase* *freedom of choice*" and that are "*liberty-preserving*". Thaler and Sunstein state that "*The paternalistic aspect lies in the claim that it is legitimate for choice architects to try to influence people's behaviour in order to make their lives longer, healthier and better.*" This means that MeBeSafe will make deliberate efforts to nudge road users' choices and behaviour into directions that will improve their lives and traffic safety. However, these nudging interventions still allow road users the freedom to choose and behave differently if they so desire. Road users are still able to refuse to conform with the behaviour or decision that the nudge is devised to promote.

4.2.1.3 Humans and econs

Thaler and Sunstein (2008) use the terms *Humans* and *Econs* to refer to homo sapiens and homo economicus respectively. Many people like to think that human beings think, choose and act without making mistakes. This view fits very well with the picture that economists usually offer of human beings. Econs make perfectly rational decisions and have no self-control problems or moral obligations. They are driven by financial incentives (e.g. taxes on candy makes them eat less candy) and do not react to supposedly irrelevant factors in the choice architecture (e.g. the order of food choices on a menu). However, real people often do not behave as Econs, they think and choose as Humans. People do not choose the right diet all the time (which leads to an increase in obesity), people do not always make choices that are beneficial to their health (they smoke and drink alcohol and are sleep deprived), people do not save enough money for their retirement, and people do sometimes not drive safely. Humans make predictable errors in forecasting and human decision making is subject to well-known biases. Humans have emotions and are social beings. They are not purely driven by a need to maximise their welfare and they often exhibit self-control problems. MeBeSafe uses this knowledge about errors and biases to develop nudges that gently push road users to make better choices regarding their own and other road users safety in traffic.

4.2.1.4 Nudge

A nudge, as Thaler and Sunstein (2008) use the term, is "*... any aspect of the choice architecture that alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic incentives. To count as a mere nudge, the intervention must be easy to implement and cheap to avoid. Nudges are not mandates. Putting fruit at eye level counts as a nudge. Banning junk food does not*".

Marchiori et al. (2017) propose several suggestions to further specify the original definition (see Hausman & Welch, 2010; Hansen & Jespersen, 2013) and come up with an elaborate working definition of nudging: "*Nudging is an umbrella term for deliberate and predictable methods of changing people's behaviour by modifying the cues in the physical and/or social context in which they act. It uses these cues to activate nonconscious thought processes involved in human decision-making. Nudging implies that none of the choices should be difficult to avoid, made mandatory, significantly incentivized economically or socially, and made significantly more costly in terms of time or trouble.*" Nudges are thus supposed to be liberty preserving. Nudges do not promote behaviour by regulating the existing freedom of choice or by changing incentives. This means for example that all defaults should be switchable with one click or an easy action. In Nudge (2008), the authors refer to this as "*one-click paternalism.*"

For MeBeSafe this means that a nudge, i.e. any aspect of the choice architecture, for instance car interiors or road infrastructure, can influence an individual's choice of a certain behaviour. MeBeSafe will deliberately design and implement nudges to softly steer road users naturally towards safe driving behaviour. MeBeSafe nudges will have a direct, immediate impact on road user behaviour and will influence in-the-moment behaviours. MeBeSafe nudges will therefore not necessarily spill over to other (un)safe driving behaviours or to other situations in which similar unsafe driving behaviours may occur. Nudges are those factors of decision making environments - in MeBeSafe car interiors and road environments - that gently guide road users towards safer behaviour at a specific time and the spot where the nudge is implemented.

4.2.2 Categorisation of nudges

4.2.2.1 Four dimensions of nudges

Several researchers have tried to categorise different types of nudges. For example, House et al. (2013) classify nudges according to four dimensions:

- *Self-control boosting nudges vs. Behavioural standard activating nudges.* Self-control boosting nudges help persons that struggle to meet their own behavioural standards (for example stop smoking, not speeding, eat healthy). Nudges that activate behavioural standards are applied when persons are not consciously aware of the behavioural standard in the specific context.
- *Self-imposed nudges vs. other-imposed nudges.* Self-imposed nudges are nudges that persons impose upon themselves voluntarily to help them to reach their own behavioural goals**.** Other-imposed nudges are nudges that are imposed by others (choice architectures). These persons do not have to seek out the nudge. The nudge is passively trying to shape their behaviour towards behavioural standards.
- *Mindful nudges vs. mindless nudges.* Mindful nudges help people to make more rational, cost-benefit decisions about how they behave. Mindless nudges influence behaviour by taking advantages of well-established behavioural biases. Such nudges include the use of emotion, framing, or anchoring to sway the decisions that people make. This type of nudge seems very much related to the original concept of a nudge.
- *Encouraging nudges vs. discouraging nudges.* Encouraging nudges facilitate the implementation or continuation of a behaviour that the nudger believes is desirable. Discouraging nudges hinder or prevent behaviour that the nudger believes is undesirable.

The distinction between self-control boosting nudges and nudges that activate behavioural standards is important in regards to user profiling. The level of engagement or motivation to change is an important difference between individuals. This distinction constitutes two important user segments that must be addressed separately. The dimension mindful nudges vs. mindless nudges resembles the lines of thought of Sunstein (2016) and Hanson and Jesperson (2013) about system 1 nudges and system 2 nudges.

4.2.2.2 System 1 nudges and system 2 nudges

Originally, nudging seemed to be mostly associated with System 1. Nudges are said to make use of the influence of (supposedly) irrelevant factors of a decision-making context. Nudges hook thus onto System 1's way of thinking by making use of biases that influence automatic unconscious processes and passive decision-making (Thaler & Sunstein, 2008). However, nowadays several authors refer to System 1 nudges and System 2 nudges (e.g., Sunstein, 2016; Hanson & Jesperson, 2013; House et al., 2013). This implies that nudges can be applied to influence people's decisions and behaviour via the automatic system 1 as well as the reflective system 2.

Sunstein (2016) distinguishes between system 1 nudges and system 2 nudges and describes system 2 nudges as "*specifically designed to increase people's capacity to exercise their own agency*", for example educative nudges that aim to boost System 2 thinking by increasing the role of deliberation and people's considered judgments. Hence, system 2 nudges are supposed to help people pay attention to what they are doing (or not yet doing) and to make them better choosers. Sunstein also provides a number of examples of nudges that were not previously considered to be nudges, for instance: a reminder, a warning, a GPS device, and disclosure of relevant information.

Hansen and Jespersen (2013) also distinguish nudges that are related to either automatic system 1 thinking or reflective system 2 thinking. They describe four types of nudges based on whether the nudge is influencing reflective choices and/or deliberate actions (type 2 nudge) or is mindlessly influencing behaviour (type 1 nudge) and whether the nudge is transparent or not. Transparency reflects here the degree to which the intention behind the nudge as well as the means by which behavioural change is sought are clear to person who is being nudged. Examples of the four types of nudges are provided in Figure 4.3 as well as the likely mechanisms behind the nudges, all derived from Hansen and Jesperson (2013). The implications for MeBeSafe are that nudging interventions seemingly are not only linked to automatic system 1 thinking. Nowadays, there also seem to be system 2 nudges that engage reflective thinking.

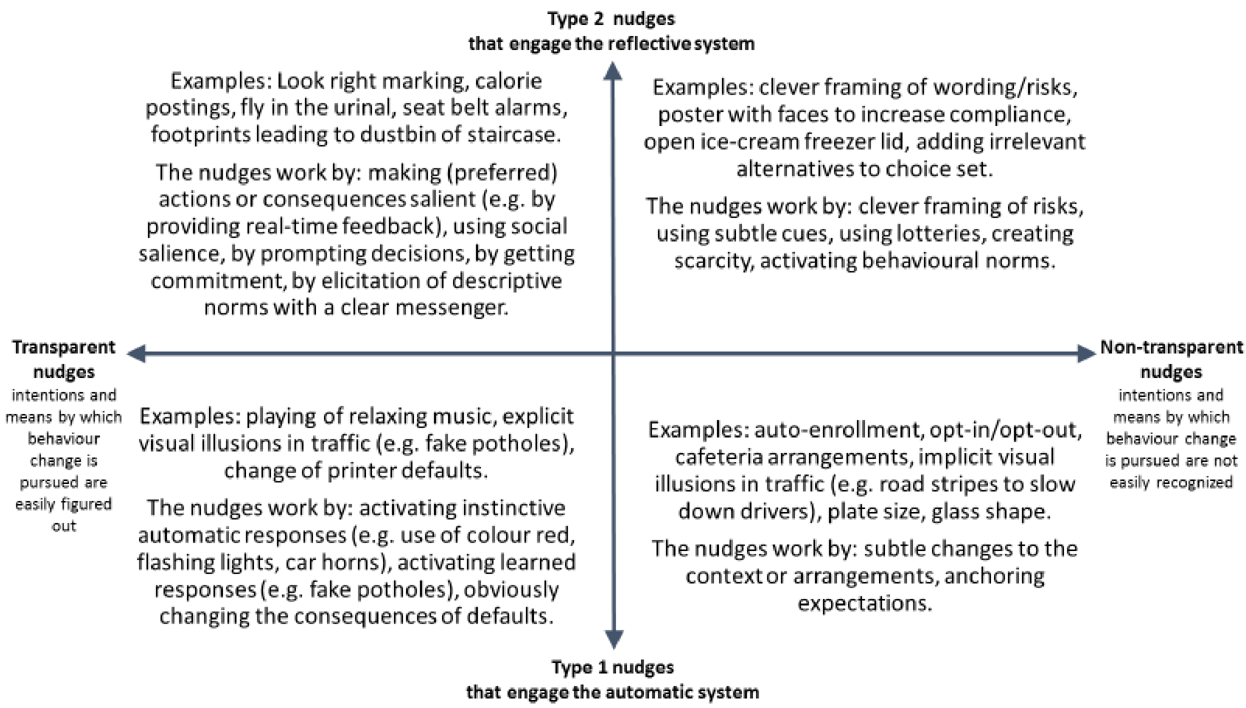


Figure 4.3: Overview of four types of nudges. Source: Hansen & Jespersen (2013).

4.2.2.3 Nudge as a form of exchange

French (2011), however, considers a nudge as a passive exchange requiring little cognitive effort and engagement. In his paper 'Why nudging is not enough' (2011) he reviews the possible contribution of nudging as social marketing tactic and as a “form” of exchange. He presents a framework that describes four basic “forms” of exchange. These four basic forms of exchange can be put into practice by government and private institutions who apply a marketing approach to create a positive social change.

French (2011) considers nudging to be one of these four forms of exchange. The other three forms are shoving, hugging and smacking. Figure 4.4 presents French's view on nudging and the other forms of exchange.

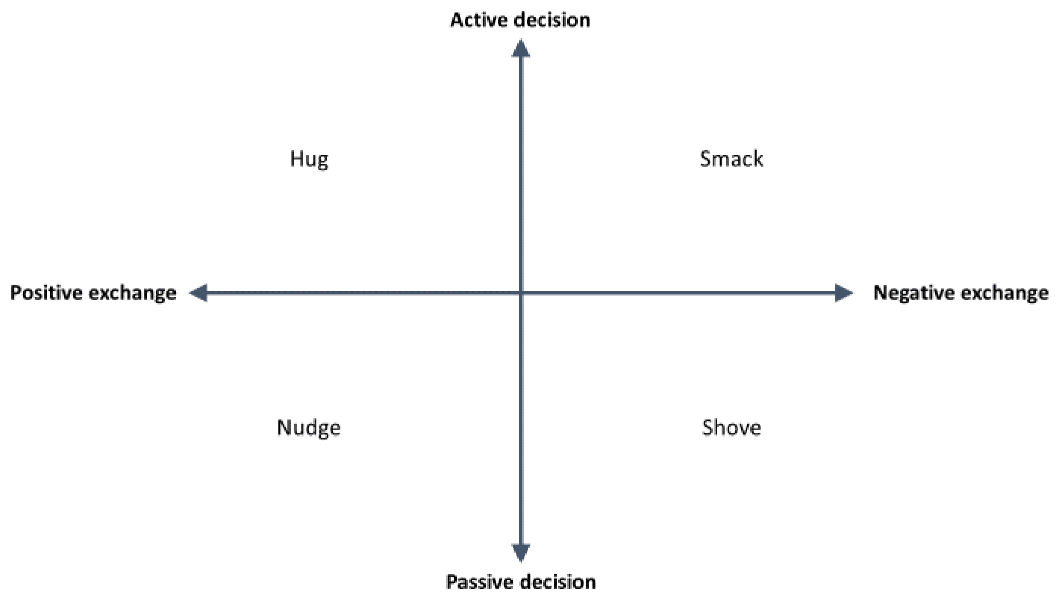


Figure 4.4: Framework: four forms of exchange. Source: French (2011).

Furthermore, according to French (2011) an exchange can be either positive or negative (first axis). A positive exchange occurs when people get a physical, social or psychological reward or benefit following a behaviour. A negative exchange occurs when people face a penalty, social disapproval or other negative consequences when they adopt a certain behaviour. The second axis shows that exchanges can require either an active decision or a passive decision. Passive exchanges require little cognitive effort and engagement while active exchanges require conscious effort and energy. French (ibid.) argues that the concept of nudging represents a form of exchange that requires little cognitive processing and aims to deliver positive consequences and that influencing mindless choosing is the focus of nudging tactics aimed at creating social change. However, following the line of reasoning by Sunstein (2016) and Hensen and Jesperson (2013), the other forms of exchange would also count as nudges, in the case of hug and smack because they result from active decision making through activating reflective system 2 thinking. House et al. (2013)

recognise discouraging nudges as a distinct category of nudges why also s*hove* can be denominated a nudge. Although French (2011) labels the axis passive–active decisions, the examples he provides also reflect a before–after behaviour dimension. Hugs and smacks are delivered after the desirable or undesirable behaviour has been performed in contrast to nudges and shoves that are shaping the context in which the behaviour is going to take place in the future. Combining the views of Sunstein (2016), Hensen and Jesperson (2016) with French (2011) it can be concluded that a shove can also be considered a nudge because it shapes the decision-making context. On the other hand, hugs and smacks are not considered nudges in MeBeSafe because they happen after the behaviour is performed. MeBeSafe explicitly focuses on situations in which unsafe behaviours have not yet been performed.

As the different types of nudges may be successful in different situations, all can be relevant to consider when developing the MeBeSafe interventions. MeBeSafe will consider the following nudges:

- *Self-control boosting nudges* help drivers that struggle to meet their own behavioural standards (for example stop speeding, stop driving while drowsy, stop harsh braking);
- *Behavioural standards activating nudges* help road users that are not yet consciously aware of the behavioural standard in the specific context (for example use ACC);
- *Self-imposed nudges* that road drivers and cyclist impose upon themselves voluntarily to help them reach their own behavioural goals (for example choose appropriate speed, stop driving while drowsy, stop harsh braking);
- *Other-imposed nudges* that passively shape road users' behaviour towards the behavioural standard without the road users having to seek out the nudge;
- *Mindful nudges* help drivers and cyclist make more rational, cost-benefit decisions about how they behave in traffic;

- *Mindless nudges* influence behaviour by taking advantages of well-established behavioural biases. These nudges include the use of emotions, framing, or anchoring to sway the decisions that people make;
- *Encouraging nudges* facilitate the implementation or continuation of a behaviour that the (self)nudger believes is desirable;
- *Discouraging nudges* hinder or prevent behaviour that the (self)nudger believes is undesirable;
- *Shoving nudges* hinder or prevent behaviour that the (self)nudger believes is undesirable.

MeBeSafe will use the nudge approach as a way to promote road users' decisions and behaviours to make traffic safer – before unsafe situations arise.

4.2.3 Theoretical basis

Nudging stems from the theory that people do not make purely rational decisions (Thaler & Sunstein, 2008; Kahneman, 2011). People's choices are influenced by systematic biases, often without them realising it. The theoretical principles behind nudging have been known for some time and are not new. However, applying these behavioural insights in practice to help people make better decisions has taken a flight since the influential book 'Nudge - Improving decisions about health, wealth and happiness' written by Thaler and Sunstein (2008).

The theoretical basis of nudging is grounded in findings from cognitive and social psychological research studies performed over the last forty years (Hansen, 2016). Nowadays, it is commonly accepted that human decision making is guided by two systems of thinking (Hofmann et al., 2009, Smith & DeCoster, 2000). Kahneman (2011) presents this two-systems approach in his book 'Thinking, fast and slow'. System 1 processes are fast and automatic and run without conscious attention. System 2 thinking is slow and deliberate and requires attention, effort and motivation (see also 4.1.2). Most of our behaviour is guided by fast, automatic, affective, non-conscious, associative thought processes.

These insights are in contrast with less recent behavioural theories and models that focus on the formation of behaviour as a result of conscious and deliberate decision making. Thus, decisions in daily life are often based on mental shortcuts (for instance: high price = good quality) instead of on a rational analysis of the advantages and disadvantages of alternatives. Interventions that apply this knowledge about automatic cognitive and social psychological processes are called nudges. In hindsight, many interventions can be considered as having applied nudging principles, although not acknowledged as so at the time. For example, the Dutch 'Sustainable safety' approach with the concept of 'self-explaining roads' (Wegman & Aarts, 2006) advocates road designs that encourage drivers to intuitively adopt behaviour consistent with their design and function by features, such as for example width of carriageway, road markings, signing, and use of street lighting. These features are consistent throughout the route, helping the road user to automatically recognize (based on the familiarity principle) what they can expect on these roads and how they are supposed to behave.

Thus, nudging theory and interventions are based on automatic, unconscious cognitive and social psychological processes. In the following section, these automatic psychological processes will be illustrated using the MINDSPACE framework of Dolan et al. (2010; 2012) and, if available, evidence will be provided of nudging interventions employing these elements to influence traffic safety behaviours.

4.2.4 Evidence

Much of the evidence base supporting the nudge approach is built on applications in contexts, such as finance, health, worker employment, law abiding behaviour and energy use rather in traffic and transport. Overall, there are not many nudging interventions aiming to influence traffic safety that have been systematically tested on a large scale (Avineri, 2014).

4.2.4.1 Evidence from literature

In this section, the MINDSPACE framework of Dolan et al. (2010; 2012) will be used to illustrate automatic psychological processes underlying nudging interventions. If available, evidence is provided of nudging interventions that have aimed to encourage safe traffic behaviour. The MINDSPACE framework is a useful tool to think about the effects of the contextual influences on behaviour. MINDSPACE is an abbreviation summarising nine contextual factors that unconsciously influence behaviour (Figure 4.5): Messenger, Incentives, Norms, Defaults, Salience, Priming, Affect, Commitment, and Ego (Dolan et al., 2010; Dolan et al. 2012).

Messenger	We are heavily influenced by who communicates information
Incentives	Our responses to incentives are shaped by mental shortcuts
Norms	We are strongly influenced by what others do
Defaults	We 'go with the flow' of pre-set options
Salience	Our attention is drawn to what is novel and seems relevant to us
Priming	Our acts are often influenced by unconscious cues
Affect	Our emotional associations can powerfully shape our actions
Commitments	We seek to be consistent with out public promises and reciprocate acts
Ego	We act in ways that make us feel better about ourselves

Figure 4.5: Mindspace – the role of context on behaviour. Source: Dolan et al. (2010) and Dolan et al. (2012).

4.2.4.1.1 Messenger

We are heavily influenced by who communicates information.

People respond not only to the message itself, but are also unconsciously influenced by who delivers the message. Three fundamental characteristics of messengers are: authority, credibility, and social attractiveness (Perloff, 2010). People are more easily influenced by messages that they get from experts, authority figures and socially attractive people – those who are nice and likable, similar in appearance and language to the recipient, and physically appealing (Cialdini, 2007). No studies have been found that explicitly investigated the influence of the messenger on increasing traffic safety. For future nudging interventions that presumably use a messenger to convey a message, it might work best if the messenger is generally perceived to be credible and likeable.

4.2.4.1.2 Incentives

Our responses to incentives are shaped by mental shortcuts.

People dislike losses (Metcalfe & Dolan, 2012) and losing 10 euros have been found to cause more pain than finding 10 euros causes pleasure (Tversky & Kahneman, 1981). Bolderdijk et al. (2011) tested whether young drivers' speed choice could be lowered by offering explicitly loss-framed financial incentives. Based on loss aversion they assumed that framing the incentive as a financial loss would have more impact on speed choice than framing the incentive as a gain. However, they found no effect of gain/loss incentive framing on speed choice. Nonetheless, one can assume that applying and systematically testing loss framing in a variety of information-based measures to stimulate safer road behaviours can be a useful approach.

4.2.4.1.3 Norms

We are strongly influenced by what others do.

Social norms are the expectations within a society or a group about which behaviours are considered appropriate and which are not. People often deduct what is accepted behaviour from the behaviour of others. Social norms exert their power through social mechanisms. Non-compliance with social norms can, on the one hand, lead to social punishments (such as being ridiculed) while conforming to social norms may, on the other hand, have positive social consequences (such as receiving compliments). Perkins et al. (2010) evaluated the effectiveness of a high-intensity social norms media marketing campaign aimed at correcting normative misperceptions and reducing the prevalence of drinking and driving among 21-to-34-year-olds. Their research showed that the social norms media campaign was successful at exposing the targeted population to social norms messages. Moreover, their results demonstrated that the campaign reduced normative misperceptions, increased use of designated drivers, and decreased drinking and driving among those young adults in counties within the intervention region.

4.2.4.1.4 Defaults

We 'go with the flow' of pre-set options.

In many situations in which we have to make choices, one of the alternatives is already pre-set as the default option. We are usually not aware of these pre-set default options. It is easier to just 'go with the flow' and not to make an active choice, meaning that the pre-set option is also the one selected. Lai and Carsten (2012) investigated the effects of an in-vehicle Intelligent Speed Adaptation (ISA) system. The system was enabled by default and could be overridden by the driver through pressing a button on the steering wheel. They found that the, by default, activated ISA system diminished excessive speeding, and also led to a reduction in speed variation, which has been argued to be associated with traffic safety. However, their research also points out that ISA tends to be overridden on roads where it is (perhaps) needed the most. Likewise, driver groups that would benefit from ISA the most tend to override the by default activated IAS systems most often.

4.2.4.1.5 Salience

Our attention is drawn to what is novel and seems relevant to us.

Our behaviour is strongly influenced by what draws our attention. To cope with the large amount of stimuli that we are exposed to everyday, we tend to unconsciously filter out much information and to a higher extent register the stimuli that are novel, accessible, and simple (Dolan et al., 2012). We are much more likely to pay attention to things that we can understand easily – to those things we can easily decipher. Therefore, simplification of the context (for example: simplifying information about complex products and services, or decluttering streets) can have profound effects on behaviour. Another way of drawing attention to situations that need increased attention is reminders. Reminders are eye-catching, unexpected and salient elements (e.g. stickers, one-liners, etc.) in the environment that draw our attention; at least the first few times we encounter these reminders. Such reminders can take the form of flashing lights, striking colours, or informative graphics. However, no empirical evidence has been found on increased salience or simplification as a way to improve traffic safety. Nevertheless, salience may still be a relevant approach to nudge road users into safe traffic behaviour.

4.2.4.1.6 Priming

Our acts are often influenced by unconscious cues.

Priming is the activation of knowledge stored in memory through subliminal cues in the environment. This subliminal activation makes stored knowledge more accessible and therefore more likely to influence the processing of new stimuli and people's subsequent behaviour. Thus, certain behaviours are more likely to come to pass when persons are first primed with certain related images, words, scents, music, etc. Avineri and Goodwin (2010) mention that in road design it is common practice to use nudges (although often not called a nudge), such as gateways, sightlines, coloured or textured road surfaces, to affect *perceived* speed and safety rather than actual. One example of such a priming nudge originates from Thaler and Sunstein (2008) who describe how optical speed bars (i.e. transverse lines on the driving lane that are painted closer to one another the closer the driver is progressing to the dangerous spot) create an optical illusion and are, as such, used to influence the perceived speed on the Lake shore drive in Chicago. A post on The Nudge blog[1] mentions 36 per cent fewer crashes in the six months after the lines were painted compared to the same 6-month period the year before. A similar, presumably speed-reducing, visual illusion influencing perceived speed can be created by planting trees along the road. Although there are more interesting examples of nudges in road design, these applications have usually not been rigorously tested in a traffic and transport context. Therefore, their effectiveness remains an open question.

[1] The online companion to Thaler's and Sunstein's "Nudge: Improving Decisions About Health, Wealth, and Happiness".

4.2.4.1.7 Affect

Our emotional associations can powerfully shape our actions.

Emotions are a strong driving force behind our actions. Generally speaking, persons in good moods have an unrealistically optimistic view of situations while persons in bad moods make unrealistically pessimistic judgements of situations. Inducing positive feelings is a tactic that is very commonly used in commercials and marketing and these positive feelings can indirectly steer people in a certain direction. However, no systematic empirical research has been found into the effects of deliberately constructed, emotion-provoking nudges on traffic safety behaviours.

4.2.4.1.8 Commitment

We seek to be consistent with our public promises, and reciprocate acts.

Human beings sometimes lack the willpower to act immediately. We postpone and delay actions even though there may be benefits in the long term (e.g., start a new diet tomorrow, quit smoking next week, exercise more next month, take a break from driving while drowsy the next time). Committing oneself to a certain goal or a certain set of actions helps stick to the plan. Only the act of writing down one's resolutions can be of help (Cialdini, 2007). Making promises publicly helps even more because people do not want to lose face in front of others. At times so-called commitment devices, such as for example safety pledge cards (Banks et al., 2010; Avineri, 2014), can be used to help people achieve to their goals,

4.2.4.1.9 Ego

We act in ways that make us feel better about ourselves.

We tend to act in ways that are supportive of our views of ourselves. We like to keep a positive and consistent self-image. The desire for a consistent and positive self-image leads to an (often automatic) tendency to compare ourselves against others. When making these comparisons, we are biased to believe that we perform better than the average person. No systematic empirical research has, however, been found regarding potential effects of deliberately constructed, ego-enhancing nudges on traffic safety behaviours. Nevertheless, this bias may require MeBeSafe to reconsider what might be optimal for supporting some behaviours.

4.2.4.2 Evidence from interviews

In the interviews, the respective interviewees were asked about their experience of nudging. In general, the interviewees had heard about the concept and they were positive to the idea although somewhat cautious. Nudging was, for example, considered as being cost effective and easy to implement, though potentially having a short lifespan due to new technology (e.g. driverless vehicles). However, none of the interviewees had any empirical experience of designing or evaluating the effects of nudging.

4.2.5 Implications

The existence of different routes (reflective and automatic) to behaviour has several implications for developing MeBeSafe interventions. For instance, purely informing drivers about the 'how' and 'why' of safe driving may not help to achieve the desired results because providing information to motivate behaviour change almost exclusively runs via cognitive effort (i.e. the reflective route). Due to the large amount of information that people face daily (e.g., work, shopping lists, television, advertising commercials), people cannot process all information thoroughly and are selective as to which of this information they really pay attention to. The assumption that all information will be considered and processed, and thus lead to an intention and performance of safe driving behaviour, is therefore often an overestimation of reality, as behaviour is often guided by the automatic route.

Deliberate, conscious decision making processes come into play when people are motivated to do so and have the capacity and the time. This is especially important in the context of driving a vehicle. Driving a vehicle or a bicycle is a cognitively taxing activity and it affects the extent to, as well as the way in which people process information that is presented to them during the trip. As a result, signals such as feedback on driving behaviour will be ignored when situational demands are high and cognitive capacity is reduced (Dogan, Steg & Delhomme 2011). More associative and intuitive processing, however, remains at people's disposal and will consequently influence their behaviour under these circumstances. Thus, information that enters the brain without demanding cognitive control or capacity is more likely to influence behaviour when the driving itself takes up a lot of effort. The reflective route to behaviour, on the other hand, comes into action when motivation is high, for instance when the driver or bicyclists commits to a certain goal (e.g., to stop driving when drowsy), and when the behaviour change is reflected and contemplated upon outside of the actual driving situation, such as during coaching beforehand or when receiving feedback afterwards.

Nudging is a subtle way to influence road user behaviour that makes use of the associative style of the impulsive system but also sometimes the reflective system. Nudging involves, for example activating safe driving goals (type 2 nudges) or safe driving social norms by simple cues in one's environment (type 1 nudges). Nudging measures may seem somewhat intangible but given that most information people face daily does not even reach full awareness and many behavioural decisions are made outside our conscious awareness, nudging measures should fulfil an important role in intervention strategies to encourage safe driving behaviour.

4.3 Coaching

Coaching has, in the last decades, become a popular approach to personnel development and learning, being used in areas such as nursing/medicine, management and teaching. It is a practical method but with little research underpinnings, in terms of theory and empirical investigations (especially controlled quantitative trials; Theebom et al., 2013).

In this section, the aim is to review what coaching actually means in theory, research, and practice, especially related to a road user context. Furthermore, the section will investigate what evidence exist of its effectiveness as well as the size of this effect, and what features of the coaching situation might influence the effect.

4.3.1 Definition(s)

There seems to exist no generally accepted definition of the term 'coaching'. Hawkins (2008) listed ten definitions, some of which are very different from each other[2]. It is therefore suggested that the term 'coach' should be subsumed under the general category of developmental relationships, as suggested by D'Abate et al. (2003) and Parker et al. (2012). Nevertheless, for ease of reading, the present text will continue using the term coaching and explore its relation to other terms.

What most definitions of coaching have in common is that it is a *one-to-one relationship*, with the aim of improving the coached person's skills, performance and/or personality. Simultaneously, there are several activities which go by names such as advising or apprenticeship, which share core characteristics with coaching (D'Abate et al., 2003). To further muddy the waters, attempts have been made to differentiate between 'coaching psychology' grounded in research, and ordinary coaching practice (Grant & Cavanaugh, 2007).

One important dividing line between different definitions of coaching is whether they focus on *instruction* (transfer of knowledge) or *facilitation* (help to achieve). The former appears closer to ordinary teaching, i.e. a transfer of knowledge and skills, while the latter seems to assume that people already have capacities that only need to be unlocked (Grant, 2001). In a broad sense, this is similar to the old nature-nurture debate. To some degree, this is probably due to the aims and situations being somewhat different in different sub-areas (Carey et al. 2011), like sports and executive coaching (Baron & Morin, 2010). Another important difference between definitions of coaching is whether they focus on *behaviour change* or *personal growth* (self-awareness, reflection etc.), or both (Carey et al. 2011).

In addition, one feature of coaching, which blends into mentoring, is the *time period* used. Although this is usually not described in the definitions (Haggard et al., 2011),

[2] The neighbouring concept of mentoring has been found to have at least forty different definitions (Haggard et al. 2011).

mentoring is apparently long-term, while coaching is usually of a shorter duration. This is probably due to that coaching is most often undertaken by an external professional, which limits the number of sessions, while mentoring is usually undertaken within an organization, which tends to secure a long-term relationship.

An important difference between coaching and mentoring is that the latter is a relationship between unequals, where the mentor is most often defined as a senior and experienced person from the same organization. A coach can be a peer, a consultant or a supervisor (using relatives or friends as coaches seem to be an unknown method), with the last being very difficult to distinguish from a mentor.

A definition of coaching, however, should be generic, and not tied to a certain kind of setting. For the present purpose, a definition is required that is broad enough to encompass different environments. Such a definition has been offered by Grant (2001); "Workplace coaching is a collaborative solution-focused, results-orientated systematic process, used with normal, non-clinical populations, in which the coach facilitates the enhancement of work performance and the self-directed learning and personal growth of the coachee." (p. 33). If the references to work are removed, the definition is broad enough to include all kinds of coaching. It can be noted that this definition does not include any specific position of the coach, or any defined knowledge. Thus, anyone can be a coach, as long as the process described takes place.

4.3.2 Key characteristics

4.3.2.1 Relation between coach and coachee

One feature of coaching which differs between different forms of this type of intervention is who the coach is in relation to the coachee.

Four possible positions are known;

- an externally hired professional coach;
- a superior in the organisation;

- a peer with the organisation and/or
- a relative or friend (although this is not applicable in organisational settings).

Each of these four positions will make the coaching relation somewhat different. It can also be noted that the (sub)-definitions of coaching will differ between these combinations. For example, Parker et al. (2015) defined peer-to-peer coaching as "… *a type of helping relationship in which two people of equal status actively participate in helping each other on specific tasks or problems, with a mutual desire to be helpful …*" (p. 2). However, the most important feature, which sets peer-to-peer coaching slightly apart from the other forms of instruction, is that both parties are expected to gain from the exchange (e.g., Parker et al. 2015).

Being a coach is to some degree similar to being a teacher or therapist. However, teachers are usually concerned with facts, not personal development, and the therapist with problems, which are outside the normal range of behaviour, not increasing performance to a higher level. Also, coaching as it is used today is very often performed in an organizational setting, i.e. it is an employer who pays the coach to improve the performance of personnel. This means that also purely skills-based learning might be called coaching if it is undertaken on a one-to-one basis. Consequently, the difference between teaching and coaching becomes vague. The difference between traditional teaching and coaching in an organization appears to be in how it is delivered.

The difference between coaching and mentoring is also unclear (D'Abate et al., 2003; Parker et al., 2008). In both, the personal relationship and conversations are defining features. Some authors, however, maintain that mentoring is undertaken by an older and more experienced person (Baron & Morin, 2010). Apparently, they do not see this difference as a necessity in coaching. From this position, the concept of peer-to-peer coaching, i.e. equals taking turns at coaching (Showers & Joyce, 1996) becomes possible. The coach would thus not necessarily be someone with superior knowledge or skills, but someone who acts as a discussion partner and friend, and in this way differentiating coaching from therapy and teaching. This also means that, in a peer-to-peer situation, both partners can be expected to improve or benefit from the interaction.

Having established that a coach does not necessarily have to be an expert (unless some sort of specific skill needs to be taught, in which case it becomes a matter of teaching or mentoring), the question is how coaches should be selected, i.e. what should their personal qualities and positions in the organization be? Neither empirical evidence has been found, nor any good theoretical reasons, apart from rather self-evident advice such as that a coach should have sound judgement, be diplomatic and perceptive etc. (Carey et al., 2011). As described earlier, a mentor is supposed to supply social support, and it can be expected that this feature would be equally true for a coach.

The choice between hiring a professional coach, using a supervisor, an experienced peer or just any person within the organization has little theoretical information to go by, and just as little empirical evidence (Carey et al., 2011). Arguments have been put forward for and against all these choices (e.g. Massman, 2012). However, it cannot be assumed that peers, per se, are good coaches. To enable this role, they need to be trained in basic methods of coaching (Massman, 2012).

The literature on coaching does not specify different coaching models for different people, but rather indicates that the coach should adapt to the situation and the needs of the coachee, etc. Some ideas about certain people being more receptive to coaching exist (e.g. Carey et al., 2011) but these results do not allow a meaningful categorization of people beforehand. Similarly, coaching pairs, who are perceived as more similar, tend to function better (Eby et al., 2013) but the exact similarities needed are not known. In a similar vein, Ludwig et al. (2010) found that drivers who did not respond to group feedback did so when they were targeted as individuals. Again, individual differences are apparent, but not possible to predict.

4.3.2.2 Feedback

One feature (or approach) of coaching, is to make the coachee's self-evaluations more similar to those of other people (e.g. Luthans & Peterson, 2003), a sort of reality check. Using objective performance feedback, instead of subjective views, appear to fill the same function; to increase self-awareness. The coachees usually become more realistic about their own behaviours and adjust them accordingly to live up to their own and other people's standards, instead of lowering their beliefs about their own behaviours (Luthans & Peterson, 2003). It is well known that most drivers think they are well above average skill (Finn & Bragg, 1986) and that this inflated self-concept is resistant to change due to experience (Groeger & Grande, 1996). The use of (preferably objective) information about the coachee's behaviour is thus an important, but rarely discussed or researched, part of coaching. This is especially so in driving, where the driver is usually not observed and thus does not get feedback about his/her behaviour.

Social support is not often discussed within the coaching literature, but is considered to be one of the two main functions of mentoring (e.g. Ghosh, 2014). This feature will therefore be discussed in more detail in the section on theories as it pertains to coaching specifically.

Taken together, it appears that coaching has borrowed some of the features from both teaching and therapy and created a hybrid model, which overlaps with both of its sources, and including some touches of mentoring.

It should be noted that feedback is not only information, but also contains an evaluative dimension. Thus, receiving numbers on performance is information, while having them put into perspective (e.g., 'This is better than 60% of our drivers') is feedback. In reality, however, some sort of evaluative dimension is almost always present when information about behaviour is given.

One important part of coaching is the availability of information about the behaviour of the coachee. This is often used as points of discussion between the coach and the coachee, and as a reference for evaluation of progress and the setting of goals. This part of the coaching process would seem to be an area of knowledge in itself, as several different questions with relevance for the design of coaching schemes can be asked, namely:

1) What kind of information should be fed back to the coachee?
2) What is the optimal level of complexity of information, for example the number of variables included?
3) What level of detail in information can be used?
4) How often should information be transferred?
5) When should information be given?
6) How and by whom should information transferred?

These questions can be summarized as: What is the optimal way of giving people information about their behaviour when we want to change it? However, in general this kind of information concerning coaching is very scarce (Johnson, 2013) and it is necessary to draw upon sources which may be somewhat peripheral to the questions asked.

1) *Qualities of the information.*

A type of research which relates to individual differences in coaching concerns how people react to feedback from other people (most often within an organization). In general, this type of method has yielded small effects (Kluger & DeNisi, 1996; Smither et al., 2005). However, indications exist that there are several variables which influence whether people react with a behaviour change to the information given. Smither et al. (2005) listed external variables such as credibility of the source, the feedback being positive, and a discrepancy between self- and other-ratings, Also, Johnson (2013) found that the combination of objective feedback and evaluation of the information yielded the strongest effects in an experimental setup. This combination would seem to be very close to coaching using objectively gathered information.

2) *Information complexity.*

Information fed back to subjects in telematics-based interventions is usually rather simple (two or three variables, comparisons between the driver and an average for the population, often a warning light in the cab when a threshold has been exceeded). Anecdotal reports from the telematics business indicates that using information which makes use of several variables and mathematically advanced concepts have not been successful. Proving this would, however, require a meta-analysis of the available literature, and given the sparsity of studies and the heterogeneity of the methodology, this is not possible today. It can therefore only be concluded that the available evidence suggests that it is possible to influence driver behaviour using rather simple information, while not excluding the possibilities for richer information (e.g. video and other context variables) having larger effects.

3) *Level of detail in information.*

Within feedback research, two different views about the optimal level of detail exist, setting fine-grained information against more general overviews (Casas-Arce et al., in press). One view states that specific examples (i.e. very detailed information) yield the best effect, while the other suggests that using a small number of examples run the risk of the 'Law of small numbers' (Tversky & Kahneman, 1971). The latter effect occurs when people use such examples as their prime source of information, and not the more comprehensive information available, i.e. they erroneously believe that the information they have is representative for the totality. It has also been argued that supplying highly task-specific information/feedback can hinder the generalization to other tasks (Massman, 2012). Apparently, the optimal level varies with the person, the problem and the situation (Massman, 2012). It is therefore difficult to transfer results from management and other areas to driving, in terms of recommending a certain amount of detail. Similarly, there is no measure of complexity which can be used across areas of behaviours. A flexible, user-defined approach to this problem is therefore recommended.

4) *Frequency of information.*

As with the optimal level of detail in feedback, two opposing views exist concerning frequency, both of which can be argued for in various ways (Casas-Arce et al., in press). However, what these two opposing theories mean in a specific situation is not really known, i.e. they do not seem to give an absolute number for the preferred level of frequency. Giving feedback once a week is a frequency used in many organisational studies, (e.g. Ludwig & Geller, 1997; Ludwig et al., 2002; Bateman & Ludwig, 2003), but lower frequencies have also been used with good effect (e.g. Stephens & Ludwig, 2005). In a study by Tate et al. (2006), participants voluntarily logged in to a support webpage at a similar rate to the feedback given from the researchers (once a week), which indicates a preference for such a time period. However, Casas-Arce et al. (2015) found that less frequent information (once a month) was more effective than weekly feedback, but Alvero et al. (2001) found no consistent pattern in their review.

5) *Timing of information.*

There are two basic positions on this question; immediate (in-vehicle) and delayed (after driving). Apparently, immediate information and feedback are more efficient for some kinds of learning tasks, like computer use (Massman, 2012). For continuous behaviour, however, this is not certain. Also, it should be noted that drivers (especially professionals) already have distraction issues in the vehicle, caused by various information systems (which are probably contributing to crashes (Green, 2004)). It can therefore be suggested that if immediate feedback is to be given it should not be visual or require any complex cognitive processing.

6) *Information - how and by whom?*

There are two basic media for transfer of information; humans and machines. The latter is objective and lacks the social dimension, while the former has the opposite qualities. In many instances, they are used in conjunction with each other, but what channel or combination is most effective cannot be concluded. In a review, Alvero et al. (2001) found that the combination of supervisor and researcher feedback was most effective.

4.3.2.3 Coaching drivers

Drivers are usually solitary workers, and traditionally (before the introduction of IVMS), very little information has been available about his/her performance, which made coaching difficult. Coaching has primarily been used for solitary workers with some success, such as among principals (Dussault & Barnett, 1996), Three different possibilities therefore exist when it comes to handling this problem. First, coaching can be based upon the subjective views of the driver about his performance. Such an approach is very much open to the biases of the driver. As most drivers are not well calibrated to their own performance (Roberts et al., 2016) and most of them believe they are superior to others (Svenson, 1981), the risk of the coaching based upon subjective views having no effect would seem to be paramount. Second, drivers can use self-observation, having the task of recording certain behaviours while they are driving. Although this method still allows for subjectivity, it has been shown to have an effect on behaviour (Olson & Austin, 2001). Third, information about driving can be provided from a telematics system. This would seem to be the more reliable, flexible and information-rich alternative available. Evidence for the effect of such systems is reviewed below.

4.3.2.4 Virtual coaching

Although coaching by definition is a developmental relationship between people, methods exist which simulate this by using computer programs acting as a coach; virtual coaching (this term is also used for human coaches working via the web; e.g. Israel et al., 2012), or e-coaching. The non-humanity of a response might be more or less apparent, although it is always acknowledged that it is not an actual human making the responses. The important point, which makes this kind of method different from pure information (for example from a telematics system), are the added features which try to mimic human interaction. This includes personalising the information, using a personal way of address (first name), asking questions and changing the way information is presented.

Such virtual coaches have been shown to have effects on exercise activities (Eyck et al., 2006; Watson et al., 2012). However, other tests have not been as successful (e.g. increasing physical activity by elderly people (Albaina et al., 2009)).

4.3.3 Theoretical basis

This section discusses theoretical approaches which may be applicable to the coaching (developmental relationships) situation. The questions asked are whether they describe the situation as such, if they can explain why coaching works, and whether they can predict which method may be especially effective, or any other novel feature. A rather diverse set of ideas will be accepted as 'theoretical', including models (although the latter are really descriptive, not predictive).

There does not seem to exist any theory for coaching in general (Jones et al., 2016), Instead, theories have been proposed for specific kinds of coaching, like mentoring in the academic field (see the review in Schunk & Mullen, 2013), and leadership coaching (Carey et al., 2011). Grant (2001) also describes several models which are specifically developed for coaching of company executives. These are not considered here, as they are too limited in scope to be applicable to the setting of driving. To be considered useful for coaching drivers, a theory should be applicable to all kinds of tasks and competences. It should also specify how coaching should be undertaken to achieve the best results. In line with the definition proposed earlier, the present text will concentrate upon more general approaches.

Furthermore, different studies and practitioners use different theoretical concepts (psychoanalysis, Whitmore's GROW model, Theory of Planned Behaviour, Social Cognitive Theory, Goal Orientation Theory (Dweck, 1986; Baron & Morin, 2010), Self-Determination Theory (Haggard et al., 2011) the Trans-theoretical Model of Change (TTM), Vygotskian concepts, etc.). The area of theory about coaching is thus rather fragmented, and it has not been possible to find a study which tests two or more theoretical concepts against each other, possibly because no theory makes predictions which are precise enough to be tested. The over-whelming majority of research in this area is a-theoretical and hypotheses are most often derived from previous results, practical considerations and logical arguments (e.g. Baron & Morin, 2010). However, there seems to exist two different possible theoretical bases for coaching, which are general enough to encompass coaching in any sort of situation (sports, business etc.). These are the *relational perspective* (Parker et al., 2008) and *cognitive-behavioural theory* (CBT) (Grant, 2001). These two approaches are complimentary, instead of rival, as they tend to describe different aspects of the coaching situation.

The perspectives of both relational theory and CBT seem to be important for the design of coaching interventions. In general, relational theory stresses the social importance, while CBT adds several techniques which increase the effect, working on the cognitive side of human nature.

4.3.3.1 The relational perspective

Relational theories and practices are based in the social nature of humans and the extreme importance of social relations for most of us, and appears to have started with Bowlby's attachment theory (Bowlby, 1988). It is thus a very broad perspective which concerns all types of behaviours and their relation to social interaction. It seems natural to apply this kind of theory to work within organizations, and how to influence behaviour; social relations are the very basis of what we do.

According to Parker et al. (2008) "*A relational approach to …//… is grounded in the assumption that interaction with others is a critical resource for learning …//…The relational view is informed by feminist literature, which emphasizes the centrality of relationships, acknowledgment of multiple viewpoints, and personal construction of meaning* …" (p. 488). As should be evident from this quote, the relational perspective assumes that a social situation is necessary for learning within an organization (and thus superior to training in the traditional meaning, which usually lacks the social component), and coaching (and/or mentoring) is an important tool for accomplishing this. Parker et al. (ibid.) also stress the advantage of coaching by people on the same organisational level, such as peer learning and the development of communication between the partners.

4.3.3.2 Cognitive behavioural therapy

The cognitive perspective within psychology stresses thinking, especially conscious processes, as determinants of behaviour. This can be seen as a reaction against the psychodynamic view, where unconscious processes based in childhood experiences is the basis of behaviour, but also against behaviourism, with its rather mindless stimulus-response model. With time, the cognitive framework has become dominating in research as well as practice with cognitive-behavioural therapy (CBT) methods as a central ingredient.

CBT methods were developed under the assumption that behaviour can be influenced by correcting erroneous thought processes, by pointing out the errors and supplying other ways of thinking about problems and behaviours. Also, the methods used for doing this, and identifying the problems, have been derived from theories about which cognitive functions shape behaviour (for example the ability to self-reflect; Bandura, 2001). Over time, this general approach has been successfully applied to a very wide spectrum of different problems and populations.

Of interest for coaching are two features of CBT: first, it is therapy, and as noted, coaching shares several core features with this kind of work; second, it specifically aims to change behaviour, and uses a number of fairly simple and well tested cognitive techniques for this end. One of the features of the cognitive approach is that it mainly stresses the internal thought processes of the individual, while less emphasis is placed upon the environment, including the social dimensions of behaviour (although this features in some theories, like Social Cognitive Theory; Bandura, 2001). This emphasis on internal thought processes can be said to be complimentary to the relational perspective in a coaching situation; the latter establishes the setting, while the former supplies the working tools.

4.3.4 Evidence

In this section, three questions are posed; (1) Is there evidence in favour of any particular theoretical approach to coaching?; (2) Is coaching an effective method for behaviour change? and (3) Is coaching an effective method for driver improvement?

To address these three questions, evidence concerning the two main theoretical frameworks described earlier will be reviewed.

4.3.4.1 Evidence for theory

The relational theory (Parker et al., 2008) would seem to imply that a social dimension facilitates learning of all kinds. This has apparently not been tested in coaching, but some results are available from similar research (some of which has been described under the heading of virtual coaching).

CBT was developed for treatment of milder psychological problems such as anxiety, and the bulk of the evidence is therefore from this area. For example, positive effects have been reported in the treatment of social anxiety disorder (Kampmann et al., 2016), and McDermott et al. (2016) meta-analysed twenty-five studies on changing health behaviours and reported a mean effect of d=0.41 on behaviour.

It can also be noted that weight-loss programs, which are apparently not based in CBT-like procedures, have been shown to have minimal effects (Tsai & Wadden, 2005). Similarly, CBT-based interventions were found to be superior to those using the Theory of Planned Behaviour (McDermott et al., 2016), although the opposite was reported by Webb et al. (2010). However, both these meta-analyses reported positive effects for CBT.

4.3.4.2 Coaching effectiveness for behavioural change

Most people would seem to be interested in how their behaviour relates to others, and how it is evaluated. Without this interest and willingness, coaching would not work. However, receiving information does not necessarily change behaviour to any significant degree (Kluger & DeNisi, 1996). Instead, several factors influence whether the feedback has an effect, such as the belief in whether it is possible to change (Smither et al., 2005).

When evaluating whether coaching has the intended effect, it should be remembered that many of the expected results of the process are rather vague to their nature, and poorly specified. In general, authors in this area have concentrated more on the description of the process itself, than the outcomes. This has led to a criterion problem in coaching (Smith et al., 2009; Jones et al., 2016). It is often not clear what skills or behaviours coaching is supposed to influence, and evaluations are therefore disparate, and their interpretation and applicability equally uncertain.

Furthermore, there exists limited research which indicates the degree of efficiency for coaching. Only two meta-analyses, with similar content have been identified. The first summarizes the results from 18 studies on the effects of coaching by professional coaches within organizations (Theebom et al., 2013) indicating that effect sizes for various kinds of dependent variables are small to medium.[3] However, few of the variables were objectively measured, and most concerned psychological features (e.g. self-awareness) which act as proxies for actual behaviour of relevance to the organization. Jones et al. (2016) undertook a new analysis, which yielded similar results, despite little overlap between samples. None of these analyses found the length of the intervention (i.e. number of coaching sessions) to be related to the effect size. However, this might be due to a kind of ceiling effect, where the change happens within the first few sessions, and the new levels remain stable. In support of such an interpretation, Eby et al., (2013) meta-analysed correlates of mentoring relationship quality and found a positive association with the frequency of interaction. Most

[3] In this literature, effects are usually given in Cohen's d or Hedge's g. These two coefficients can be interpreted in the same way, as the latter is a Cohen's d corrected for small sample over-estimation bias. The size of Cohen's d is usually interpreted according to the following guideline; <0.2= trivial, 0.2 to.5 small, 0.5 to 0.8 medium, 0.8 to 1.3 large and >1.3 very large. However, it should also be remembered that most effects in social science are in the small range.

interestingly, Jones et al. (2016) found that their meta-analytic results favoured internal coaches (who were not supervising the coachee) and not using feedback from multiple sources. Some results indicate that the combination of coaching and information/feedback is more effective than either on its own (Luthans & Peterson, 2003).

It can therefore be concluded that coaching seems to work in general, but that the effects are larger for certain methods, including added information, peer coaching and repeated coaching sessions.

4.3.4.3 Driver coaching effectiveness

4.3.4.3.1 General results

There is little evidence available about coaching in driving safety, and the available studies have used rather different set-ups (designs, methods, populations), but the results are in general positive.

One premise of coaching in driving is that the majority of drivers would like to receive more feedback about their driving, from respected people within their organization and from technology (Roetting et al., 2003; Huang et al., 2005; Huang et al., 2008). Information about driving behaviour from telematics is therefore viable as a support in coaching, and most (if not all) studies on driver coaching use some sort of objectively gathered information about driving behaviour as the basis for the intervention.

The first studies to use coaching-like methods for drivers were carried out by Misumi, (1989) and Gregersen et al. (1996), where group discussions were used to reduce crash rates and costs within organisations. Reductions of at least fifty per cent were noted during follow-ups after at least two years. Similarly, Olson and Austin (2001) used self-monitoring, supervisor observations and feedback, and achieved a 12 per cent increase in observed safe behaviours of bus drivers.

In studies using a combination of telematics and coaching, positive results have also been reported by several studies (Bell et al., 2017; Carney et al., 2010; Farmer et al., 2010; Hedges & Moss, 1996; Hickman & Hanowski, 2011; Larson et al., 1980; Ludwig et al., 2010; McGehee et al.,2007; Olson, & Austin, 2001; Shimshoni et al., 2015; Simons-Morton et al., 2013; Strömberg & Karlsson, 2013; Tapp et al., 2013; Toledo et al., 2008). However, most of these studies are of low methodological quality. For example, several of them lack a control group (Carney et al., 2010; Hickman & Hanowski, 2011; McGehee, et al., 2007; Toledo et al., 2008). This means that any interpretation of the effects should be very tentative. Especially for studies on teenage drivers, maturation and increased experience during the study is a rival explanation for the results. For older drivers, other changes in the environment could also have influenced results. This latter possibility was very apparent for Toledo et al., (2008), who reported that the drivers in the rest of the company (a kind of control group) experienced a reduction in crashes which was half as large as that of the intervention group.

Also, most studies have not used crashes as a dependent variable (with the exceptions of Larson et al., 1980; McGehee et al., 2007; Simons-Morton et al., 2013), but various driving behaviours which are assumed to be correlated with crashes, but without any evidence for this having been presented (see af Wåhlberg, 2009). Also, most intervention time periods were less than a year, and only three studies used a post-intervention period for testing whether the results were sustainable without the intervention (Bell et al., 2017; Carney et al., 2010; Ludwig et al., 2010). It can therefore be concluded that although the results for driver do look positive, the effect sizes have probably been over-estimated.

Finally, most studies have used several different intervention techniques simultaneously, and the effect of coaching is thus blended with those of the other interventions. It is therefore impossible to know what each has contributed, while telematics-based feedback has been shown to have an effect on its own (Adell et al., 2008; Bolderdijk et al., 2011).

In the end, however, what is an effective approach for driver improvement must be judged against the alternatives. Today, the main rival would be the classic driver training. However, instruction in safe driving in the classical sense has largely failed, as no type of skills- or knowledge-based teaching has been shown to have any safety effects (Klein, 1966; Kaestner, 1968; McGuire & Kersh, 1969; Lund & Williams, 1985; Struckman-Johnson et al., 1989; Mayhew et al., 1998; Vernick et al., 1999; Christie, 2001; Mayhew & Simpson, 2002; Masten & Peck, 2004; Ker et al., 2005; Strathman et al., 2007; Lonero, 2008; Roberts, Kwan & Cochrane, 2008; Peck, 2011). It can be noted that this result can be expected from the relational theory perspective, as these approaches to driver behaviour lack the social ingredient, as well as a long-term application.

4.3.4.3.2 Effects due to different types of coaches

As already noted, there are four possible types of coaches; external, supervisor and peer within organisations, plus relatives and friends for non-professional settings.

Ludwig et al. (2010) used group goal-setting (a peer-to-peer technique) to influence drivers to use turn signals and other safety features, which showed large positive effects. This method is similar to that of the classic intervention study by Gregersen et al. (1996). In this latter study, having drivers discuss safe driving habits, their own driving, and setting a personal goal, in small groups three times led to a fifty per cent reduction in crashes over the next two years. Other interventions in the same company also had positive effects, but not as large as this one.

Coaching by supervisors is probably the most common method in industry. The evidence for the effects of this method is, in comparison, scarce. Bell et al. (2017) used event-triggered video as a basis for supervisor coaching, yielding an effect of $d \approx 0.33$ versus a control group (reduction in 'risky driving behaviours'). Similar effect sizes were found in Hickman and Hanowski (2011).

Only three studies on coaching drivers by external professionals have been found. Tapp et al. (2013) used in-vehicle data recorders and reported sustained effects on gforces seven months after the intervention, but did not report an effect size, or even per cent reduction for this. Furthermore, no control group was used and the rate of drop-out was high. The study by Stanton et al. (2007) did not include measures of everyday driving and used dependent variables which are only vaguely related to safety. Both of these studies used coaches from a motoring organization, while the third (Simons-Morton et al., 2013) utilized employees of the company which provided their telematics equipment. Although the study was well executed, it is not possible to ascertain the effect of external coaches as such, as their work was only part of a comprehensive intervention package for novice drivers. The reported effect size was very large (d=1.67), but it is uncertain how it was calculated. Thus, none of these studies can be said to be fully reliable. However, the Simons-Morton paper is by far the most informative.

It can be noted that in many of these studies, it is impossible to ascertain that the effect was due to the intervention as such (e.g. Ludwig et al., 2010). This is shown by the results of Bell et al., (2017), where the control group also reduced their risky driving events over the study period, although the coaching intervention showed a greater effect. This kind of impact make the results of the studies without control group problematic, as their reported effects might very well be inflated (e.g. Hickman & Hanowski, 2011).

In summary, evidence regarding effects of coaching drivers by different coaches is very limited, and of low quality. From this literature alone, it is not entirely possible to ascertain what is the best method for the MeBeSafe project, and the suggestions at the end of this document is therefore mainly based upon research on coaching in general.

4.3.4.3.3 Teaching versus directing drivers

Do drivers need to be explicitly told how to drive safely, or do they know this, and just need to be reminded? Such a question does not seem to have been explicitly researched, but some results can be forwarded in support of the facilitation position.

Evidence for a facilitation effect is very limited. However, within eco-driving training, it has been noted that although the reduction in fuel consumption during training is rather large (10-20%), this effect very quickly vanishes (af Wåhlberg, 2007). Actually, drivers can achieve a fairly strong reduction in consumption without instruction, but simply by being asked to drive carefully (a kind of coaching, Laurell, 1985), or by being given feedback (Runnion et al, 1978).

In summary, coaching is about reminding a person that their existing knowledge should be used. As phrased by Grant (2001); *"The process of coaching is essentially about helping individuals regulate and direct their interpersonal and intrapersonal resources to better attain their goals."* (p. 52). It would then seem important to guide drivers towards new goals, not train in them in specific skills. This approach is similar to the self-monitoring method of the behaviour-based safety approach, where the knowledge of one's own behaviour is enough to cause change. This method is especially useful for drivers, who work alone (Olson & Austin, 2001), and can use telematics data for feedback.

4.3.4.4 Evidence from interviews

In one of the companies coaching has been used to address basic road safety, making it personal and including personal consequences of behaviours. Coaching has also used in the context of defensive driver training and IVMS. Coaching was seen as effective and as a major tool to change behaviour, for example regarding the use of safety belts. Ensuring that coaching was done in a positive way was considered as important, in addition to ensuring that the correct message was communicated. In addition, context specific coaching was deemed imperative. Nevertheless, the long-lasting impacts of coaching were questioned.

In another company, coaching was considered very effective for harsh driving and to reduce fuel consumption, but according to the interviewees it requires interaction and customization, taking in account the target population needs and expectations, as well as what could become an obstacle for translation of attitude change into behaviour modification. It was further argued that coaching could be helpful but only if the driver is already motivated to adopt the particular behaviour.

Another interviewee argued that several studies show that coaching works well when leverage is present (teen driving, fleet driving). When leverage is not present, other means of drawing drivers to a modified behaviour have to be employed. This tangentially couples to the gamification arena, where a lot of thought is put into how to, with non-expensive means, create user involvement in a way that alters behaviour.

4.3.5 Implications

In the light of the theories and evidence presented here, the coaching approach, supported by telematics, would seem to be promising for influencing truck driver behaviour.

The most important function of coaching is to *make the behaviour of the coachee apparent* to this person. This feature works to change behaviour by counteracting various cognitive biases (see also Chapter 5). Also, personal standards might be involved, where it becomes obvious that the coachee is not behaving according to whatever beliefs (s)he holds.

The second most important feature is to *make the coachee socially accountable.* Driving is a behaviour which is usually very anonymous. Under such circumstances, people will tend to do things they would not do if these actions would become known to society, especially significant others.

Thirdly, the coach and coachee often make more or less explicit *agreements about future behaviour*, which function as contracts. This supports the social accountability, as it is a general human rule that agreement should be honoured.

Furthermore, for coaching to be efficient, it should have the following properties:

- *The choice of coach.* Results indicate that internally recruited coaches are preferable (but should not be supervisors). This indicates a peer-to-peer approach.

- *The duration of coaching.* The number of coaching sessions and the duration of the intervention have been found not to influence the effect size. However, this should not be interpreted as evidence that coaching can be discontinued after a few weeks, as the effect is then likely to wane. The mentoring and peer-to-peer approach of a long-term relationship is probably preferable.
- *Social context.* The social part of the coaching situation should be underscored in training and encouraged by management. Positive feedback is essential, as is collaboration.
- *Timing of information.* A combination of information/feedback and coaching seem to be more effective than each on its own, and is therefore preferable. Feedback is probably more effective if presented just before a drive. Pure information, on the other hand, should be available after each drive.
- *Frequency of feedback.* Presenting feedback once a week is probably sufficient, but a flexible and interactive feedback schedule is preferable.
- *Frequency of coaching*. The frequency of sessions should be dependent upon the reactions of each driver. A suggested starting level could be once every two weeks. Thereafter, the frequency can be reduced for those who respond positively.
- *Features of feedback.* Information needs to be simple, objective, relevant (i.e. understandable and pertaining to driving) and from a respected source. Information about individual behaviour should only be made available to the coaching pair. Overall (average) results for the whole company should be available to all drivers and supervisors for reasons of comparisons (reality check).
- *Driver profiling.* There is currently very little evidence which suggests that different drivers could benefit from different types of coaching, and even less which specifies what these types of coaching would be. Usually, coaching is a single, unitary approach, and individual differences are handled by the coach. However, the term profiling can also cover aspects of information used in coaching. There is currently no evidence that psychological concepts and tests

for these, like personality, can be used to any advantage in coaching of drivers. Information from telematics systems should be used to differentiate between drivers in terms of the topics which are to be covered in the coaching sessions. This kind of profiling will create objective, individualized feedback which is current, understandable and highly relevant for the coach and coachee.

- *Training for coaches.* When coaches are internally recruited, some basic training in coaching methods should be given. The simplest, most efficient and well-tested method for developmental relationships would seem to be CBT.

4.4 Integrated framework

Nudging and coaching represent two very different approaches to behaviour change. This section will first compare the two approaches and then put them in relation to the intervention strategies discussed in section 4.1. In order to introduce an integrated framework developed to aid the further development of MeBeSafe interventions.

4.4.1 Comparison of the nudging and coaching approaches

As they have different theoretical foundations, their aims as well as the ways through which they seek to influence behaviour differ, as do the type and degree of influence they may have on a road user's behaviour. To further clarify the differences between the two approaches, an overview of important aspects is provided in Figure 4.6.

A NUDGING APPROACH		A COACHING APPROACH
Support automatic behaviour and decision making in a specific situation	**Aim of approach**	*Support reflective learning to influence behaviour in various situations*
Supportive choice architectures (humans influenced by the context, technology etc)	**Overall intervention type**	*Supportive coaching experiences (humans influenced by humans, but sometimes mediated by technology)*
Narrow - must influence behaviour in a specific situation	**Window of opportunity**	*Wide - can influence behaviour both in a specific situation and beyond*
Influences behaviour directly every time the situation arises	**Frequency of influence**	*Can influence behaviour directly during a coaching event and indirectly in situations in-between events*
Momentary or short - influences behaviour in a specific situation	**Duration of influence**	*Short or long - influences behaviour over time with repeated coaching quires a willingness to learn and change*
Specific to location - influences behaviour at the location where the supportive choice architecture is provided	**Location of influence**	*Independent of location - can influence behaviour at other places than where the coaching is provided*
Requires that the road user attends to or makes use of the specific choice architecture	**Key prerequisite for successful influence**	*Requires the development of a quality relationship between coach and coachee built on trust and commitment*

Figure 4.6: A comparison of the Nudging and Coaching approaches.

Nudging as an approach argues for primarily supporting automatic behaviour but also decision making in specific situations through the design of supportive choice architectures. A coaching approach on the other hand, argues for human-to-human coaching (sometimes mediated by technology) as a way to support reflective learning, which can influence behaviour in various situations. Consequently, the *window of opportunity* for applying a nudging or a coaching approach varies. While nudging can only be used for influencing behaviour in a specific situation, coaching can be used for influencing behaviour in a specific situation, as well as prior to, and after the situation.

Frequency is another important aspect to discuss which differentiates the approaches. For nudging, a supportive choice architecture will influence behaviour directly every time a situation arises in which the choice architecture is part of the driving context. For coaching, the frequency of influence depends on how and when the coaching is provided. If the coaching takes place during particular driving situations, it influences behaviour directly during each coaching event. However, if the coaching events are less frequent compared to how often a road user experiences a particular driving situation, the coaching can influence behaviour indirectly due to learning outcomes. The same can be argued for coaching that takes place after a situation (or prior to the next). For this type of coaching, behaviour is not influenced directly at each event, but learning outcomes can influence behaviour indirectly in-between coaching events.

Yet another important difference between the two approaches is the *duration* of influence. As illustrated in Figure 4.7, nudging will influence behaviour momentary in a specific situation (type 1 nudges) or shortly after (type 2 nudges). Coaching can influence behaviour either during a short period or over a longer period of time if the coaching is repeated over time or if it has resulted in learning outcomes that have lasting effects on behaviour.

Interventions based on a nudging approach can be said to be specific to the *location* or context in which the supportive choice architecture is provided. In comparison, coaching can be provided in many different locations and situations apart from a specific driving situation and also influence behaviour in other locations than where a coaching event has taken place, which makes this approach independent of where the intervention is located.

Lastly, the two approaches differ in regard to their key *prerequisite* for a successful intervention. Nudging requires that the road user attends to or makes use of the specific choice architecture, for instance, perceiving cues designed to guide drivers to keep an appropriate distance between cars, or making use of in-vehicle functions designed to facilitate safe driving choices. Coaching requires that a quality relationship is developed between coach and coachee so that both can trust each other and commit to making the coaching a good learning experience.

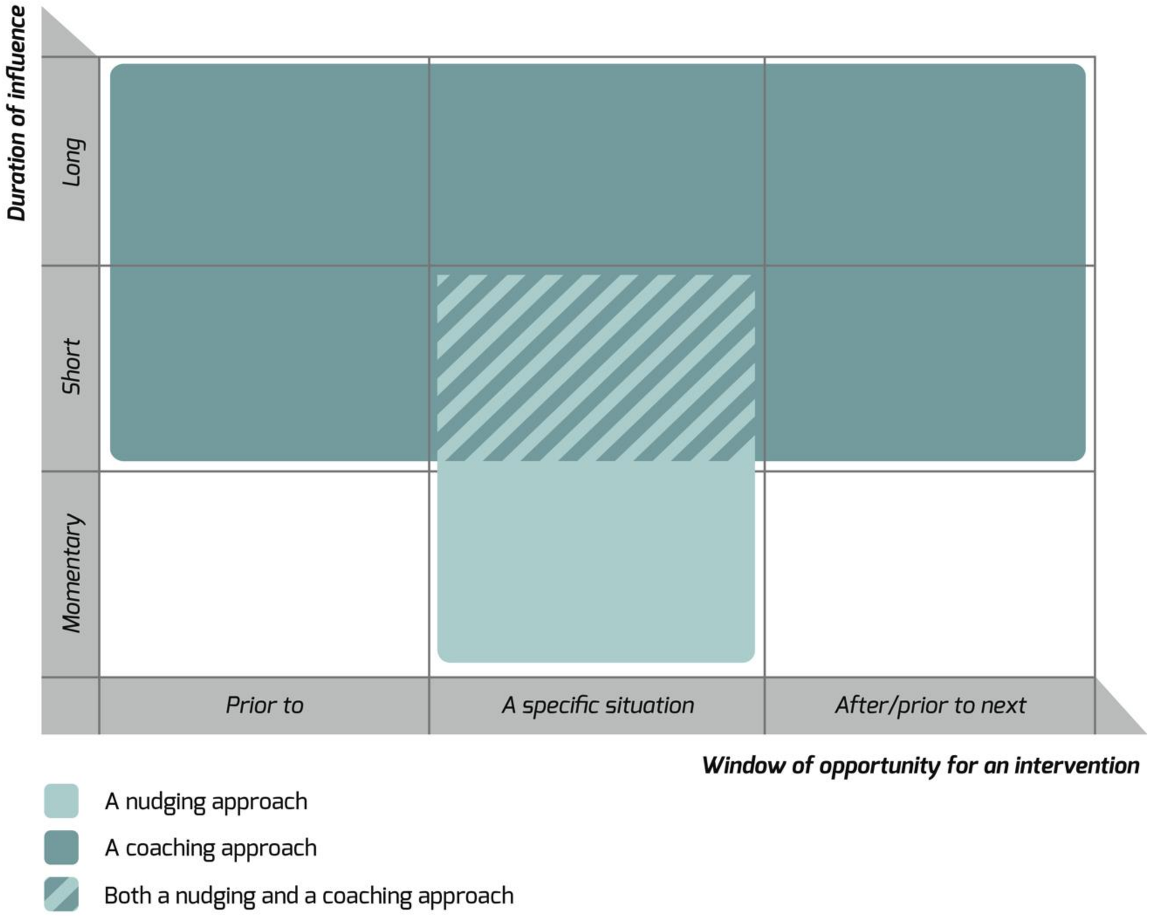


Figure 4.7: Nudging and Coaching in relation to window of opportunity and duration of influence

4.4.2 Integration of approaches and intervention strategies

As these approaches work through or address different behavioural mechanisms, they make use of the four main types of intervention strategies in different ways and to different extent. As a nudging approach is concerned with (re)designing choice architectures, it can easily be interpreted as an approach that addresses only the context, i.e. the driving context as discussed within MeBeSafe. However, nudges are any aspect of the choice architecture that influences people's behaviour, including for instance, priming or framing of wording during conversations or the provision of information to raise awareness and knowledge. Thus, a nudging approach covers all four types of strategies (even though some are more frequently discussed in literature than others) but the approach is primarily focused on addressing opportunities for safe driving in a specific situation as illustrated in Figure 4.8. It can be used for addressing both the automatic system of thinking (type 1 nudges) and the reflective system of thinking (type 2 nudges).

Considering the coaching approach, it can be argued that it is primarily concerned with influencing the behaviour of individuals, even though some forms of coaching requires technology or a (re)design of the context. Consequently, as shown in Figure 4.8, it covers the two types of strategies related to the road user as discussed within MeBeSafe. In contrast to nudging, a coaching approach is not primarily focused on influencing behaviour in a specific situation, it also covers strategies that can be applied and influence behaviour or learning both prior to, and after a specific situation.

Given the identified differences between the two approaches, one might claim that they are in conflict with each other. However, in relation to the scope of MeBeSafe, it can be argued that the two approaches are complementary and that they simply represent different ways of addressing risky behaviours. As they provide different perspectives on how to contribute to safe driving, the two approaches can even be combined into interventions that address both the design of the choice architecture and opportunities for reflective learning.

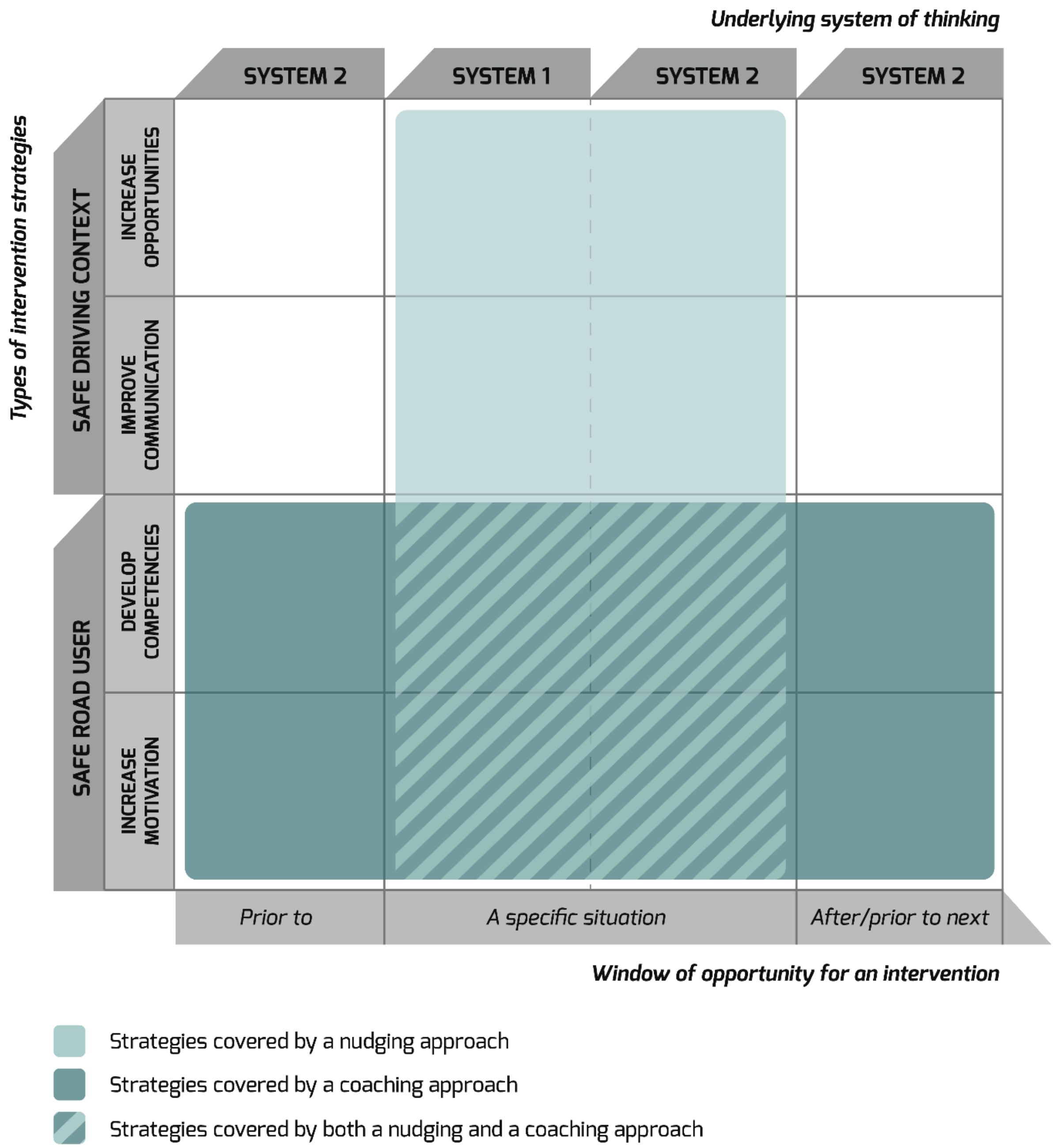


Figure 4.8: An integrated framework that relates the four main types of intervention strategies relevant to MeBeSafe, the two approaches Nudging and Coaching that will be addressed within MeBeSafe, and the window of opportunity for MeBeSafe interventions.

5 Underlying Theories and Models

5.1 Rationale

This chapter provides the theoretical background and the state of the art on which the intervention strategies and the nudging and coaching approaches discussed in Chapter 4 are based. To understand how and why nudging and coaching may improve safety, the underlying causes of risky road behaviours are of utmost importance. Human behaviour is, directly or indirectly, responsible for an estimated 96% of crashes (Sabey and Taylor, 1980). Also, road crashes and injuries are not equally distributed in the road user population. Some road users have a higher crash involvement rate than others (e.g., af Wåhlberg, 2009; Visser et al., 2007).

For the understanding and prevention of road crashes and casualties, two approaches are to be distinguished that fundamentally differ in their analysis of the nature of road risk and in their approach to prevention strategies. First, the *safe system approach* (OECD-ECMT, 2008; 2016). This approach explains crash involvement from imperfections in the design of the road system in such a manner that road users start behaving risky. The road system design creates the task demands that road users should to meet. Behaviour models based on this safe system approach deal with questions of how to design the road system such that it makes it 'easy' for road users to behave safely.

The second approach, here coined as the *individual approach*, explains crash involvement from road user characteristics. Here three categories of behaviour models can be distinguished:

- models on *road user competencies*,
- models on *road user states*, and
- models on *motivations & decisions*.

The models on road user *competencies* deal with questions as What skills needs a road user to perform the traffic task? What underlying processes play a role, such as information processing, visual perception and attention? How are these skills acquired? And what might go wrong and why? *Road user state* models address questions such as how risk factors as fatigue, poor vision, haste, alcohol and drugs, and biorhythm influence behaviour and subsequently crash risk. These issues concerning road user state are not addressed in this Chapter but in Chapter 8 on User Profiling. Finally, models on motivation and decision making refer to factors which motivate road users to make decisions that might impede their own safety and that of others. These models fall into one of two categories. The first category is based on the assumption that the underlying processes are basically conscious and that road users engage in mental processes such as weighing the pros and cons, developing opinions and beliefs, and assessing barriers and opportunities. In contrast, the second category assumes that most decisions are automatic, and more importantly that they are heavily biased and substantially less rational than most people believe.

The two approaches identified at the beginning of this section, the safe system approach and the individual approach are not completely unrelated. Both use the characteristics of humans, their competences, skills, motivations and decisions as a starting point. However, they differ in the prevention strategies. The individual approach often aims to adapt the road users to the task demands of the road system, whereas the safe system approach aims to adapt the task demands to the competences and skills of the road users, i.e. safety by design. Thus, the latter aims to 'bend the tool, rather than its user'. Figure 5.1 presents the different categories of road user models schematically and serves as an aid to illustrate the structure of the current Chapter and as a first step towards an integrated model.

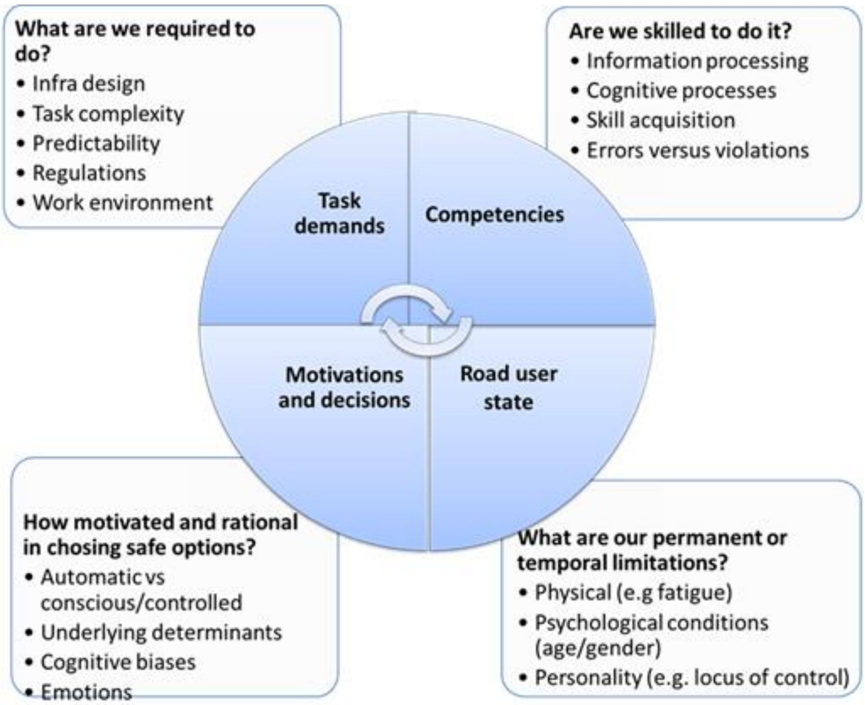


Figure 5.1: Classification of behaviour models.

5.2 MeBeSafe interventions and profiles

As indicated, the two approaches, the safe system approach and the individual approach, lead to a wide range of possible interventions. Of all possible interventions, MeBeSafe focuses on just two: nudging and coaching. In this chapter, three of the four categories[4] of behaviour models are described, as visualised in Figure 5.1 and discuss the implications of these models for the two types of interventions. The behaviour models will be used to identify if and how individual differences in road traffic behaviour and the underlying causes of this behaviour, and individual differences in responses to interventions such as nudging and coaching, play a role and would be relevant for road user profiling. The latter will be discussed in more detail in Chapter 6. Finally, behaviour models are helpful for understanding at what moment in time an intervention may be most effective, and have least negative side effect. The implications will be described.

[4] Road user state models are dealt with in Chapter 6 on User Profiling.

5.3 Task demand models: 'Safe by design'

5.3.1 The historical background: Haddon, Reason, and TRIPOD

As mentioned earlier, design of the road system sets the task demands that road users need to meet. For example, road users may be required to cross a busy road with fast moving traffic or may be offered an underpass for reaching the other side. Needless to say, that the task demands for crossing the road are much higher and, hence, that this is much more risky compared to the use of the underpass. By building an underpass, safety has improved by design and not by improving the road crossing competencies of road users.

Safety by design is often a very effective strategy, as was already recognised in the early eighties by Haddon, studying the effects of public health interventions (Haddon, 1980). He used the analogy of the epidemiology and prevention of infectious diseases to advocate a shift from an individual to a community-cantered emphasis. The provision of purified milk and water rather than relying on the individual's action of boiling milk and water before consumption is a compelling example. Haddon concludes (Haddon, 1980; p. 416): "It has been the consistent experience of public health agencies concerned with the reduction of other causes of morbidity and mortality that measures which do not require the continued, active cooperation of the public are much more efficacious than those which do".

Another inspiration for 'Safe by design' comes from studies aiming to understand how individuals interact with systems, equipment and products. In his book 'The design of everyday things', Norman (1988) applies human factors concepts and describes examples of poor product designs, showing how these poor designs lead people to make errors. Norman appeals to designers to ensure that errors are easy to detect, have minimal consequences and that their effects can be reversed. Similarly, the TRIPOD model (Wagenaar et al., 1990) has applied insights from human factors to the understanding of crash causation in a wide range of fields, such as the oil and chemical industry, oil platforms, and hospitals, but also road traffic.

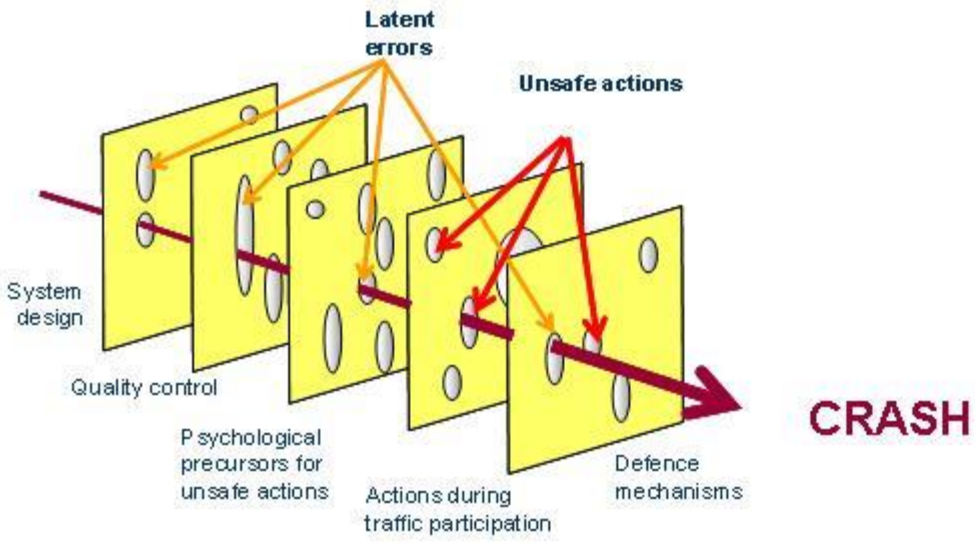


Figure 5.2. Reason's model of latent errors and unsafe actions. Source: Reason (1990).

The TRIPOD model is based on the so-called 'Swiss cheese model' of Reason (see Figure 5.2). His crash causal chain indicates that there are potential flaws (latent errors) in the whole system: from flaws at an organisational level to unsafe actions by road users. In road crash investigations, the latent errors early in the chain may easily remain unnoticed as the focus is often on the road users and their unsafe behaviours. For instance, a right turning truck driver may overlook a cyclist who is positioned at the right side of the truck, and be blamed for the collision. However, a latent error earlier in the chain may have been the decision to have heavy good vehicles and vulnerable cyclists sharing the road. This model further shows that preventing the latent errors early in the chain, is more effective than relying on the road user as the last line of defence.

Haddon's approach, Reason's Swiss cheese model, human factors, and further operationalization such as the TRIPOD model, have inspired later safe system approaches, such as Sustainable Safety in the Netherlands (Wegman and Aarts, 2006), and Vision Zero in Sweden (Tingvall and Haworth, 1999). Here, the more recent OECD-ECMT reports are referred to for a more detailed discussion on safe system approaches to road safety (OECD-ECMT, 2008; 2016).

5.3.2 Implications

The safe-by-design approach has several implications for the elaboration of the MeBeSafe interventions of nudging and coaching, as well as for profiling drivers.

- *Nudging:* The safe-by-design approach corresponds with the basic ideas of nudging, as defined by Thaler and Sunstein (2008). They advocate to design the task environment (the choice architecture) in such a manner that the desired behaviour almost automatically follows.
- *Coaching:* Coaching in traffic most often addresses the individual road user. However, according to the safe-by-design models the road user is the last line of defence. If coaching is to play a role, it should be at a level higher in the system than the road users, e.g., national policy makers or the management in transport companies.
- *Profiling:* In principle, safety by design is meant to be beneficial for all drivers, independent of gender or personality or their level of experience. However, driver experience might play a role in developing the skill of 'reading the roads'. Although many features may be 'intuitive' and therefore easy to interpret, such as markings. Other features such as 'predicting what another road user is going to do' may be far more complex to learn.

5.4 Competence models: safe by a competent road user

5.4.1 Levels of and information processing for the traffic task

It is to be expected that the safe-by-design approach cannot tell the whole story. Safe traffic participation also requires specific road user competences. Road users continuously have to monitor latent dangers and react to them. The strategies that road users apply to control these dangers have been studied extensively (see Cacciabue, 2007 for an overview). This section does not review the competence models in detail, but only as related to the objectives, the target behaviours and the intervention of MeBeSafe.

Michon (1985) described the road traffic task in terms of three different, but interdependent hierarchical levels. The first level contains the *strategical tasks* and deals with decisions concerning the planning of the trip, the choice of mode of transport, and departure time. It also may involve an assessment of one's fitness to drive, for instance after an evening out. These strategical decisions are taken before the trip and are not time and data limited. One has sufficient time to gather the relevant information and to take decisions. Additional information may be welcomed as it may assist in the decision making, if the content is relevant and easy to understand.

The second and third level – respectively manoeuvring and operational tasks – are relevant during the trip. The *manoeuvring tasks* concern decisions like overtaking, whereas the *operational tasks* concern tasks like keeping the vehicle on the road, and keeping one's distance to other road users. Decisions on the manoeuvring level have an available time window of seconds and on the operational level of only milliseconds. Thus, both levels are time-limited, and actions need to be carried out quite fast. Extra information, for instance from feedback systems, may interfere with these tasks, if it is complex, unexpected, and not intuitive.

Another relevant distinction in task performance is the level of attentional control, as developed by Rasmussen (1985). The levels of control tell us what mental processes are involved in the traffic task in terms of the required level of attention. Rasmussen distinguished *knowledge-based information processing* and *skill-based information processing.* Knowledge-based processing requires active information seeking and processing, whereas skill-based processing is a more or less automatic execution of highly practiced routines. This level of automaticity is the preferred mode of performing tasks, given that these routines are engrained correctly.

The driving or traffic interaction task can also be described in terms of *processing and integration of information from* a wide range of sources. Ossen (2008, p. 14) defines the task of driving as "a comprehensive term that consists of all tasks a driver must execute to reach his travel destination safely, comfortably and timely". Such tasks are operating the vehicle itself, driving behaviour of the vehicle, vehicle reactions that were caused by the driver himself, environmental influences and anticipation of possible upcoming events. Regarding the amount of information, the driver has to intervene, when necessary, in order to keep the vehicle on track and himself, as well as other road users, safe (following Heißing & Brandl, 2002). For instance, Macadam (2003) defines lateral and longitudinal control tasks like path following, obstacle avoidance and headway control - as examples of steering and braking - as crucial for the control aspect of the human driver. From control tasks, he excludes behavioural aspects like driver distraction, side tasking or driver impairments. In our categorisation of behaviour models (Figure 6.1) these are dealt with as 'driver state' models.

Krüger et al. (1999) argue that the driver has to fulfil a driving task on the one hand, but that he is also in charge of keeping himself in a state of being able to drive: effort-management. This approach considers the vehicle as a tool for driving. The authors promote *an exteroceptive and an interoceptive loop* of the driving action (see Figure 5.3 for an illustration). In the exteroceptive loop, the driver anticipates a goal within his driving environment, which he wants to achieve by driving his car. Usually he gains feedback via the visual channel whether he achieved his goal. Deviations are either compensated for or form the basis for new goals. In the interoceptive loop, the driver implements his intention from the exteroceptive loop into an operation, which forms the effectorial action component. He gains feedback about the effects via the vehicle's reaction in a sensory, usually kinaesthetic (body distributed) fashion. Both loops are not independent, but interact. For example, anticipation is piloted by the interoceptive loop, if the set goals are only reachable within the subjective part of the operational action scope. All components interact with each other. In consequence, the driving characteristics of a vehicle are the result of the driver's actions and its interaction with the driving environment. For permanent activities (e.g., driving a well-known route) there are continuous feedback loops to monitor whether the driving task is executed the way it should. Within a feedback loop, the driver alters his actions constantly. This feedback is automated and not perceived consciously. The driver might for example subconsciously notice a small deviation from the ideal driving trajectory and correct it without being directly aware of it. Only if deviations from the usual driving process reach the driver's consciousness, the automatic loop is left and the adequacy of a previously automatic action is examined. This might result in changes in information perception, processing and action execution and finally in increased cognitive effort.

The theory of Krüger et al. is helpful in understanding how the road user may shift from automatic to conscious processes and how that may lead to changes in the automatic routines. It also shows that these types of disruptions of automatic routines can be detrimental for performance, as it increases cognitive effort.

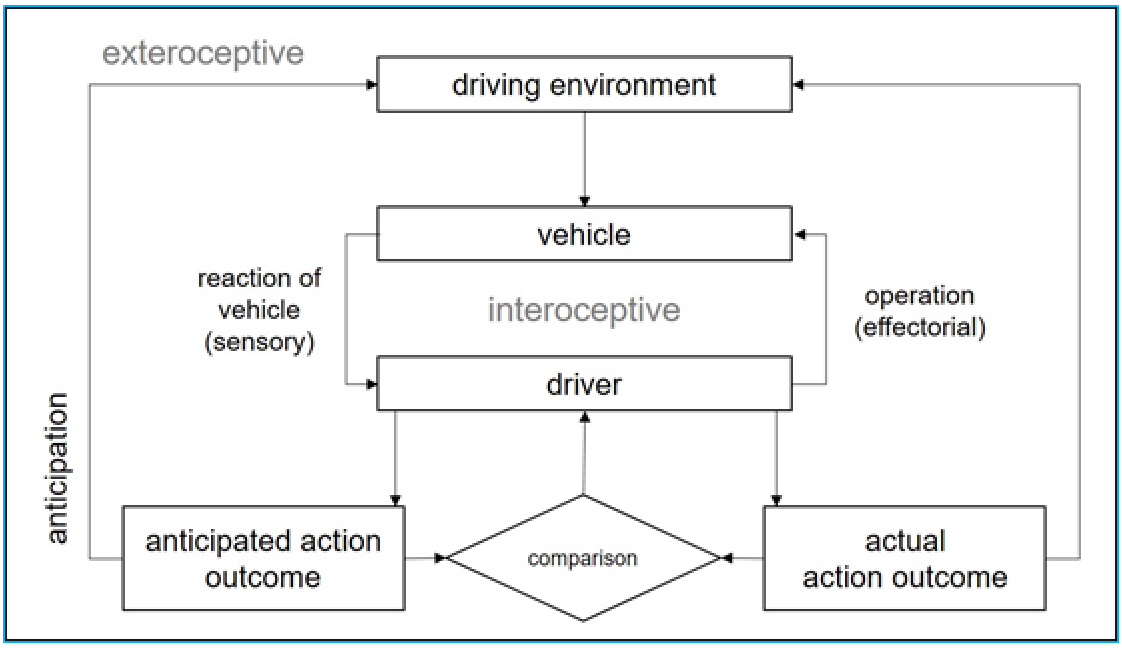


Figure 5.3: Exteroceptive and interoceptive loop of the driving action (Krüger, Neukum, & Schuller, 1999).

From the *Theory of Event Coding* (TEC) as published by Hommel et al. (2001) it is known that anticipated effects of an action influence its execution. According to TEC, action planning and action execution share a common representation. In addition, the proximal and distal action effects are represented in a shared event code. A proximal action effect while driving is, for example, the pressing of the foot on the accelerator pedal, while the distal action effect would be the acceleration of the car. Put simply, the pedal serves as a tool to translate the proximal action effect into the distal action effect (modelled after Müsseler & Sutter, 2012). Visual action effects are broadly known to dominate the visual-haptic perception, especially when size, shape or position have to be estimated (see also Ladwig et al., 2012; Ladwig et al., 2013). For instance, visual dominance occurs in situations where the variance that comes along with visual estimations is smaller than the variance that comes along with haptic estimations (Ernst & Banks, 2002). But in the process of driving, much different sensory information contributes to the perception of our surroundings and our own action execution.

The proper integration of different types of information is not easy for the human information processing system. In the context of information processing, the construct of the bottleneck is central (Welford, 1952). In case the information processing system has to integrate a high number of information bits at once, not all aspects can be processed as fast as if they would occur separately. Furthermore, Kahneman (1973) sees attention as a limited, flexibly applicable and stimulating resource. Attention can be limited to one action or it can be divided between more actions, while difficult tasks always demand a higher amount of attention. This is in line with Cowan et al. (2005) who state that the working memory is an instance with only limited capacity for processing information from different sources. However, the working memory (see also Baddeley et al., 2009) has a crucial supporting function in the simultaneous processing of more than one task. In the context of driving this underlines the struggle the driver has to face during the complex driving task.

To show the interrelationships between task demands, information processing, and cognitive processes, Endsley constructed the *Situation Awareness paradigm*. Situation Awareness defines the traffic task as a dynamic decision task (DDT) that requires 'interdependent' decision making in an environment that changes over time, either by previous actions of the decision maker or by events outside the control of the decision maker. Within this context, a road user reaches a decision by perceiving and selecting the relevant elements in the environment, by comprehending their meaning, and projecting their status in the near future, all within a limited amount of time and space (Endsley, 1995). Thus, Situation Awareness uses elements of the information processing paradigms as discussed above, but integrates them into an overarching framework, as can be seen in the Figure 5.4 below.

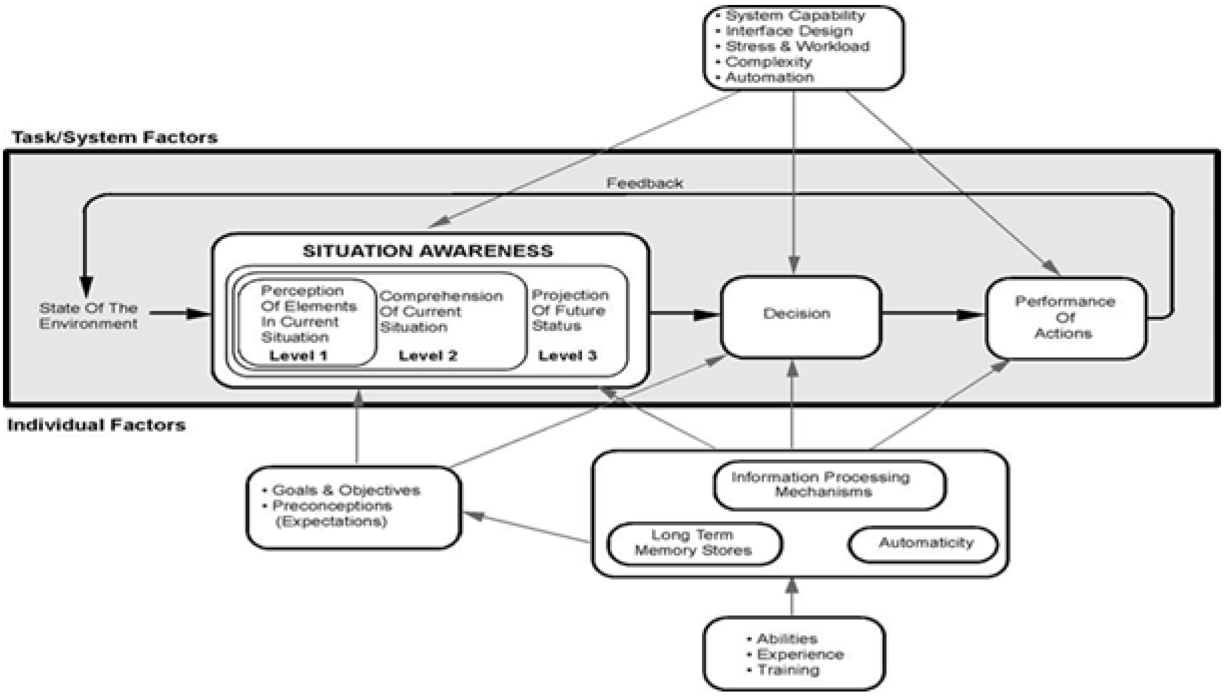


Figure 5.4: Theories of situation awareness (Source: Endsley, 1995)

Cyclists approaching an intersection may serve as an illustration of this process. Cyclists first need to perceive all relevant elements of the situation, e.g., what are the priority rules, how wide is the intersection, is a car approaching and if so at what speed? This perception is followed by comprehension of the meaning, e.g., has the approaching car right of way?, and finally the projection of the status in the near future: given the speed of the car, the width of the intersection, and the cyclist's own speed and agility, is the available time sufficient for clearing the intersection?

This task demands the integration of information from many different sources. In heavy traffic, such decisions need to be made and carried out within a time period of only a few seconds. The higher the information load and the shorter the time frame, the higher the *workload*, meaning that attention, memory and perception are easily overloaded (Grayson, 1981). Fortunately, the workload is determined only partly by the traffic condition. It is also partly under the control of the individual road user. For instance, the cyclist at the intersection may decide to select the shortest possible gap in the stream of cars, but may also wait for a longer gap. Whereas the first option may only be safe if every single one of the cyclist's assessments is correct, the second leaves room for incorrect assessments and will result in safer outcomes. For example, the car may go faster than estimated, but because of the larger gap, the cyclist has still sufficient time to cross safely.

This model of Situation Awareness shows the interrelationships, but it misses out how road users perceive their own capabilities. This relates to the question of how road users balance task demands, i.e., what the task requires a road user to do, and task capabilities, i.e., what a road user is capable of doing. In fact, driving requires not only the perception and comprehension of the environment, and the projection of future status. Driving is a task that is self-paced most of the time, for instance by the speed one drives, or the length of gaps one accepts when crossing streets. This allows the driver to align the task to his capabilities and competencies.

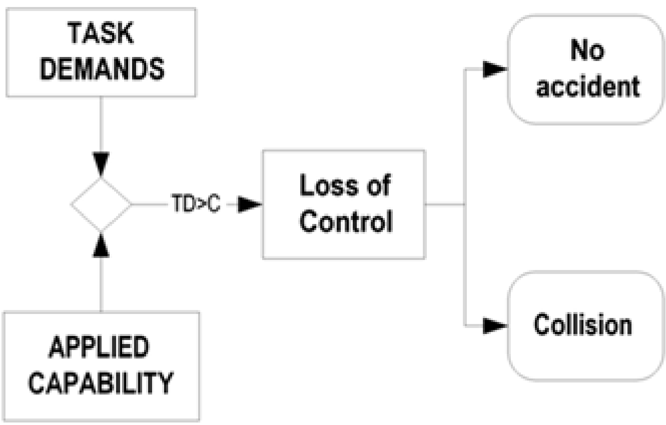


Figure 5.5: Example of a simplified calibration model If task demands (TD) are higher than applied capability (C) then safety margins are compromised, resulting in loss of control and crashes may happen.

Hence, assessment of one's own competences is another important aspect. *Task competency models* postulate that danger arises when task demands exceed task capabilities. Examples of task competency models include the model of subjective safety (Brown and Groeger, 1987), the task capability interface model (Fuller, 2005), the calibration model (De Craen, 2010; see Figure 5.5), and the zero-risk theory (Summala, 1988).

5.4.2 Skill acquisition

As suggested by the competence models, the development of interventions requires – amongst other –also a thorough understanding of the process of skill acquisition. The content of this section is largely based on Twisk (2014).

Learning safe road behaviour requires practice, whereby novices go through distinct stages of competence, progressing from knowledge-based learning (knowing what to do) to skill-based performance (knowing how to do it) (Anderson, 1982; Rasmussen, 1985). By extensive practice on the task, the task becomes automated, which means that perceptions and actions no longer require conscious processing, and require little attention (Shiffrin and Schneider, 1977). For reaching 'expert' levels of performance, deliberate practice is the most important factor for success, in all fields (Ericsson et al., 2007) as was also illustrated by examples from Malcolm Gladwell's book *Outliers: The Story of Success*. For expert levels in road traffic performance not only the amount of practice matters, but also the variety of traffic situations. For instance, complex situations, which are characterized by a combination of high information load and short decision time, require more practice than simple traffic situations. Also, driving in darkness differs from driving in day light, and driving in dense, fast moving traffic differs from driving on a quiet rural road. Such varied learning helps novice drivers to recognize situations and differentiate in which certain trained routines do apply and in which they do not (Rothengatter, 1985).

5.4.3 Risky acts: Errors and violations

In important distinction in understanding and preventing risky behaviours, is that between errors and violations, as is depicted in Reason's Generic Error Modelling System (GEMS) (Reason, 1990) (Figure 5.6).

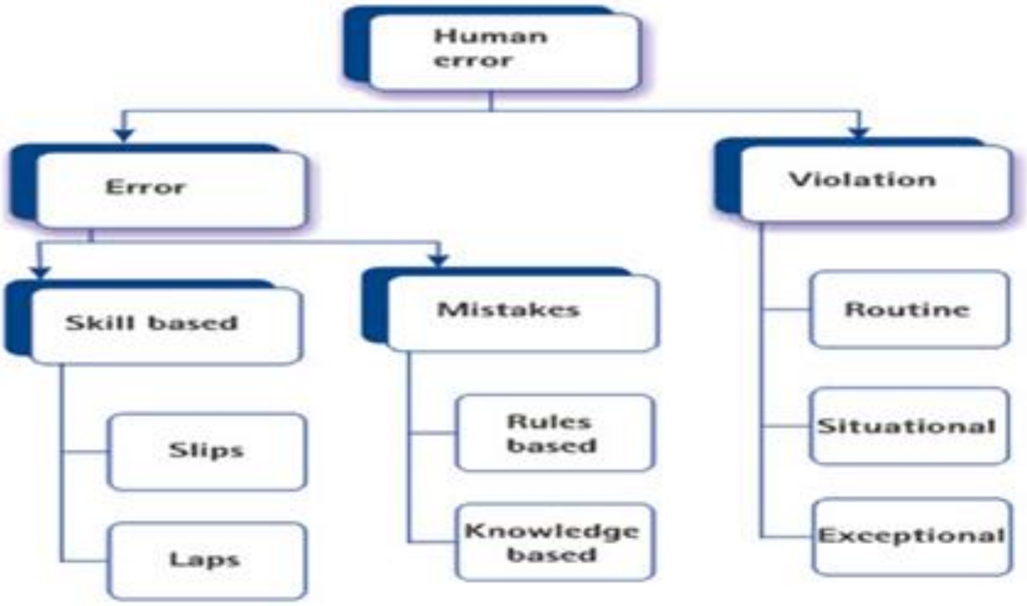


Figure 5.6: Differences between errors and violations (Wagenaar and Reason, 1990).

Central in this model is the role of intention. Consistent with the GEMS, and partly based on Rasmussen's model of control, an unsafe act is defined as an 'error' if a person unintentionally deviates from the 'safe line of action'. For example, a red traffic light is overlooked, or the meaning of a traffic sign is misunderstood. These errors are elicited by factors such as inexperience, lack of competency, fatigue, or confusing traffic conditions. The skill models, discussed in the previous section, provide the theoretical framework for interpreting these errors.

In contrast, intentional risky acts are deliberate transgressions of rules, procedures, and precautions. For instance, a cyclist sees the red traffic signal, but still decides to disobey it. Intentional risky acts originate from extra motives such as 'enjoying' risks (e.g., driving extremely fast on a motorway in the middle of the night) and impressing friends. Motivation and decision models – discussed in Section 6.4 - provide the theoretical framework for understanding these dangerous decisions, that are made intentionally.

5.4.4 Implications

The competence models have several implications, both general and more specific.

- *General:* Implications are that task demands should be low, but not too low. Procedures and interventions should not interfere with automatic 'good' routines, they should not increase mental workload in critical situations; not be distractive; and not be confusing. Type and timing of procedures and interventions should be appropriate for the level of the task, e.g., preferable at strategic level in case of coaching, and immediate in case of operational problems, such as exceeding the speed limit or fatigued driving.
- *Nudging:* The competence models show potential for nudging as they show the importance of automatic guidance, and subconsciously drawing attention to the potentially hazardous conditions. However, they also show the risks of nudging if it interferes with 'safe' automatic routines. This could happen if attention is directed towards conditions that are less relevant at that moment, for instance when an irrelevant nudge is presented during an overtaking manoeuvre.
- *Coaching:* Learning from coaching requires introspection, e.g. when coaching on the more strategical level such as decisions on travel times, or routes. Coaching could also address the balance between self-perceived competencies and task demands, assisting in an accurate perception of personal skills and the complexity of the task. Similarly, coaching could address the error – violation distinction as underlying determinants of risky acts. Coaching on specific behaviours during a trip might be less effective, because, as the competence models show, most behaviour is subconscious. Nevertheless, it might help to give feedback on specific behaviours, for instance on speed violations, but in that case feedback should take place during the ride, immediately after a relevant event. Coaching on specific behaviours after the

trip may be less adequate as most of the events will have been forgotten, as they are not actively logged in memory.

- *Profiling:* The competence models are relevant with respect to the level of skills of drivers, i.e. how competent they are and how much experience they have with the task. This could be a basis for profiling.

5.5 Motivation and decision models

In motivation and decision models on road behaviour, the understanding of deliberate risk taking is central. Basically, two subcategories can be distinguished. The first subcategory assumes that 'risk' is not just a negative characteristic, but that it has positive connotations as well. Several authors (Näätänen and Summala, 1974; Wilde, 1982) postulate that road users pursue an optimal level of 'risk' and 'arousal'. While enjoying the excitement associated with risk taking, road users also aim to keep risk levels within preferred boundaries. The second subcategory deals with extra motives of traffic participation. Road travel is not just a task, but also a means to an end, fulfilling extra motives. Examples of such extra motives may be 'impressing peers', 'conforming to group norms', and 'tension release'.

Both the theory on preferred levels of arousal and the theory on extra motives explain why safety countermeasures are frequently less effective than expected. The safety gains are partly lost because of road users adapting their behaviour by taking extra risks (OECD, 1990). This has been demonstrated for many safety measures, such as for safety belts (Janssen, 1994), airbags (Sagberg et al., 1997), and helmet use (Kemler et al., 2009). This phenomenon is often referred to as risk adaptation.

On motivation in general and on risk behaviour specifically, an abundance of behaviour models is available (Eccles and Wigfield, 2002). In their handbook on health behaviour and health education, Glanz, Rimer & Viswanath (2008) provide an overview of a large number of these models. This section limits the discussion to those models most frequently used for road behaviour.

There are two broad types of motivation and decision models. The first type presumes internal processes based on which people consciously reach a decision on a preferred action, such as stopping to drive while under the influence of alcohol. The second type also deals with internal processes, but these are not conscious, but most often (95% of the cases) automatic. Moreover, these automatic decisions are strongly influenced by so called 'cognitive biases'. It is on the latter type of findings that nudges originally were based.

5.5.1 Conscious decision models

5.5.1.1 Theory of Planned Behaviour

The Theory of Planned Behaviour (TPB; see Armitage 2001 for an overview) aims to predict behaviour and behaviour change from underlying behaviour determinants.

Central to TPB is the assumption that if people evaluate behaviour as positive (attitude), and assume that significant others want them to perform the behaviour (subjective norm), this deliberation results in a stronger motivation (intention) and a higher likelihood that they will perform the behaviour. TPB advances the earlier Theory of Reasoned Action (TRA) by introducing the concept of perceived control over opportunities, resources, and skills (Montano & Kasprzyk, 2008). Of all these relationships, behavioural intention is presumed to be the strongest predictor of actual behaviour, and has therefore frequently been used as an outcome criterion in evaluations of road safety interventions (Dragutinovic & Twisk, 2006).

Several reviews have assessed the actual strength of the intention–behaviour relationship (e.g., Armitage & Conner, 2001; Webb & Sheeran, 2006). Based on a meta-analysis of 185 studies, mainly studies of correlations between intention and behaviour, Armitage and Conner (2001) concluded that behavioural intention was a strong predictor of behaviour, accounting for 27% of the variance. However, correlation studies do not clarify the causality and the mechanisms in the relationship. Moreover, correlation studies do not provide information about the strength of a relationship after an intervention. To find an estimate of this strength, Webb and

Sheeran (2006) conducted a meta-analysis that only included studies that evaluated the effect of an intervention, and that also met the following criteria:

- random assignment of participants to treatment and control groups;
- significant difference in intention scores between the treatment and control groups; and
- follow-up of actual behaviour.

Although, the results confirmed the postulated mechanism of intentions changing behaviour, compared to the Armitage and Conner review, the strength of the relationship was considerably weaker. A medium-to-large change in intention resulted in only a small-to-medium change in behaviour. Therefore, the authors concluded that behaviour is not solely influenced by intention, but that the intention-behaviour relationship is mediated by other factors as well.

Unfortunately, the Webb and Sheeran meta-analysis did not include studies on traffic behaviour, nor did it study the strength of the relationship in different populations. However, several studies suggest that this relationship may differ between populations. For example, some studies explicitly studied the relationship among adolescent road users. A prospective study on drink-driving, for instance, showed that among a group of adolescents who had expressed a strong intention not to drink and drive, one year later about 40% reported having engaged in this risk behaviour (Gibbons et al., 2002). Further, a review of studies on health-compromising behaviour concluded that the strength of the intention-behaviour relationship was weaker in younger than in older age groups (Gerrard et al., 2008). The researchers pointed out that this weak relationship could also be a result of the low variance in the extreme risk behaviours in the adolescent group. An aspect that potentially may weaken the intention-behaviour relationship in traffic behaviour is the character of the traffic task itself. Traffic participation is a highly skilled task (Fuller, 2008), and road users with inadequate road skills may unintentionally engage in risky behaviour.

Note that there is no 'external world' in TPB. All processes are internal, and the deliberations underlying the intention to change behaviour are not dependent on the features in the external world. The internal process is only one of introspection, weighing pros and cons, and assessing one's capabilities necessary for change. In this process, information may be used to change one's beliefs and attitudes, and previous experiences may convince individuals of their capacity to change. Thus, in this model neither incentives, punishment nor nudges are relevant. However, the model is very helpful for 'coaching activities' as it encourages reflection on these variety of intrapersonal attributes.

5.5.1.2 Social Cognitive Theory

While TPB focuses on internal processes only, social cognitive theory (SCT) emphasizes the people's interaction with and influences from the social environment.

SCT (Bandura, 1989) is a 'social learning theory' based on five core concepts:

- observational learning/modelling;
- outcome expectations;
- self-efficacy;
- goal setting, and
- self-regulation.

Figure 5.7 schematically presents a more elaborate description of SCT. Observational learning/modelling is an important element that seems unique for SCT. It refers to the phenomenon that people not only learn because of explicit instructions, but also by observing what others do. The theory sees actors as active agents in changing their circumstances. As it is primarily a learning theory, it may accommodate most relevant factors in to help road users gain experience.

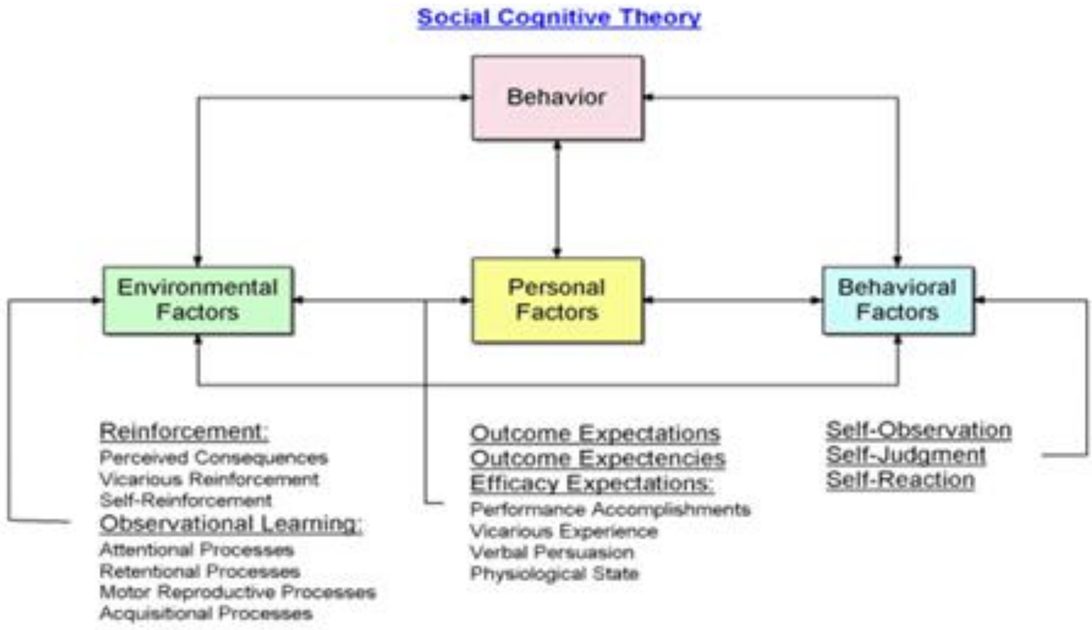


Figure 5.7:A schematic representation of Social Cognitive Theory (Source: https://www.pinterest.co.uk/pin/112660428152956341/?lp=true).

5.5.2 Automatic decision models

Most motivation and decision models assume a fairly correct assessment of the level of risk and one's vulnerability, and some form of rational decision making in terms of risks, costs and benefits. TPB and partially also SCT assume that decisions are based on rational considerations and that these are a result of conscious deliberations. However, systematic experiments (Kahneman, 2003) have shown that decisions are often automatic, with people providing a rationale for the decision afterwards, and not before. In addition, these automatic decision processes appeared to be biased (Kahneman, 2003). Partly, the automatic decisions are based on unconscious, more or less innate responses to our environment. Recent studies showed that changing the environment to encourage the most healthy and safe behaviours can be effective.

In fact, now this chapter on human behaviour models have now come to full circle. The automatic versus conscious processes that are at the core of competence models and skilled performance also apply to the motivation and decision models. To be complete, Table 5.1 lists (again) the main characteristics of unconscious (System 1) and conscious (System 2) reasoning which often work in combination or iteration (dual-processing). Moreover, some authors assume a relationship of these systems with different brain structures, that mature in a different pace.

Table 5.1: Overview of System 1 and 2 characteristics (modified from Shiffrin and Schneider, 1977).

System 1	**System 2**
Unconscious Reasoning	Conscious Reasoning
Implicit	Explicit
Automatic	Controlled
Low Effort	High Effort
Large Capacity	Small Capacity
Rapid	Slow
Default Process	Inhibitory
Associative	Rule-Based
Contextualized	Abstract
Domain Specific	Domain General
Evolutionarily Old	Evolutionarily Recent
Nonverbal	Linked to language
Includes recognition, perception, orientation	Includes rule following, comparisons, weighing of options
Modular Cognition	Fluid Intelligence
Independent of working memory	Limited by working memory capacity
Non-Logical	Logical
Parallel	Serial

System 1 - the intuitive/socio-emotional system - corresponds to the brain's limbic system, while System 2 - the reasoning and cognitive control system - corresponds to the prefrontal cortex (Gerrard et al., 2008; Gibbons et al., 2009; Kahneman, 2003). In adolescence (between 10 and 24 years of age) these two systems change changes at different pace.

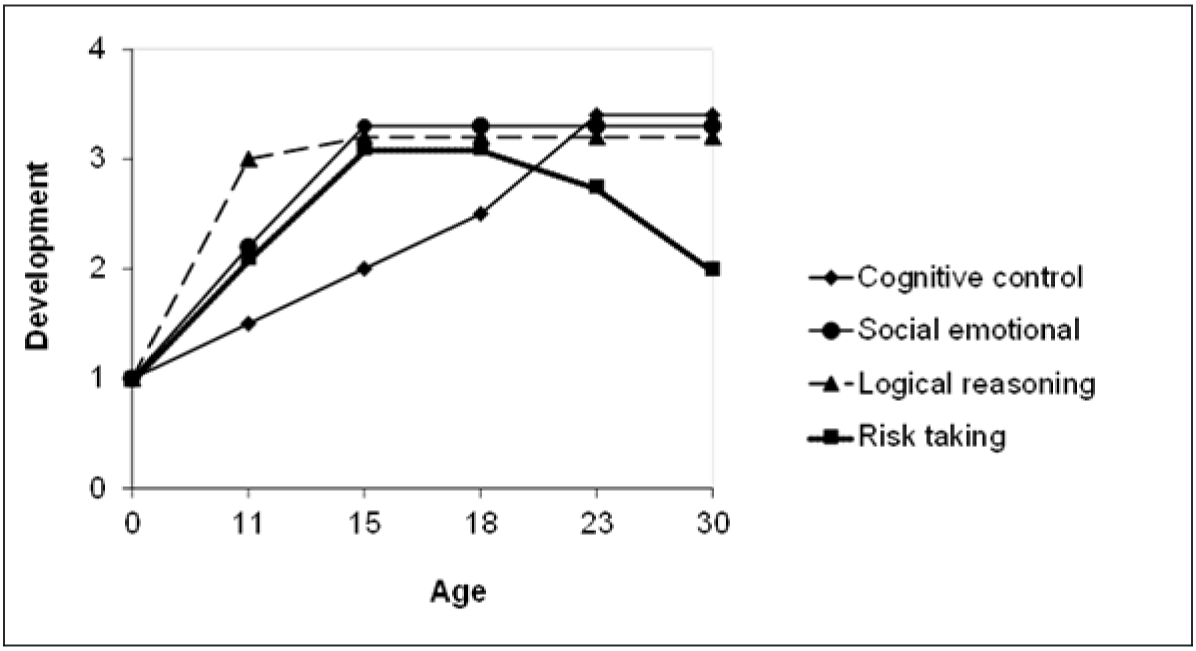


Figure 5.8:Schematic representation of the relevant developments from childhood to adulthood (Brijs et al., 2009).

As illustrated in Figure 5.8, in adolescence the socio-emotional functions (System 1) as part of the limbic system are characterized by an early and sharp activation already in early adolescence, whereas the control functions (System 2) located in the pre-frontal cortex develop much slower. In Steinberg's words (Steinberg, 2008), this difference in pace, results in a 'window of risky opportunities' with the limbic system generating high emotions and high energy, without the control system being able yet to channel and direct that energy 'wisely'. Young people become very energetic, but have as yet little control. 'It is like turning on the engine of a car without a skilled driver at the wheel' (Steinberg quoted by Wallis, 2008). Even though the ability to think 'logically' has reached (almost) mature levels in adolescence, this is not sufficient to deter adolescents from engaging in harmful activities in emotionally arousing (hot) conditions (Séguin et al., 2007). This state wears off with the maturation of the brain, but lasts up to a person's early twenties.

Another relevant distinction in motivation and decision models is between what is known as hot and cold decisions. Hot decisions imply high emotional arousal, such as anger, haste, or peer pressure. Studies show that hot driving decisions are more risky. So far most of the examples on traffic behaviour and hot decisions were generated under laboratory conditions but have also been generalized to understand the high crash rates in adolescence (e.g., Keating, 2007; Keating & Halpern-Felsher, 2008). Furthermore, the role of peers has been studied by observing the influence of passengers. Higher risk taking was found among young drivers when a peer-aged passenger was present (Gardner & Steinberg, 2005), and when the passenger was perceived as sexually attractive (opposite sex pairs) (White & Caird, 2009), as 'cool' (same sex pairs) or as risk-accepting (Simons-Morton et al., 2014).

5.5.3 Exploiting cognitive biases

Human decisions are far less 'deliberate' than most people think and also far less rational and accurate. Decisions are often systematically biased, and thus inaccuracies are not random. It is these cognitive biases in our thinking and in our actions that are exploited in nudging, and that may be addressed in coaching strategies.

Biases exist in the perception of risk and harm, as well as in the perception of the severity of the consequences. The work of Morgan (1993) illustrated that there are two dimensions that influence the feeling of risk in a particular situation:

- controllability, i.e. the extent to which people feel that they can control the risk or not; and
- observability, i.e. the extent to which people can observe the risk.

Road behaviour risks are in the bottom-left quadrant in the figure. People believe that these risks are largely controllable, and that one can observe a risk evolving and start corrective actions in time.

Fig. 3. Public perception of risks in terms of risk space quadrants (Morgan, 1993)

Figure 5.9: Perception of risks in terms of controllability and observability. Source: Morgan (1993).

Studies on self-perceived skills also showed road users, in this case car drivers, to suffer from an optimism bias (see de Craen, 2010), i.e. they think that they belong to the top category of competent car drivers. An explanation could be that road users have often experienced that violating rules, such as drink-driving, red light running and speeding have not led to a crash.

This type of biases in the perception of risk and severity of consequences are extremely important in understanding risk behaviour. The biases mean that most people systematically underestimate the risk of car crashes, as well underestimate the risk of 'killers' such as speeding or alcohol use.

Aside of the perception of risk, there are many other cognitive biases in how people perceive the world. A selection of additional biases is shown in Table 5.2. All these biases can be used when developing nudging approaches, and these are far more biases than identified in the already classic book *Nudge: Improving Decisions about Health, Wealth, and Happiness* by Thaler and Sunstein (2008). In fact, interventions need to take these biases into account or exploit them for the common good, as also suggested by Thaler and Sunstein's libertarian paternalism concept.

Table 5.2: An overview of cognitive biases (Wikipedia, accessed 19-07-2017; https://en.wikipedia.org/wiki/List_of_cognitive_biases#cite_note-iverson2008-12)

Name	Description
Anchoring or focalism	The tendency to rely too heavily, or "anchor", on one trait or piece of information when making decisions (usually the first piece of information acquired on that subject)
Anthropomorphism or personification	The tendency to characterize animals, objects, and abstract concepts as possessing human-like traits, emotions, and intentions.
Automation bias	The tendency to depend excessively on automated systems which can lead to erroneous automated information overriding correct decisions.
Availability heuristic	The tendency to overestimate the likelihood of events with greater "availability" in memory, which can be influenced by how recent the memories are or how unusual or emotionally charged they may be.
Availability cascade	A self-reinforcing process in which a collective belief gains more and more plausibility through its increasing repetition in public discourse (or "repeat something long enough and it will become true").
Backfire effect	The reaction to disconfirming evidence by strengthening one's previous beliefs.
Bandwagon effect	The tendency to do (or believe) things because many other people do (or believe) the same.
Base rate fallacy or Base rate neglect	The tendency to ignore base rate information (generic, general information) and focus on specific information (information only pertaining to a certain case).

Choice-supportive bias	The tendency to remember one's choices as better than they actually were.
Confirmation bias	The tendency to search for, interpret, focus on and remember information in a way that confirms one's preconceptions.
Conjunction fallacy	The tendency to assume that specific conditions are more probable than general ones.
Conservatism (belief revision)	The tendency to revise one's belief insufficiently when presented with new evidence.
Continued influence effect	The tendency to believe previously learned misinformation even after it has been corrected. Misinformation can still influence inferences one generates after a correction has occurred.
Denomination effect	The tendency to spend more money when it is denominated in small amounts (e.g., coins) rather than large amounts (e.g., bills).
Dunning–Kruger effect	The tendency for unskilled individuals to overestimate their own ability and the tendency for experts to underestimate their own ability.
Focusing effect	The tendency to place too much importance on one aspect of an event.
Forer effect or Barnum effect	The observation that individuals will give high accuracy ratings to descriptions of their personality that supposedly are tailored specifically for them, but are in fact vague and general enough to apply to a wide range of people. This effect can provide a partial explanation for the widespread acceptance of some beliefs and practices, such as astrology, fortune telling, graphology, and some types of personality tests.
Framing effect	Drawing different conclusions from the same information, depending on how that information is presented
Frequency illusion	The illusion in which a word, a name, or other thing that has recently come to one's attention suddenly seems to appear with improbable frequency shortly afterwards (not to be confused with the recency illusion or selection bias). This illusion may explain some examples of the Baader-Meinhof Phenomenon, when

	someone repeatedly notices a newly learned word or phrase shortly after learning it.
Gambler's fallacy	The tendency to think that future probabilities are altered by past events, when in reality they are unchanged. The fallacy arises from an erroneous conceptualization of the law of large numbers. For example, "I've flipped heads with this coin five times consecutively, so the chance of tails coming out on the sixth flip is much greater than heads."
Hard–easy effect	Based on a specific level of task difficulty, the confidence in judgments is too conservative and not extreme enough.
Identifiable victim effect	The tendency to respond more strongly to a single identified person at risk than to a large group of people at risk.
Illusion of control	The tendency to overestimate one's degree of influence over other external events.
Illusion of validity	Belief that further acquired information generates additional relevant data for predictions, even when it evidently does not.
Illusory correlation	Inaccurately perceiving a relationship between two unrelated events.
Illusory truth effect	A tendency to believe that a statement is true if it is easier to process, or if it has been stated multiple times, regardless of its actual veracity. These are specific cases of truthiness.
Loss aversion	The disutility of giving up an object is greater than the utility associated with acquiring it.
Money illusion	The tendency to concentrate on the nominal value (face value) of money rather than its value in terms of purchasing power.
Negativity bias or Negativity effect	Psychological phenomenon by which humans have a greater recall of unpleasant memories compared with positive memories.
Neglect of probability	The tendency to completely disregard probability when making a decision under uncertainty.
Normalcy bias	The refusal to plan for, or react to, a disaster which has never happened before.

Omission bias	The tendency to judge harmful actions as worse, or less moral, than equally harmful omissions (inactions).
Optimism bias	The tendency to be over-optimistic, overestimating favourable and pleasing outcomes.
Ostrich effect	Ignoring an obvious (negative) situation.
Outcome bias	The tendency to judge a decision by its eventual outcome instead of based on the quality of the decision at the time it was made.
Overconfidence effect	Excessive confidence in one's own answers to questions. For example, for certain types of questions, answers that people rate as "99% certain" turn out to be wrong 40% of the time.
Post-purchase rationalization	The tendency to persuade oneself through rational argument that a purchase was good value.
Projection bias	The tendency to overestimate how much our future selves share one's current preferences, thoughts and values, thus leading to sub-optimal choices.
Recency illusion	The illusion that a word or language usage is a recent innovation when it is in fact long-established.
Regressive bias	A certain state of mind wherein high values and high likelihoods are overestimated while low values and low likelihoods are underestimated.
Restraint bias	The tendency to overestimate one's ability to show restraint in the face of temptation.
Risk compensation / Peltzman effect	The tendency to take greater risks when perceived safety increases.
Selective perception	The tendency for expectations to affect perception.
Semmelweis reflex	The tendency to reject new evidence that contradicts a paradigm.
Status quo bias	The tendency to like things to stay relatively the same.
Stereotyping	Expecting a member of a group to have certain characteristics without having actual information about that individual.
Time-saving bias	Underestimations of the time that could be saved (or lost) when increasing (or decreasing) from a relatively low speed and

	overestimations of the time that could be saved (or lost) when increasing (or decreasing) from a relatively high speed.
Third-person effect	Belief that mass communicated media messages have a greater effect on others than on themselves.
Weber–Fechner law	Difficulty in comparing small differences in large quantities.
Well travelled road effect	Underestimation of the duration taken to traverse often travelled routes and overestimation of the duration taken to traverse less familiar routes.
Zero-risk bias	Preference for reducing a small risk to zero over a greater reduction in a larger risk.
Zero-sum bias	A bias whereby a situation is incorrectly perceived to be like a zero-sum game (i.e., one person gains at the expense of another).

5.5.4 Implications

- *Nudging and coaching*: Motivation and decision models distinguish between unconscious processes (System 1) and conscious processes (System 2). Nudging and coaching address these two processes in different ways. *Nudging* focuses on the unconscious processes in System 1. Exploiting cognitive biases are at the basis of this. In contrast, *coaching* requires reflection on behaviours, uses language to address those, is logical, and requires the weighing of options, thus addressing the conscious processes in System 2. This way, coaching and nudging are complementary in dealing with motivations and decisions. Nevertheless, there are many psychological processes that can be addressed both by nudging and by coaching, even though the approach would be different. For instance, the systematic overestimation of time savings when driving at higher speeds can be addressed by coaching through raising awareness of the fallacy, and by nudging through providing continuous feedback on the estimated arrival times. The motivation and decision models highlight the effect of emotions. The implication is that the role of emotions in traffic should not be ignored, neither in *nudging*, nor in *coaching*.

- *Profiling*: The motivation and decision models show the importance of age in addressing risky behaviours. While most car drivers will be older than 18 years of age, cyclists – the other target group of MeBeSafe - also include children and adolescents. Up to a persons' early twenties, socio-emotional processes dominate cognitive control processes and logical reasoning.

6 User Profiling

6.1 Rationale

The basic idea behind profiling is that road users differ in their behaviour in traffic and subsequently in accident records. Theoretically, they might also differ in the extent to which they are susceptible for specific features of an intervention. The term 'user profiling' signifies an intention to identify individual as well as environmental factors contributing to crash risk, identify (groups of) road users that are at risk and find the cause(s) for this.

This chapter discusses how knowledge about user characteristics should be used in MeBeSafe. The following sections provide initially an overview of general user characteristics that play a role in the context of traffic behaviour and combine this with input from the GIDAS database (see Annex B) on accident involvement. These were selected according to their relevance in distinguishing between different risk groups, such as elderly people or cultural aspects. Specific user characteristics and factors playing a role for the interventions, i.e. nudging and/or coaching, are then addressed.

However, the chapter does not aim to provide distinct implications or user profiles for each problem to be addressed (this will be part of the actions in the respective work packages to follow in the MeBeSafe project). Instead, the chapter provides implications that need to be considered when looking at certain user groups. This is especially relevant as MeBeSafe aims to improve the traffic behaviour of all drivers, i.e. not only of the "rotten apples" who form a small part of the overall population, but also of those who pose an unintentional risk at times (see Chapter 5 on theories and models).

6.2 General user characteristics

Demographic aspects play a crucial role in assessing traffic behaviour. Shinar et al. (2001) investigated the relationship between safe driving behaviour and gender, age, education, and income. They found that three behaviours (belt use, observing speed limits, and abstaining from drinking and driving) were quite independent from each other and that there was no single high-risk group that was more likely to violate all three safe-driving behaviours. The number of people who reported that they observed the speed limit at all times increased with age, but decreased with increasing education and income. This shows that demographic aspects are strongly interrelated and sometimes co-vary.

The following sections provide more detailed information on the most relevant demographic topics that distinguish different road user groups; age, gender, education and income, expertise and finally culture. The section points out the relevant topics that need to be considered when creating targeted user profiles for the specific interventions. The purpose is to provide a guideline on how to create these user profiles but not to create them before interventions are specified in more detail. This will be an important task in WP2, WP3, WP4 and WP5.

However, it should also be pointed out that even though the interviews also emphasised large inter-individual differences in behaviours related to driving, these do not always map general demographic attributes such as age, gender, etc.

6.2.1 Age

6.2.1.1 Motor vehicle driving

Age is a well-researched field that shows how much different age groups differ in driving, driving-related actions and overall traffic behaviour. The age of road users is one of the most differentiating factors in many aspects when analysing accident data (as evidenced by the European project SENIORS).

In general, the younger drivers are, the more risky they behave in traffic (Goede et al., 2013). Perepjolkina and Renge (2011) as well as Shope and Bingham (2008) have found that being young is associated with higher scores on *aggressive driving*. Another group is older drivers. A survey on mobility in Germany in 2008 (SENIORS project deliverable D1.1; infas & DLR, 2010) revealed that the highest rate of injured or killed car drivers was found among the 18- to 20-year olds. With increasing age the number dropped and remained fairly low for persons between 35 and 69 years of age. Only from an age of 70 years, the rate of injured or killed car drivers started to climb again and reached for seniors aged 75 years and older a level comparable to that of persons in their early 30s.

Overall, the categories may remain the same in the future but a study by Liers et al. (2017) on the development of drivers' age found that in the past 15 years, the average driving age has increased by 6 years and that the average age will continue to increase in the future. One reason another reason is that the possession of a driving licence or an own vehicle is not longer a status symbol for young people, another reason is demographic change in Europe (and elsewhere), While at the moment one road traffic fatality out of five is aged 65 or older in Europe, it is expected that by 2050 one road traffic fatality out of three will be an older person which is an increase of 13%.

A slightly different age pattern was found in a study by Hannawald and Ziegler (2016) who investigated the causes of *fatigue* accidents. Even though younger drivers under 35 years caused one-third of all fatigue accidents, the majority of drivers who fell asleep at the steering wheel and caused an accident were between 36 and 55 years old. Many accidents are caused by truck drivers and commuters, especially on the motorway during long trips with constant speed.

Age brings changes to *skills* that are central to the driving task (cf. Chapter 5). There are clear and well evidenced changes to motor, visual and cognitive functions which compromise drivers' abilities to negotiate complex road scenarios, such as junctions. Although these functions have different effects on driving, they share common processes and it is likely the combination of deficiencies that results in the increased crash risk with increasing age (SENIORS project deliverable D1.1). In a study by Schlag (1993), elderly drivers in Germany proved worse in visual acuity (even when corrected) by daylight and in the dark compared to younger drivers, had a worse performance in a traffic-related tachistoscopic perception tests, needed more time in tracking and had longer reaction times compared to younger drivers. An important aspect is that elderly drivers tend to neglect changes in their own fitness or are unaware of relating these to their driving behaviour. However, even though the performance of elderly drivers in the laboratory tasks proved worse than the one of middle-aged drivers, real-world driving tests did not show a difference in performance. The authors argue that the capacities measured in the laboratory might be less relevant to normal driving demands and, in most cases, compensated by adequate ability to adapt. On the other hand, elderly drivers tend to avoid difficult or stressful traffic situations, which is also in line with the findings by Doroudgar et al. (2017) and the SENIORS project (SENIORS project deliverable D1.1).

Elderly drivers are less prone to show *risky behaviour*, they drive less often and drive shorter distances than their younger counterparts, avoid driving under bad weather conditions and driving at nighttime. In sum, the pattern of safer driving with increasing age is in line with increased use of seat belts and an increasing constant observance of speed limits increasing (Shinar et al., 2001).Findings from the SENIORS project showed that seniors had rarely or never driven faster than the speed limit allowed inside built-up areas and they use seat belts more often than any other age group (SENIORS project deliverable D1.1).

To assess driving performance of elderly people properly, *driving exposure* needs to be considered. In a study by Perepjolkina and Renge (2011) on aggressive driving behaviour, younger participants had a higher annual mileage then older drivers. This is in line with Schrammel et al. (1998), who observed annual mileage to decrease with increasing age. If both driving exposure and accident involvement of elderly drivers are considered, the accident rate of this group is higher than the one of middle-aged drivers, the most favourable age group regarding driving performance (Schlag, 1993). Here, the so-called 'low mileage bias' plays a role. Janke (1991) recognized that when crash rates are computed, annual mileage is rarely taken into account. Hence, drivers with a higher annual mileage usually show fewer crashes per mile compared to people driving less. Furthermore, driving fewer miles is associated with driving on roads with a higher crash risk, whereas drivers with a higher annual mileage usually spend a lot of time on freeways, which have a lower overall crash risk.

These aspects regarding age should be noted when creating user profiles throughout the MeBeSafe project[5].

6.2.1.2 Cyclists

Road users include not only car drivers but also cyclists (and other vulnerable road users, VRUs). Cyclists make up 8% of all fatalities on European roads. The number of cyclist fatalities has decreased by 3% compared to the total fatality decrease of 18% from 2010 to 2013.

Overall, teen drivers, young cyclists and elderly people in general form high-risk groups. Data in the GIDAS database confirms that most bicycle accidents happen in urban areas and that the share of younger cyclists is higher than older cyclists. Consequently, the average cyclist age in GIDAS is around 35 years. However, older people have a low average annual mileage and they are more vulnerable to injuries. The risk of older cyclists being seriously injured in accidents is two times higher than for younger cyclists. In a study on older cyclists' crash-involvement, the authors analysed three age groups of cyclists (50 to 64 years, 65 to 74 years, and one group of 75 years and older). Overall, they found that the latter group of cyclists seemed to be involved in crashes more often than the former groups (BoeleVos et al., 2017). The SENIORS project reveals that the highest number of injured or killed cyclists was found among the 18- to 29-year-olds. With increasing age the number dropped and remained relatively low for persons between 30 and 69 years of age but from an age of 70 years, the rate of injured or killed cyclists started to climb again and reached for seniors aged 75 years and older the highest rate among all age groups.

Another studies have investigated cyclists' risk of being involved in a crash taking into account exposure. Martínez-Ruiz et al. (2014) found that this risk was highest for

[5] If more input is needed, the GOAL project (http://www.goal-project.eu/index.html) as well as the SENIORS project (http://www.seniors-project.eu/) provide more detailed input.

cyclists younger than 30 and older than 65 years of age and that death rates increased with age. Kinosada and Usui (2012) state that, according to the National Statistics Center of Japan, bicycle-related accidents often happen at intersections without traffic lights and, further, that the age groups with the highest number of people injured or killed in 2010 were adults aged under 24 years and adults aged over 65 years.

The main violation of traffic rules that bicyclists make is cycling on sidewalk and, even though this could be seen as a way to self-regulate their driving by avoiding certain situations, all age groups tend to overestimate their driving skills and are therefore more likely to be involved in risky situations and, in the end, crashes. While the driving behaviour of younger drivers seems to have a social component, the issue with elderly drivers might be on information processing, which is in line with the pattern among motor vehicle drivers. Older cyclists do not observe warnings due to talking on the phone, riding in the dark without lights, and alcohol (in accordance with self-reported data on behaviour). Similar to car drivers, the lack of attention and traffic signal violation is a more frequent cause of accidents for senior bicyclists than for younger ones (SENIORS project deliverable D1.1).

6.2.2 Gender

Similar to age, differences between genders exist. These do sometimes, but not always, co-vary with age.

Overall, male drivers, or rather people with a higher score on a masculinity scale, tend to be a higher risk group than women. In the same way as being young is related to being involved in more accidents, being male is related to accident involvement (Perepjolkina & Renge, 2011). The same relationship between age and gender emerge when looking at teenage drivers. Male teens have the highest fatal crash rates, followed by female teens. Correspondingly, male teenage drivers are more likely to engage in risky driving and to report drinking and driving (Shope & Bingham, 2008). Furthermore, young female drivers tended to underestimate the risk at crossings, but younger female drivers assessed the risk of darkness and traffic junctions higher than male or older drivers in a study by Schrammel et al. (1998). Here, the gender difference appears to be crucial, as teen drivers are, on the one hand, referred to as driving more risky and aggressively, but, on the other hand, female teens to drive more carefully than their male peers. Also Begg and Langley (2001) have observed risky driving to be predominantly a male activity.

In the previously referred to study by Shinar et al. (2001), women reported higher observance rates of all three behaviours investigated (i.e. belt use, observing speed limits, abstaining from drinking and driving). Classen et al. (2012) found no differences in the type or number of driving errors between genders, but at the same time women were 22% more likely to pass an on-road test. Further, older women had more avoidance behaviours compared to older men. The SENIORS project (SENIORS project deliverable D1.1) has shown that rates for motor vehicle-related crashes are twice as high for older men compared to older women, but the proportion of fatalities is higher for older women.

From driver interviews (reported in GIDAS) and European statistics (Eurostat) can be concluded that most average annual kilometres are driven by men. One of the main reasons is that, in Europe, more males than females hold a driving licence. Consequently, the risk that a male driver is involved in a road traffic accident is higher than for women.

The accident occurrence in GIDAS reveals that men and women caused a high proportion of driving accidents in longitudinal traffic and accidents caused when turning into a or when crossing a road, but also that the latter accident scenario occurred more frequently for women. The majority of accidents caused by men and women happened because of speeding, disregarding the right of way and turning off. However, the proportion of turning off accidents and priority accidents were higher for women. Furthermore, male drivers caused more accidents under the influence of alcohol, where their share was nearly three times higher than for women.

6.2.3 Education and Income

The use of safety belts has been found to increase with *education* for both men and women and with *income* for women (Shinar et al., 2001). Paschall (2003) found that full- time college students were more likely to report always wearing a seatbelt as a driver or passenger. Correspondingly, more driving problems, including drinking and driving, are found among those with less education (Shope & Bingham, 2008). In another study, people with less education showed more traffic offenses (Banse et al., 2014).

The number of people who observes the speed limit at all times decreases with higher education and increasing *income* (Shinar et al., 2001). A special group here might be the cohort of college students. In a study on college attendance and risk-related driving behaviour, Paschall (2003) found that the prevalence of drinking and driving behaviour was highest for full-time college students than for other categories.

In a study by Banse et al. (2014), education showed no correlations with self-reported driving behaviour. In some cases, people with a higher level of education and/or income seem to show a safer traffic behaviour. In other cases, like the aforementioned observance of speed limits, the pattern is contradictory. Hence, a consistent pattern does not seem to exist.

6.2.4 Expertise

Expertise is another relevant topic that differentiate drivers of motor vehicles as well as vulnerable road users (VRUs). Therefore, these aspects need to be kept in mind when creating user profiles for the interventions.

The level of expertise corresponds strongly with age. Novice drivers of any age have, in general, more crashes and must develop skills in car-handling and essential manoeuvres through practice. Novice teen drivers are less able to recognize and detect risks than more experienced drivers (Shope & Bingham, 2008) and novice drivers have a higher risk to be involved in accidents than drivers having seven to eight years of driving experience for the first two years of driving (Schrammel et al., 1998;

Schlag, 2006). In a study on cognitive workload, the authors compared experienced and inexperienced drivers using a secondary task in a field trial (Patten et al., 2006). According to the results, less experienced drivers had around 250ms longer reaction times to a peripheral stimulus than the other group. This implies that drivers can automate the driving task more effectively with more training and experience, which is in line with elderly drivers being able to compensate for deficiencies.

Lloret-Catalá et al. (2012) mention that professional drivers are less receptive to safety messages but that a critical self-reflection happens when the information aims at increasing the desire to prevent accidents. Another publication revised the relationship between the tendency of young commercial drivers to take risks in daily life and their accident involvement (Moriizumi et al., 2012). Based on the hypothesis that young drivers, who have been involved in an accident, are likely to experience an accident again, the researchers asked Japanese bus drivers about their tendency to take risks. The authors concluded that the more risks the drivers took in daily life, the more likely they would be to be involved in accidents. Nevertheless, they found that drivers who had caused an accident were less likely to cause another accident.

In order to be able to assess actual driving experience, it is also important to know for how long people have had their driving licence. In the GIDAS dataset, more than half of the car drivers have had their driving licence for longer than 10 years. The average number of HGV drivers have had their driving licence for longer, as the average HGV drivers is older than the average car driver. However, taking into consideration years holding a driving licence, average mileage and the number of accidents, it cannot be concluded that HGV drivers are the more experienced drivers. As mentioned earlier, the majority of truck drivers spend a lot of time on motorways with lower crash risk, whereas passenger car drivers drive many kilometres on urban or rural roads with higher crash risk.

Xu et al. (2014) investigated the effects of situational factors and impulsiveness on drivers' intentions to violate traffic rules. Their results indicated that, with increased driving experience, drivers became more sensitive to cues, less influenced by individual factors and, correspondingly, more likely to behave in a manner that was congruent with the surrounding situation. Therefore, effects of situational factors and impulsiveness on drivers' intentions to violate traffic rules depended on driving experience. On the other hand, Perepjolkina and Renge (2011) observed that having higher annual driving exposure was associated with higher scores on aggressive driving.

Taking expertise into account, annual mileage also plays a role. Drivers with a higher annual mileage (private as well as professional) tend to have fewer crashes. Again, the 'low mileage bias' (mentioned earlier) should be considered. Drivers with a higher annual mileage usually show fewer crashes per mile than people driving less. However, not only the sheer driving exposure, which could easily be taken as expertise, plays a role. Driving fewer miles is associated with driving on roads with a higher crash risk, whereas drivers with a higher annual mileage usually spend a lot of time on freeways, which have a lower overall crash risk. Langford and Koppel (2005) replicated these findings. Once more, the study by Langford et al. (2013) mentioned in the context of age needs consideration. The authors conducted a study with elderly drivers over 70 and found that low mileage drivers usually tend to have a reduced fitness to drive. So not only expertise in terms of mileage, but also fitness to drive seems to play a role.

6.2.5 (National) Culture

The influence of cultural aspects is a highly controversial topic. In this section, a few studies that show profound statistical data of the influence of culture on traffic behaviour and mobility are outlined with a focus on Europe (which is also the focus of the MeBeSafe project).

6.2.5.1 Road user behaviour

Özkan et al. (2006) examined cross-cultural differences in driving skills between drivers in Finland, Greece, Great Britain, The Netherlands, Turkey, and Iran. Age was negatively related to the number of traffic accidents in Finland and Britain but positively related to the number of traffic accidents in Greece and Iran. Being male was related to a higher number of traffic accidents in Greece and Iran, whereas a high number of self-reported penalties was related to accidents in every country except Great Britain. Being female was related to a low level of self-reported perceptual-motor skills in every country and only in Iran negatively related to the number of penalties. Annual mileage was positively associated with either the number of traffic accidents or penalties in every country except Turkey. Self-reported accident involvement was positively related to perceptual-motor skills only in Iran, but negatively related to safety skills in Finland and the Netherlands. The statistically significant interaction between perceptual-motor skills and safety skills on the number of penalties was found only in Finland and Turkey.

Another study examined cross-cultural differences in driver behaviour at work (Dorn & Gandolfi, 2012). They questioned more than 4.000 non-UK participants, who were grouped into five regions according to their geographical origin (Africa, the Middle East, the Far East, South East Asia, and Europe) and over 34,000 UK participants according to the so-called "Fleet Driver Risk Index". They found that the tendency to a risky driving style seems, to some degree, to be moderated by the geographic region of origin. Participants from the UK showed the lowest levels of work related risk, whereas people from Africa, South East Asia and the Middle East reported a greater tendency to take risks when under pressure at work. Nevertheless, excitement seeking was found to be highest among UK drivers compared with other geographic regions. Participants from the Far East reported significantly higher levels of driving fatigue and showed a generally maladaptive coping profile when dealing with driver stress, usually caused by self-blame. Furthermore, the authors concluded that Far Eastern fleet drivers may become more vigilant to hazards under stress and may try to learn from their mistakes as a result from increased levels of driving focus and self evaluation. Participants from the Far East reported significantly higher levels in Driving Concerns, Driving Focus and Self-Evaluation. On the confrontationscale, the Far East had the second lowest score after Europe. Concluding, Dorn and Gandolfi stated the UK, Europe and the Middle East were less likely to overestimate their abilities and underestimate their risk compared with the other three geographic regions, based on scores on the confidence factor.

There are no consistent pattern or differences that could ascribe people's driving behaviour to nationality or cultural background. Hence, this is likely to be a component that can be discarded in the user profiling process.

6.2.5.2 Mobility patterns

Another factor that may influence who is (and will be) involved as well as the type of accidents is mobility patterns.

Data analysis (in Germany, Spain and Italy) and literature research show that the mobility of elderly is increasing (Fornells et al., 2017). Although mobility data are referred to different sampling years (Spain 2006, Germany 2008 and Italy 2014), a comparison between older people's habits in the three countries was conducted. It was found that men in all three countries do more trips a day and cover longer daily distances than women. In addition, German people in 2008 moved more frequently, for longer time and distances compared to Italian people in 2014 and Spanish people in 2006.

It appears as though older persons' preferred means of transportation is walking. Walking is the transport mode preferred by the Italian and the Spanish elderly, even though motorized individual transport in Germany is a lot higher than for other modes of transport. Motorized individual transport is popular among German, Spanish and Italian older road users, actually the rate of elderly driver's license owners has risen over the years. In Germany the car is typically used for longer distances and time compared to Italy. Considering bicycling in Germany, the proportion of e-bikes/pedelecs compared to other kind of bikes is rather small in group of seniors, but the proportion of e-bikes/pedelecs among seniors compared to overall population is higher. In Italy the usage of bicycle reduced from 2013 to 2014. Cycling is preferred by Italian seniors especially during free time and for short trip (around 4 km).

6.3 Factors to be considered for nudging and coaching

The MeBeSafe project will address different traffic problems by nudging and coaching interventions. This section attempts to describe user profiles that may have an impact on the design of the respective type of interventions as well as the design and interpretation of the outcome of the trials.

6.3.1 User profiling and nudging

Reisch and Sunstein (2016) investigated the influence of *nationality* on nudge in the context of politics. The results showed a lower support for nudges in Hungary and Denmark but a general European consensus: When Europeans believe that a nudge has legitimate purposes and is consistent with the interests or values of most people, majorities are likely to support it.

In another multi-country study, Sunstein et al. (2017) investigated differences in *public attitudes* toward nudging. They compared countries in the context of politics. They reported that a strong majority in all countries supports nudges, with the important exception of Japan, and with spectacularly high approval rates in China and South Korea. They marked three distinct categories. First, a group of nations, mostly liberal democracies, where strong majorities approve of nudges whenever they (a) are considered to fit with the interests and values of most citizens and (b) do not have illicit purposes. These countries were Canada, Australia, Germany, Italy, France, the UK, the US. Second, a group of nations where overwhelming majorities approve of nearly all nudges, namely South Korea and China, and third group of nations with markedly lower approval ratings for nudges, namely three confucian Asian countries.

Furthermore, the influence of *age* is strong but operates differently for different nudges. That means that older people tend to favour less intrusive interventions. *Education* has, however, a weaker influence: The longer education, the higher the approval level for governmentally mandated information nudges and the lower the approval level for subliminal advertising (Sunstein et al., 2017).

Focusing on road users, *driving style* has also been identified to influence the degree to which drivers approve of and appreciate nudging measures. Musselwhite (2004) found that even though people in general are positive towards receiving feedback on driving patterns, drivers with more aggressive and risky driving manners are especially positive compared to other drives when such nudge measures are combined with financial incentives that reward safe behaviours.

6.3.2 User profiling and coaching

Roelofs et al. (2014) found in a study evaluating a coaching program for young drivers that drivers with different driving styles had been attracted to join the program. Apart from a large group of drivers who were considered to represent the average driver, other groups with specific driving characteristics were also identified. Some drivers showed low accident rates, stayed calm during driving and obeyed the speed limits. Others had more unfavourable driving characteristics and were more frequently involved in accidents and got more fines. Some of these drivers were very much aware of their own behaviour while others reported a too positive self-image. In addition to highlighting that coaching programs can attract a mix of drivers, the study also showed that the drivers' motivation to participate was correlated with their driving styles and also set the conditions for the subsequent learning (Roelofs et al., 2014). Unclear motives or extrinsic pressure were related to more unfavourable driving styles while intrinsic motivation or internalized motives were related to more favourable driving styles and positive learning conditions. The importance of intrinsic motivation has also been identified in the executive coaching research literature (for an overview, see Passmore & Fillery-Travis, 2011), the motivation to learn and the readiness for change were prime factors influencing learning outcomes from coaching.

Literature is, however, scarce on how coaching measures can be used to specifically encourage traffic safety why very limited information can be found on how user characteristics, such as age, gender, education, income, or level of expertise influence the effectiveness of coaching. Passmore and Fillery-Travis (2011) argue that coaching can be a very useful tool for increasing the efficiency of driver training and for reducing novice driver accidents among younger drivers (17-25 years old). In addition to age, others have discussed aspects such as gender (Singh & Vinnicombe, 2005), learning style or personality type (Dawdy, 2004) to explore if any user segments may benefit more from coaching than others. However, none have reported any evidence that these types of characteristics influenced the outcomes in terms of coaching effectiveness.

6.4 Implications

Even though MeBeSafe should address all road user equally, i.e. everyone's traffic behaviour should be improved, there are most probably groups that need further encouragement to behave accordingly. These are to be identified during the respective work packages when the interventions are specified further. This section summarise the most important general factors that need consideration throughout the MeBeSafe project.

Based on the information summarised in the former sections, and taking into consideration also the recommendations of the FESTA handbook (FESTA handbook 5.4, 2017), the following can be concluded. Drivers differ on a large variety of characteristics, which may all influence on how they drive and use different systems and services. These differences may be important to take into account when planning an evaluation. Four key categories of driver characteristics may be distinguished:

- *Demographic characteristics:* gender, age, educational level, income, socio-cultural background, etc.
- *Driving experience*, and driving situation and motivation: experience in years and in mileage, private or professional, etc.

- *Personality traits and physical characteristics*: sensation seeking, locus of control, cognitive skills, physical impairments or weaknesses etc.
- *Attitudes and intentions*: attitudes towards safety, environment, technology etc.

More specifically, the implications and recommendations are:

- *Cater to different levels of the ability of information processing and action execution.* Different information processing abilities and levels of fitness to drive should be taken into consideration. The interventions should not overload inexperienced drivers with information as this could lead to an even higher risk.
- *Care for an equal share of age groups.* Young and/or inexperienced drivers with a low annual mileage have been identified as risk groups. Elderly drivers pose another a risk group. The same pattern applies to cyclists, even though this also has a passive component: cyclists are vulnerable road users and are more likely to be injured in crashes without behaving wrongly. Consequently, the age of drivers needs consideration. The effects of nudging and/or coaching interventions on "everyone" should be investigated and, if possible, compared. Where appropriate, samples should be put together with respect to an equal share of all age groups, correspondingly to their share in the overall population.
- *Care for an equal distribution of gender.* Differences in gender characteristics exist why gender should be considered and controlled for, when possible, in designing and evaluating the outcome of the trials.
- *Assess fitness to drive.* When assessing especially elderly road users, fitness to drive and general information processing abilities need to be addressed. It must be ensured that the nudging and coaching interventions do not pose a threat to the nudged or coached road users or to any other road user.
- *Keep different levels of education and income in mind, as well as technical and professional knowledge with regards to traffic and roads (assess profession if possible).* In designing the trials, the socio-economic status of participants should be assessed in order to be able to control for this variable.

- *Care for an equal share of people with different levels of expertise, driving exposure, use of different vehicles etc., and assess these features beforehand.* Annual mileage should be assessed and drivers with different levels of driving exposure need to be considered. A distribution between private and professional drivers would not suffice, as annual mileage differs a lot among private drivers.
- *Consider differences in information processing at different times of day.* Driving behaviour changes according to, for example weather conditions. Environmental conditions need to be controlled for and weather conditions as a possibly interfering variable need to be considered. The same applies to nighttime versus daytime road use. It is harder to see for example a cyclist in the dark, whereas it is harder to spot infrastructural roadside nudging measures based on light during daytime, due to differences in the contrast between measure and surroundings.
- Including thoroughly validated instruments on personality traits, such as sensation seeking and/or perceived locus of control and similar, is advised (cf. the FESTA handbook).
- *Consider cultural differences and interpret results accordingly.* When it comes to nudging, studies on the role of user characteristics focus mainly on cultural differences. As there are no consistent pattern regarding cultural influences among road users, culture seems to be not necessary to take into account.

Summing up, in the future work of MeBeSafe, it is essential to be aware of different user characteristics and traits. Where possible, individual differences need to be kept in mind. When collecting data, it is advised to collect as information as possible on personality traits without violating data protection laws and personal space of participants.

7 Design Considerations

This chapter merges the insight from the previous chapters with the aim of aiding further development of the MeBeSafe interventions in WPs 2, 3, and 4. As illustrated in Figure 7.1, the process of designing the interventions consists of three main stages and decision gates, each of which requires input from various sources to aid decision making. Based on the insight gained during WP1, this chapter summarises the main design considerations that need to be taken into account when further developing the planned interventions during the different stages of the design process. Apart from gaining insight into relevant aspects to consider for Stage 1, WP1 has also generated knowledge relevant for Stage 2 and Stage 3 of the design process. The insights on intervention strategies and the nudging and coaching approaches (Chapter 4), the theories and models (Chapter 5), and well as the user profiling (Chapter 6), provide valuable input that will aid WP leaders to make decisions at Stage 2 and Stage 3.

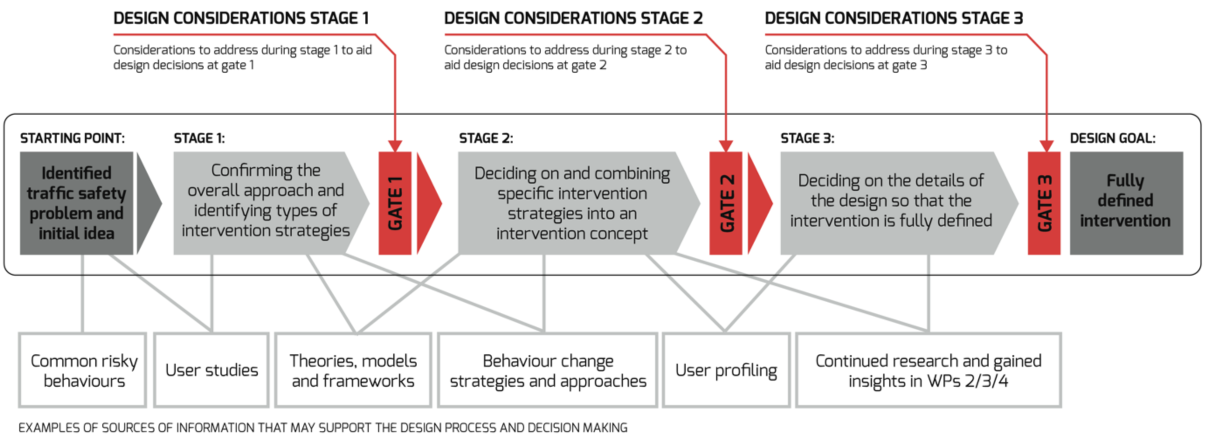


Figure 7.1: An overview of the design process for developing MeBeSafe interventions

This chapter is divided into one section for each of the target behaviours associated to the problematic unsafe driving behaviours described in Chapter 3. Each section starts with a short summary about the addressed problem and the overall idea for the proposed intervention as originally described in the MeBeSafe project plan. Next, aspects that need to be considered during Stage 1 in order to narrow down the broad overall idea of the intervention to a more specific intervention are discussed. This discussion is based on an analysis mapping out the characteristics of the problematic unsafe driving behaviours so that informed decisions regarding the overall approach and types of interventions strategies can be made at Gate 1. The main part of the analysis was carried out during the workshop in The Hague were a number of aspects were discussed among MeBeSafe consortium members. The insights gained through the analysis, i.e. the identified design considerations, have already supported some WP leaders to modify and narrow down their broad overall ideas of the interventions into more specified ones. However, some WP leaders still need to gain more insight before all questions can be answered and final decisions can be taken at Gate 1. Each section also discusses additional design considerations identified in WP1 that are relevant to take into account during Stage 2 and Stage 3 for each target behaviour as well as additional key questions to explore further in WP2, WP3, and WP4 to gain more insight that will aid decisions at Gate 2 and Gate 3. The last section of the chapter provides a short summary and comparison of the proposed MeBeSafe interventions.

7.1 Adopt appropriate speed - car drivers

7.1.1 Addressed problem

Over 50% of all accidents occur on inter-urban roads, including a large number of single-vehicle accidents caused by the driver losing control of the vehicle. Half of the accidents on inter-urban roads are directly attributable to high speed. One problematic unsafe driving behaviour is that drivers often adopt a speed that is inappropriate for the stretch of interurban two-way road they are driving on or the momentary specific situation at a certain location, due to i.e. traffic congestion or other.

7.1.2 Overall idea of the proposed intervention

The initial idea proposed in the MeBeSafe project plan is to develop an infrastructure nudging intervention aimed at supporting drivers to adopt an appropriate speed (as opposed to driving at the speed limit). The infrastructure nudging intervention will presumably consist of dynamic illuminated road markings in combination with roadside sensors instead of static painted markings.

7.1.3 Design considerations Stage 1

The addressed problem, i.e. drivers' adoption of an inappropriate speed, has been analysed in relation to the insights gained in WP1 in order to: i) confirm that the overall nudging approach initially proposed for the intervention is suitable to address the problem, and ii) to identify relevant types of interventions strategies and types of nudges that the intervention can be based on.

The insights, summarized in Figure 7.2, map out the characteristics of the addressed problem. As illustrated in the figure, a number of different aspects have been considered to identify the underlying causes to why drivers adopt an inappropriate speed. The analysis confirms that an overall nudging approach is suitable and that redesigning the driving context, in this case the infrastructure, by primarily targeting system 1 also seems fitting to address the problem. The insights gained suggest that both types of strategies for designing a safe driving context are relevant, i.e. strategies for *increasing opportunities for safe driving* and strategies for *improving the communication of safe driving opportunities*.

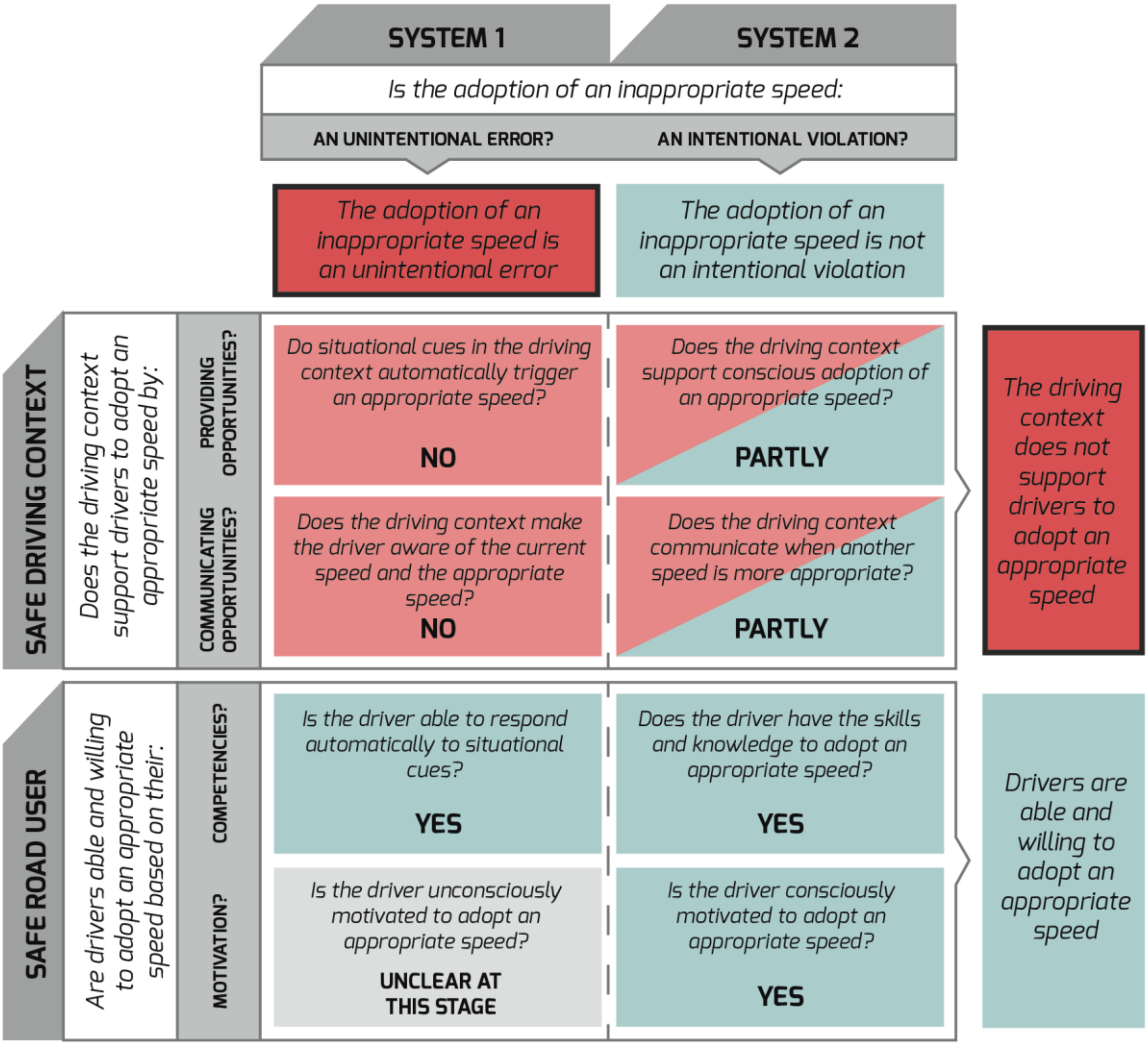


Figure 7.2: An overview of design considerations and conclusions drawn in Stage 1 addressing drivers' unsafe adoption of inappropriate speed

Additionally, a number of categories of nudges have been identified suitable to address drivers' adoption of an inappropriate speeds:

- Nudges that activate the behavioural standard (i.e. adopt an appropriate speed) to help drivers that are not consciously aware of the behavioural standard in that context yet;
- Passive exposure nudges that support drivers in adopting an appropriate speed even when they do not seek out the nudge;

- Mindless nudges that influence drivers adopting an appropriate speed by taking advantage of well-established behavioural biases;
- Encouraging nudges that facilitate drivers to adopt an appropriate speed.

7.1.4 Design considerations Stage 2

As decisions have been made at Gate 1 regarding the overall approach and relevant types of interventions strategies and types of nudges, additional aspects now needs to be considered so that a more specific intervention concept can be developed in Stage 2. These considerations must support decision making at Gate 2 regarding which specific intervention strategies that should be combined so that the intervention fits the addressed problem and its target group and context. Some aspects have already been identified during WP1 while additional ones need to be identified and explored in WP3. Aspects important to consider in WP3 include:

- *Who should be nudged by the intervention?* Tentative insights from WP1 suggest that the design of the nudge should be beneficial for all: young and old, men and women, inexperienced and experienced drivers. However, the balance between automatic and conscious processes is dependent on age, with young people being more impulsive, because of brain immaturity.
- *What information processing abilities does the target group have?*
- *What level of cognitive effort can be expected for drivers in situations when the addressed problem arises?* The insights from WP1 suggest that driving in general is a cognitively taxing activity and it affects the extent to, as well as the way in which people process information that is presented to them during driving. For instance, feedback on speed risks being ignored when situational demands on the road are high and cognitive capacity is reduced. Hence, the design of the intervention must take drivers cognitive load into consideration.
- *Which types of biases can be predicted for the target group?*
- *Which of the relevant intervention strategies and types of nudges have potential to be effective for the target group?* Inspiration and examples of intervention

strategies for redesigning the driving context so that opportunities for safe driving increases and are better communicated can be found in Appendix A.

- *What potential risks need to be considered?* Tentative insights from WP1 suggest that the nudge should not interfere with automatic 'good' routines; It is important to be aware of potential risks of interfering with automatic routines. Activating automatic reactions may interfere with other automatic responses, for instance by guiding attention to less relevant 'dangers'.
- *Does the concept require any technology? If so, what type of technology is suitable to use?*

7.1.5 Design considerations Stage 3

When decisions have been made at Gate 2, additional aspects needs to be considered so that the intervention can be further developed and detailed in Stage 3. Some aspects have already been identified during WP1 while additional ones need to be identified and explored in WP3. Aspects important to consider in WP3 include:

- *How should the nudge be designed to have good effect and reduce potential risks?* Tentative insights from WP1 suggest that the nudge should be designed so that it does not increase mental workload in critical situations; it should not be distractive and not be confusing.
- *How should the intervention be designed to communicate appropriate speed in an easy perceptible and understandable way?* Several parameters influencing the drivers' possibility to perceive and interpret the communicated message should be considered so that a flexible solution can be developed. For instance, the road environment, the social environment, the weather, the level of daylight, and the illumination colour used all influence how drivers will perceive and interpret the nudge.
- *If the concept requires technology, how should it be integrated and adjusted to this specific infrastructure intervention?*

7.2 Adopt appropriate speed - cyclists

7.2.1 Addressed problem

A large part of bicycle accidents happen on bicycle lanes, where bicyclists may be in conflict with, e.g., other bicyclists or pedestrians, or where bicycle lanes intersect with other type of roads, i.e. where bicyclists conflict with, e.g., motorised vehicles. There are several contributing factors, one of which is the inappropriately high speed of bicyclists when approaching intersections. More appropriate (lower) cycling speeds will allow car drivers more time to respond to cyclists at intersections as well as allow bicyclists more time to pay attention to other road users and more time to take action to avoid possible collisions.

7.2.2 Overall ideas of the proposed intervention

The initial idea proposed in the MeBeSafe project plan is to develop two infrastructure nudging interventions to reduce the speed of bicyclists when approaching critical intersections. The initial ideas about the infrastructure nudging intervention focus on a 'haptic' intervention. The second infrastructure nudging intervention is thought to be a visual nudge on the bicycle lane at a certain distance before intersections.

7.2.3 Design considerations Stage 1

The addressed problem, i.e. cyclists' adoption of an inappropriate speed, was not directly discussed during the workshop in The Hague and has thus not yet been analysed to the same extent as some of the other unsafe behaviours. Hence, this problem needs to be investigated further by WP3 members so that: i) it can be confirmed that the overall nudging approach initially proposed for the intervention is suitable to address the problem, and ii) relevant types of interventions strategies and types of nudges to build the intervention can be identified.

The analysis should strive to map out the characteristics of the addressed problem. As illustrated in Figure 7.3, a number of different aspects can be considered in order to identify the underlying causes to why cyclists adopt an inappropriate speed, which in turn will facilitate decisions at Gate 1.

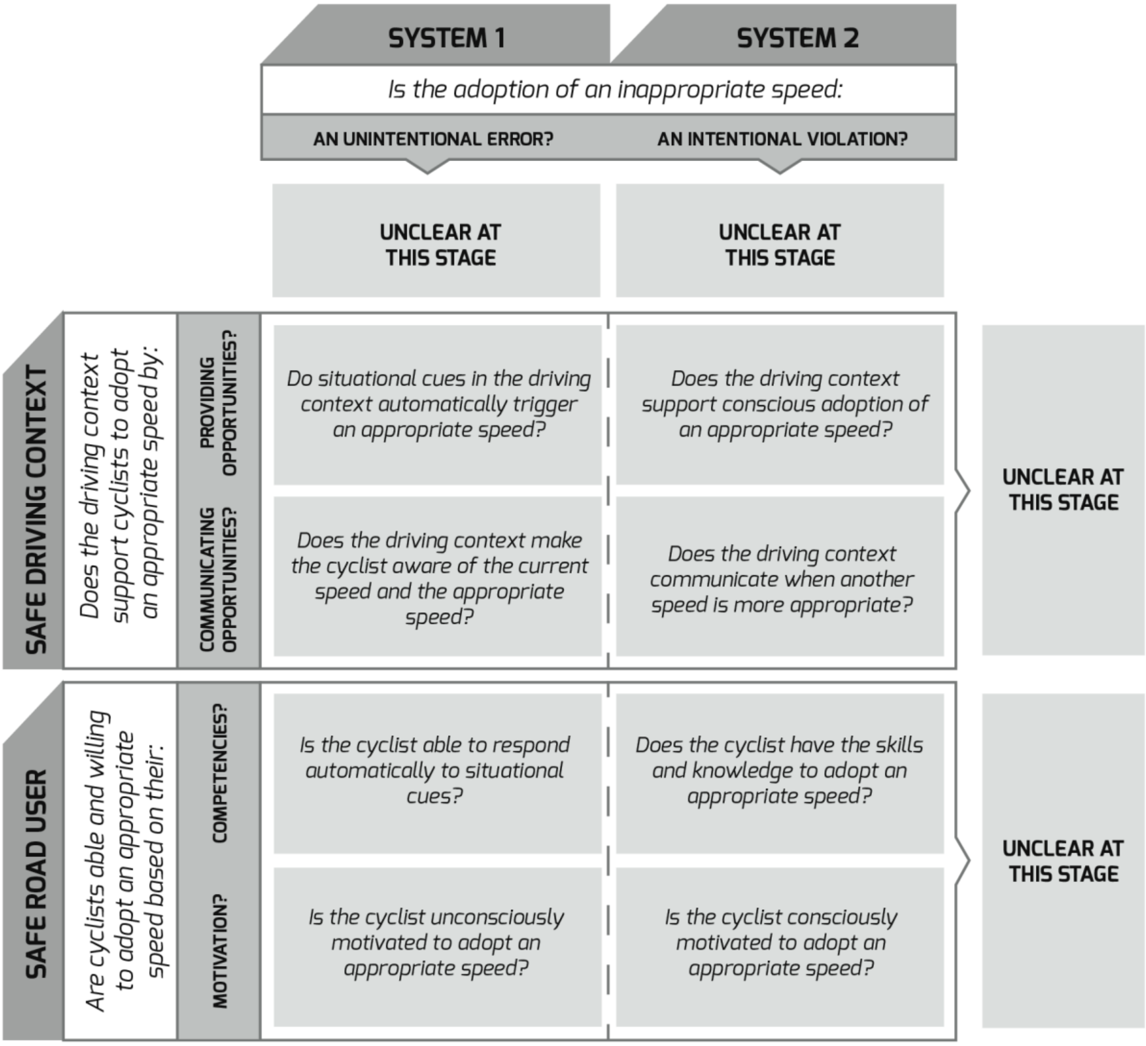


Figure 7.3: An overview of aspects that can be explored in regard to cyclists' unsafe adoption of inappropriate speed in order to aid decision making at Gate 1

7.2.4 Design considerations Stage 2

When decisions have been made at Gate 1 regarding the overall approach and relevant types of interventions strategies and types of nudges, additional aspects now needs to be considered so that a more specific intervention concept can be developed in Stage 2. These considerations must support decision making at Gate 2 regarding which specific intervention strategies that should be combined so that the intervention fits the addressed problem and its target group and context. Some aspects have already been identified during WP1 while additional ones need to be identified and explored in WP3. Aspects important to consider in WP3 include:

- *Who should be nudged by the intervention?* Tentative insights from WP1 suggest that the design of the nudge should be beneficial for all: young and old, men and women, inexperienced and experienced cyclists. However, the balance between automatic and conscious processes is dependent on age, with young people being more impulsive, because of brain immaturity.
- *What information processing abilities does the target group have?*
- *What level of cognitive effort can be expected for drivers in situations when the addressed problem arises?* The insights form WP1 suggest that the design of the intervention must take cyclists cognitive load into consideration.
- *Which types of biases can be predicted for the target group?*
- *Which of the relevant intervention strategies and types of nudges have potential to be effective for the target group?* Inspiration and examples of intervention strategies for redesigning the driving context so that opportunities for safe driving increases and are better communicated can be found in Appendix A.
- *What potential risks need to be considered?* Tentative insights from WP1 suggest that the nudge should not interfere with automatic 'good' routines; It is important to be aware of potential risks of interfering with automatic routines. Activating automatic reactions may interfere with other automatic responses, for instance by guiding attention to less relevant 'dangers'.
- *Does the intervention require any technology? If so, what type of technology is suitable to use?*

7.2.5 Design considerations Stage 3

When decisions have been made at Gate 2, additional aspects needs to be considered so that the intervention can be further developed and detailed in Stage 3. Some aspects have already been identified during WP1 while additional ones need to be identified and explored in WP3. Aspects important to consider in WP3 include:

- *How should the nudge be designed to have good effect and reduce potential risks?* Tentative insights from WP1 suggest that the nudge should be designed so that it does not increase mental workload in critical situations; it should not be distractive and not be confusing.

- *How should the interventions be designed to communicate appropriate speed in an easy perceptible and understandable way?* Several parameters influencing the cyclists' possibility to perceive and interpret the communicated message should be considered so that a effective solution can be developed. For instance, the road environment, the weather, the level of daylight, and the haptic feedback used all influence how cyclists will perceive and interpret the nudges.
- *If the intervention requires technology, how should it be integrated and adjusted to this specific infrastructure intervention?*

7.3 Follow appropriate trajectory

7.3.1 Addressed problem

The target behaviour 'Follow appropriate trajectory' is closely linked to the target behaviour 'Adopt appropriate speed'. Drivers often follow a trajectory (and speed) that is inappropriate for the stretch of interurban two-way road or specific situation at a certain location they are driving on.

7.3.2 Overall idea of the proposed intervention

The initial idea proposed in the MeBeSafe project plan is to develop an infrastructural nudging intervention to help drivers to follow a risk-minimising trajectory as opposed to driving at a trajectory that supports maximum allowable speed. The idea that will be explored by MeBeSafe is an infrastructure nudging intervention that presumably consist of dynamic illuminated road markings in combination with roadside sensors instead of static painted markings.

7.3.3 Design considerations Stage 1

The addressed problem, i.e. drivers' adoption of an inappropriate trajectory, was not discussed in depth during the workshop in The Hague and has thus not yet been analysed to the same extent as some of the other unsafe behaviours. Even though some tentative insights has been gained in WP1, this problem needs to be investigated further by WP3 members to: 1) confirm that the overall nudging approach initially proposed for the intervention is suitable to address the problem, and 2) to identify relevant types of interventions strategies and types of nudges that the intervention can be based on.

The tentative insights, summarized in Figure 7.4, map out some of the characteristics of the addressed problem. As illustrated in the figure, a number of different aspects have been considered to identify the underlying causes to why drivers adopt an inappropriate trajectory. The initial analysis suggest that an overall nudging approach is suitable and that redesigning the driving context, in this case the infrastructure, by primarily targeting system 1 also seems fitting to address the problem. The insights gained suggest that both types of strategies for designing a safe driving context are relevant, i.e. strategies for *increasing opportunities for safe driving* and strategies for *improving the communication of safe driving opportunities*.

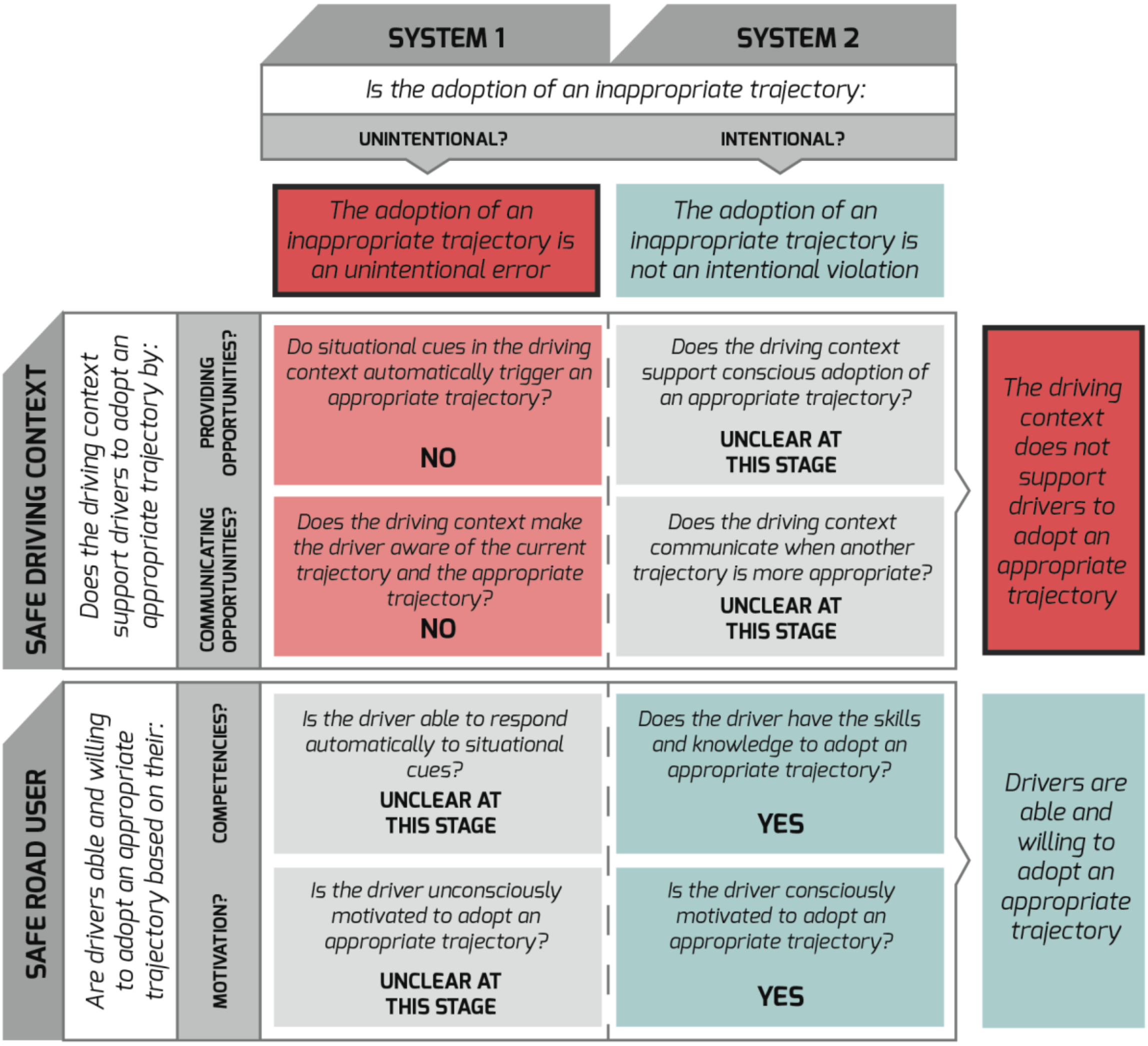


Figure 7.4: Overview of design considerations and tentative conclusions drawn in Stage 1 addressing drivers' unsafe adoption of an inappropriate trajectory

Based on these tentative answers it can also be hypothesize that some categories of infrastructure nudges are more suitable than others to address drivers' adoption of inappropriate trajectories. Types of nudges that are expected to be suitable include:

- Nudges that activate the behavioural standard (i.e. follow appropriate trajectory) to help drivers that are not consciously aware of the behavioural standard in that context yet
- Passive exposure nudges that support drivers in following an appropriate trajectory even when they do not seek out the nudge

- Mindless nudges that influence drivers following an appropriate trajectory by taking advantage of well-established behavioural biases
- Encouraging nudges that facilitate drivers to follow an appropriate trajectory.

7.3.4 Design considerations Stage 2

When final decisions have been made at Gate 1 regarding the overall approach and relevant types of interventions strategies and types of nudges, additional aspects needs to be considered so that a more specific intervention concept can be developed in Stage 2. These considerations must support decision making at Gate 2 regarding which specific intervention strategies that should be combined so that the intervention fits the addressed problem and its target group and context. Some aspects have already been identified during WP1 while additional ones need to be identified and explored in WP3. Aspects important to consider in WP3 include:

- *Who should be nudged by the intervention?* Tentative insights from WP1 suggest that the design of the nudge should be beneficial for all: young and old, men and women, inexperienced and experienced drivers. However, the balance between automatic and conscious processes is dependent on age, with young people being more impulsive, because of brain immaturity.
- *What information processing abilities does the target group have?*
- *What level of cognitive effort can be expected for drivers in situations when the addressed problem arises?* The insights from WP1 suggest that driving in general is a cognitively taxing activity and it affects the extent to, as well as the way in which people process information that is presented to them during driving. For instance, feedback on trajectory risks being ignored when situational demands on the road are high and cognitive capacity is reduced. Hence, the design of the intervention must take drivers cognitive load into consideration.
- *Which types of biases can be predicted for the target group?*
- *Which of the relevant intervention strategies and types of nudges have potential to be effective for the target group?* Inspiration and examples of intervention

strategies for redesigning the driving context so that opportunities for safe driving increases and are better communicated can be found in Appendix A.

- *What potential risks need to be considered?* Tentative insights from WP1 suggest that the nudge should not interfere with automatic 'good' routines; It is important to be aware of potential risks of interfering with automatic routines. Activating automatic reactions may interfere with other automatic responses, for instance by guiding attention to less relevant 'dangers'.
- *Does the intervention require any technology? If so, what type of technology is suitable to use?* The intervention idea requires technology integrated in the road infrastructure to communicate appropriate trajectory. The intervention also requires technology to determine the current trajectory, for instance, roadside sensors.

7.3.5 Design considerations Stage 3

When decisions have been made at Gate 2, additional aspects needs to be considered so that the intervention can be further developed and detailed in Stage 3. Some aspects have already been identified during WP1 while additional ones need to be identified and explored in WP3. Aspects important to consider in WP3 stage include:

- *How should the nudge be designed to have good effect and reduce potential risks?* Tentative insights from WP1 suggest that the nudge should be designed so that it does not increase mental workload in critical situations; it should not be distractive and not be confusing.
- *How should the dynamic illuminated road markings be designed to communicate appropriate trajectory in an easy perceptible and understandable way?* Several parameters influencing the drivers' possibility to perceive and interpret the communicated message should be considered so that a flexible solution can be developed. For instance, the road environment, the social environment, the weather, the level of daylight, and the illumination colour used all influence how drivers will perceive and interpret the nudge.

- *If the intervention requires technology, how should it be integrated and adjusted to this specific infrastructure intervention?*

7.4 Direct attention to possible risk

7.4.1 Addressed problem

Especially in urban traffic, hazards can come from every possible direction. Drivers are having difficulties in predicting episodes of increased risk. They are not used to paying attention to potential hazards in pre-conflict situations.

7.4.2 Overall idea of the proposed intervention

The initial idea proposed in the MeBeSafe project plan is to develop an in-vehicle nudging intervention. The in-vehicle nudging intervention is thought to increase drivers' level of attention to potential hazards in pre-conflict situations (i.e. situations that occur quite frequently in everyday driving). The in-vehicle nudging intervention is meant to direct a driver's attention towards forecasted and detected hazards before they actually pose a critical risk.

7.4.3 Design considerations Stage 1

The addressed problem, i.e. drivers' inattention to possible risk, was not discussed in depth during the workshop in The Hague and has thus not yet been analysed to the same extent as some of the other unsafe behaviours. So, this problem needs to be investigated further by WP2 members so that: 1) it can be confirmed that the overall nudging approach initially proposed for the intervention is suitable to address the problem, and 2) relevant types of interventions strategies and types of nudges to build the intervention can be identified.

The analysis should strive to map out the characteristics of the addressed problem. As illustrated in Figure 7.5, a number of different aspects can be considered in order to identify the underlying causes to drivers' inattention to risk, which in turn will facilitate decisions at Gate 1.

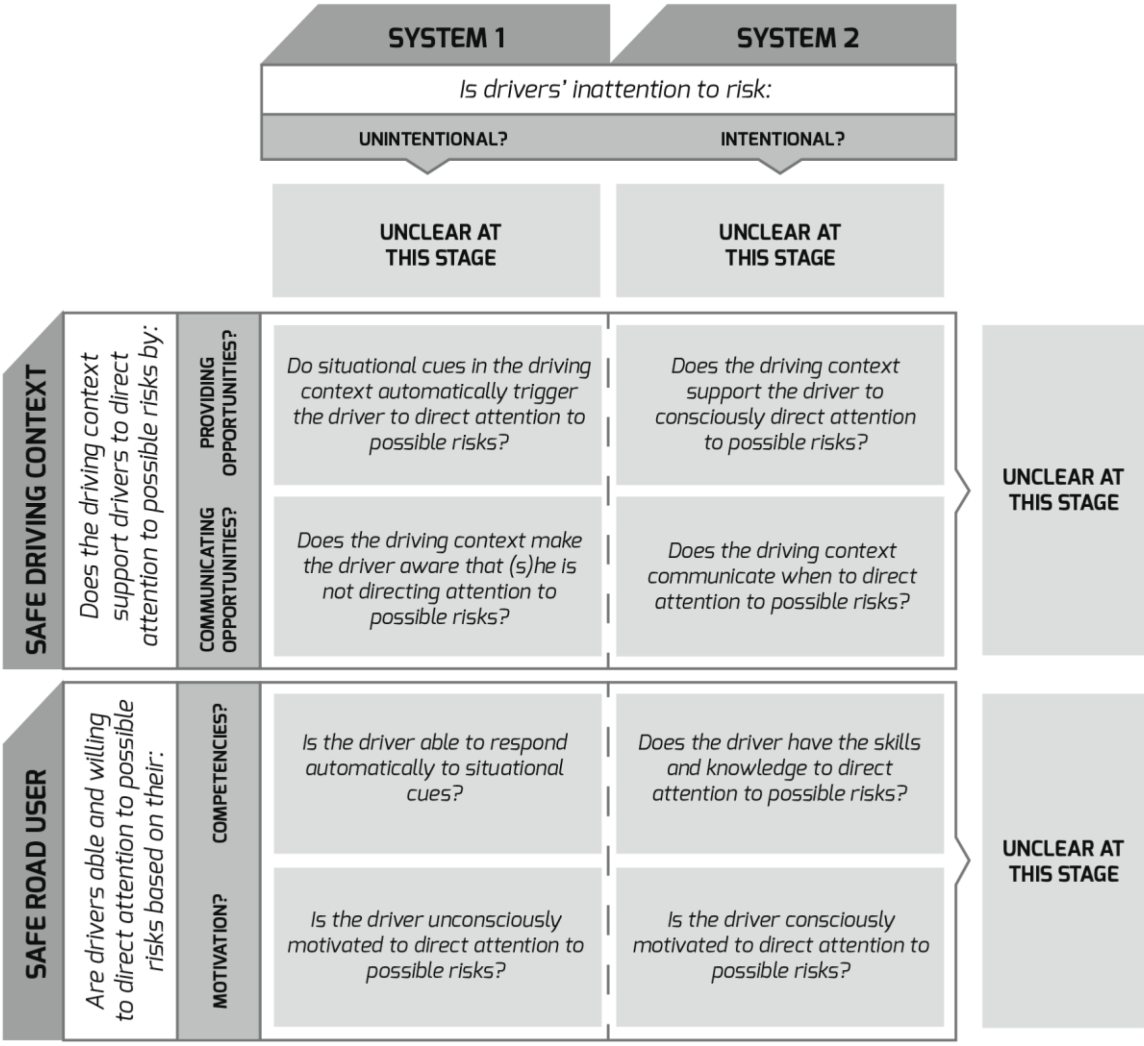


Figure 7.5: An overview of aspects that can be explored in regard to drivers' inattention to risk in order to aid decision making at Gate 1

7.4.4 Design considerations Stage 2

When decisions have been made at Gate 1 regarding the overall approach and relevant types of interventions strategies and types of nudges, additional aspects now needs to be considered so that a more specific intervention concept can be developed in Stage 2. These considerations must support decision making at Gate 2 regarding which specific intervention strategies that should be combined so that the intervention fits the addressed problem and its target group and context. Some aspects have already been identified during WP1 while additional ones need to be identified and explored in WP2. Aspects important to consider in WP2 include:

- *Who should be nudged by the intervention?* Tentative insights from WP1 suggest that the design of the nudge should be beneficial for all: young and old, men and women, inexperienced and experienced cyclists. However, the balance between automatic and conscious processes is dependent on age, with young people being more impulsive, because of brain immaturity.
- *What information processing abilities does the target group have?*
- *What level of cognitive effort can be expected for drivers in situations when the addressed problem arises?* The insights from WP1 suggest that driving in general is a cognitively taxing activity and it affects the extent to, as well as the way in which people process information that is presented to them during driving. For instance, information on possible risks can be ignored when situational demands on the road are high and cognitive capacity is reduced. Hence, the design of the intervention must take drivers cognitive load into consideration.
- *Which types of biases can be predicted for the target group?*
- *Which of the relevant intervention strategies and types of nudges have potential to be effective for the target group?* Inspiration and examples of intervention strategies for redesigning the driving context so that opportunities for safe driving increases and are better communicated can be found in Appendix A.
- *What potential risks need to be considered?* Tentative insights from WP1 suggest that the nudge should not interfere with automatic 'good' routines; It is important to be aware of potential risks of interfering with automatic routines. Activating automatic reactions may interfere with other automatic responses, for instance by guiding attention to less relevant 'dangers'.
- *Does the intervention require any technology? If so, what type of technology is suitable to use?*

7.4.5 Design considerations Stage 3

When decisions have been made at Gate 2, additional aspects needs to be considered so that the intervention can be further developed and detailed in Stage 3. Some aspects have already been identified during WP1 while additional ones need to be identified and explored in WP2. Aspects important to consider in WP2 include:

- *How should the nudge be designed to have good effect and reduce potential risks?* Tentative insights from WP1 suggest that the nudge should be designed so that it does not increase mental workload in critical situations; it should not be distractive and not be confusing. The design of the intervention should, for instance, not include acoustical feedback/warnings which run the risk of being too annoying, which may make the drivers ignore them. Multimodal warnings, thermal imaging and visual stimulation can be explored as alternatives.
- *If the intervention requires technology, how should it be integrated and adjusted to this specific infrastructure intervention?*

7.5 Increase use of ACC

7.5.1 Addressed problem

Adaptive Cruise Control (ACC) has been available in passenger cars since its introduction in 1999. The sensing systems and control algorithms are reliable and increasingly able to deal with not just motorway traffic but also interurban and urban driving. Using ACC has been shown to significantly decrease the number of times a car has insufficient headway to the lead vehicle compared to unaided driving. Over the years there has been continuous improvement in ACC technology, in particular in the speed range and context in which it is usable. While early systems could only be used to keep a set distance from a lead vehicle travelling in the same straight lane at relatively high speed and low traffic density, current ACC systems are able to safely control vehicle speed from standstill to speed limits. However, only some drivers actively use ACC and they do not switch ACC on in many situations where its use would increase their own safety and the safety of other road users. The drivers that use ACC do so, for example when driving on motorways but switch it off when they exit the motorway.

7.5.2 Overall ideas of the proposed intervention

The initial idea proposed in the MeBeSafe project plan is to develop in-vehicle nudging interventions that will prompt drivers to increase their use of ACC in order to keep a safe distance to the vehicle in front. The idea is to show drivers what the ACC system would have done in specific situations so that the drivers can see the benefits of the ACC, increase their trust in the system, and ultimately increase their use of ACC. The interventions will target drivers that never uses ACC as well as drivers that use it but only in specific situations.

7.5.3 Design considerations Stage 1

The addressed problem, i.e. drivers' non-usage of ACC, has been analysed in relation to the insights gained in WP1 in order to: i) confirm that the overall nudging approach initially proposed for the intervention is suitable to address the problem, and ii) to identify relevant types of interventions strategies and types of nudges that the intervention can be based on.

Tentative insights, summarized in Figure 7.6, map out some of the characteristics of the addressed problem, both in relation to drivers that sometimes use ACC and drivers the never use ACC. As illustrated in the figure, a number of different aspects have been considered to identify the underlying causes to why drivers do not use ACC (to its full potential). Even though these aspects were discussed during the workshop in The Hague, WP2 members should further investigate this problem. Nevertheless, the analysis highlights that the driving context, i.e. the in-vehicle interface, does not support drivers to use the ACC to its full potential. Additionally, some drivers do not have the competencies to use ACC while others are intentionally choosing to not use ACC to its full potential. These insights preliminarily suggest that an overall nudging approach seems beneficial, however, applying an approach combining both nudging and coaching is also possible.

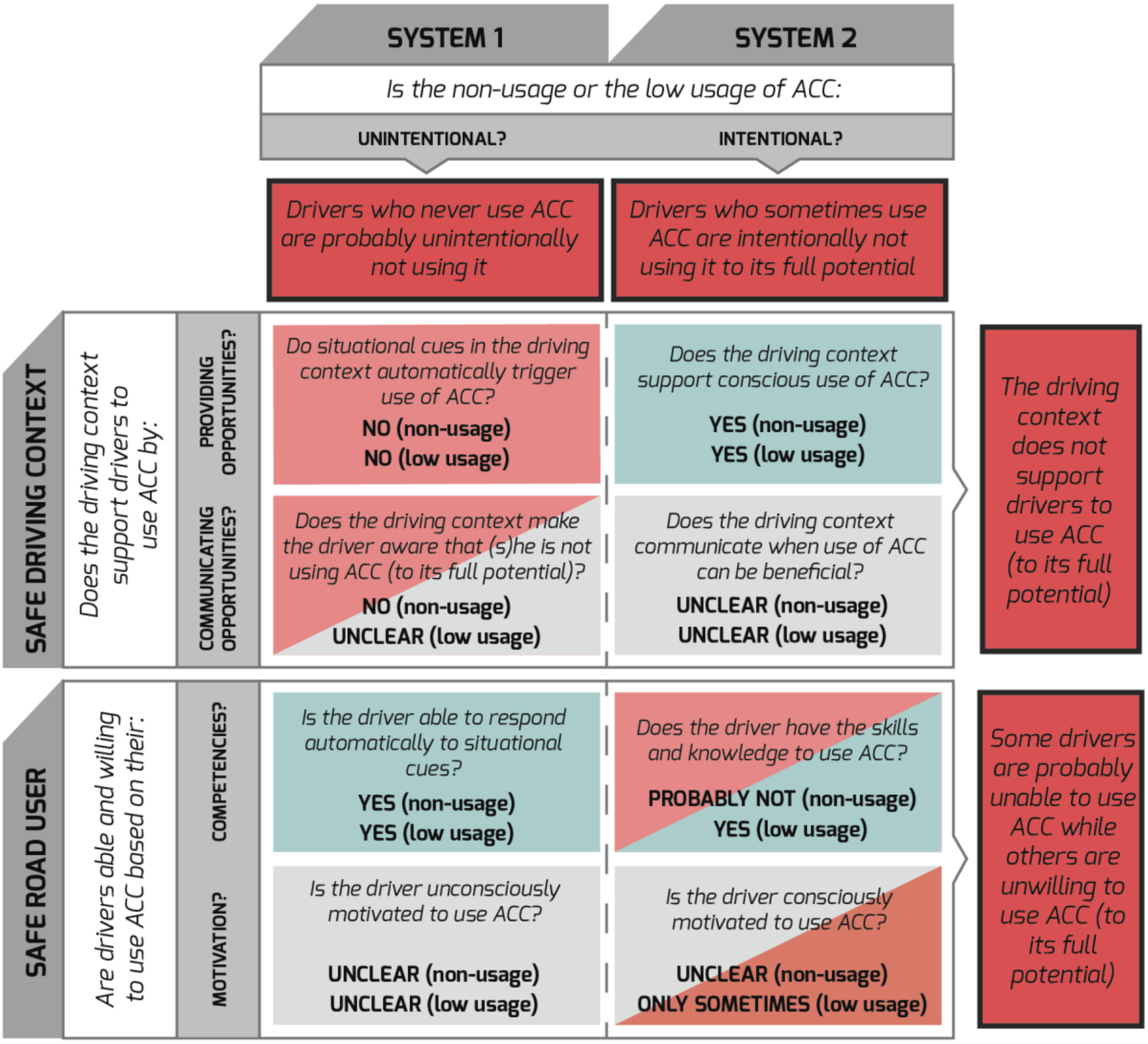


Figure 7.6: Overview of design considerations and tentative conclusions drawn in Stage 1 addressing drivers' non-usage or low usage of ACC

Based on these preliminary insights it can be hypothesize that these categories of in-vehicle nudges are suitable to address this problem behaviour:

- Self-control boosting nudges that help drivers to increase their ACC use;
- Nudges that activate the behavioural standard (i.e. enable ACC function as often as possible);
- Nudges that drivers who are motivated to (increase) use ACC impose upon themselves voluntarily to help them to increase ACC use;
- Passive nudges that support drivers in using ACC to its full potential;

- Mindful nudges that help drivers to make more rational, cost-benefit decisions about (not) increasing ACC use;
- Mindless nudges that influence drivers to increase ACC use by taking advantage of well-established behavioural biases;
- Encouraging nudges that facilitate the driver to increase ACC use;
- Discouraging nudges that hinder or prevent disabling the ACC function.

7.5.4 Design considerations Stage 2

When final decisions have been made at Gate 1 regarding the overall approach and relevant types of interventions strategies and types of nudges, additional aspects needs to be considered so that a more specific intervention concept can be developed in Stage 2. These considerations must support decision making at Gate 2 regarding which specific intervention strategies that should be combined so that the intervention fits the addressed problem and its target group and context. Some aspects have already been identified during WP1 while additional ones need to be identified and explored in WP2. Aspects important to consider in WP2 include:

- *Who should be nudged by the intervention?* Tentative insights from WP1 suggest that the design of the nudges should be beneficial for all: young and old, men and women, inexperienced and experienced drivers. As the aim is to address both driver that never uses ACC and drivers that use it occasionally, the nudges muse be tailored to the drivers' driving support preferences (i.e. one type of nudging for those who already use the system, but in a limited way, and another for those who do not use it at all).
- *What information processing abilities does the target group have?*
- *What level of cognitive effort can be expected for drivers in situations when the addressed problem arises?* The insights from WP1 suggest that driving in general is a cognitively taxing activity and it affects the extent to, as well as the way in which people process information that is presented to them during driving. For instance, information about ACC risks being ignored when situational demands on the road are high and cognitive capacity is reduced.

Hence, the design of the intervention must take drivers cognitive load into consideration.

- *Which types of biases can be predicted for the target group?*
- *Which of the relevant intervention strategies and types of nudges have potential to be effective for the target group?* Inspiration and examples of intervention strategies for redesigning the driving context so that opportunities for safe driving increases and are better communicated, and intervention strategies for increasing road users' competencies and motivation can be found in Appendix A.
- *When should drivers be nudged?* The nudges should be tuned to context so that they support use of ACC in the situations when ACC is normally not used. For instance, an opt out implementation where the system automatically turns on unless you actively block it may be restricted to a highway/interurban context where the expected uptime of the function once activated could be expected to be fairly long.
- *What potential risks need to be considered?* Tentative insights from WP1 suggest that the nudge should not interfere with automatic 'good' routines; It is important to be aware of potential risks of interfering with automatic routines. Activating automatic reactions may interfere with other automatic responses, for instance by guiding attention to less relevant 'dangers'.
- *Do the interventions require any technology? If so, what type of technology is suitable to use?*

7.5.5 Design considerations Stage 3

When decisions have been made at Gate 2, additional aspects needs to be considered so that the intervention can be further developed and detailed in Stage 3. Some aspects have already been identified during WP1 while additional ones need to be identified and explored in WP2. Aspects important to consider in WP2 which have been identified already at this stage include:

- *How should the nudge be designed to have good effect and reduce potential risks?* Tentative insights from WP1 suggest that the nudge should be designed so that it does not increase mental workload in critical situations; it should not be distractive and not be confusing. Hence, attention must be paid to the details of the in-vehicle intervention designs so that they communicate their message in an appropriate way.
- *If the interventions require technology, how should it be integrated and adjusted to the specific interventions?*

7.6 Take a break when drowsy

7.6.1 Addressed problem

Today, in-vehicle systems are capable of detecting when drivers get drowsy based on sensing and fusing steering wheel input, lane position, pressure on accelerator pedal, eye blinking and gaze direction, and head pose. However, existing in-vehicle systems have been not (as yet) been so successful in actually changing behaviour (i.e. drivers to take a break when drowsy). It appears that just informing the driver that his alertness is waning is insufficient to get him to take a break.

7.6.2 Overall idea of the proposed intervention

The initial idea proposed in the MeBeSafe project plan is to develop an in-vehicle nudging intervention to stimulate drivers to take a break when they are drowsy. As information and feedback is insufficient to get drivers to take a break, MeBeSafe wants to provide an additional incentive that is limited in time and builds on the drivers' hedonic needs. The idea is to present drivers with a discount voucher for a cup of coffee to be used a Shell service stations. This idea will be explored in the form of an app that works in combination with VCC's Driver Alert technology.

7.6.3 Design considerations Stage 1

The addressed problem, i.e. drivers' unwillingness to take a break when tired, has been analysed in relation to the insights gained in WP1 in order to: i) confirm that the overall nudging approach initially proposed for the intervention is suitable to address the problem, and ii) to identify relevant types of interventions strategies and types of nudges that the intervention can be based on.

Tentative insights, summarized in Figure 7.7, map out some of the characteristics of the addressed problem. As illustrated in the figure, a number of different aspects have been considered to identify the underlying causes to why drivers are unwilling to take a break when driving drowsy. Even though these aspects were discussed during the workshop in The Hague, WP2 members should further investigate this problem. Nevertheless, the analysis preliminarily suggest that an overall nudging approach that focuses on *increasing drivers' motivation* for taking a break seems suitable as drivers intentionally do not take breaks when driving drowsy. The insights gained suggest that nudges that target system 2 seems most fitting to address the problem even though targeting system 1 could potentially also be suitable.

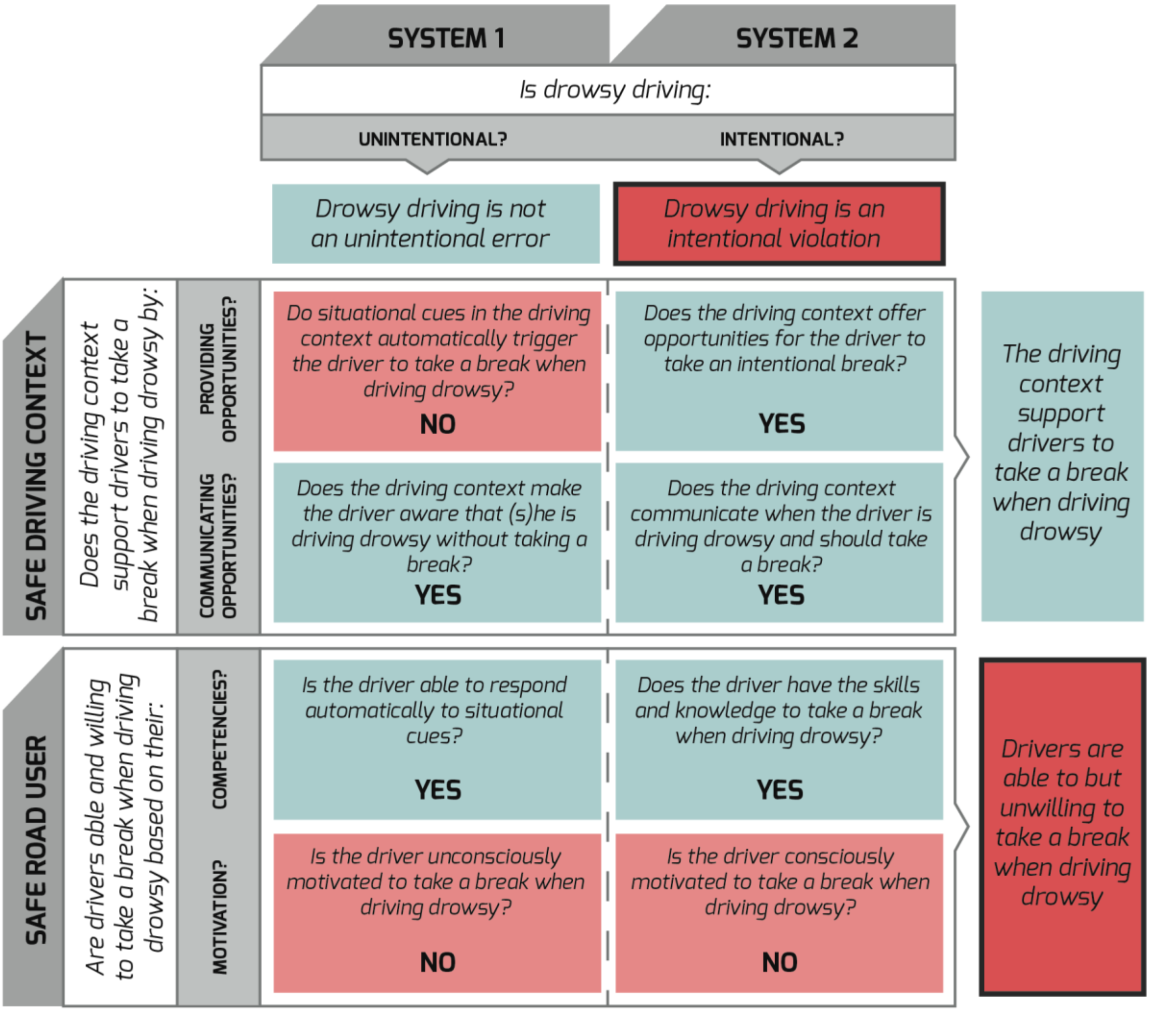


Figure 7.7: An overview of design considerations and tentative insights gained in Stage 1 addressing drivers' unwillingness to take a break when driving drowsy

Based on these preliminary insights is can be hypothesize that these categories of in-vehicle nudges can be suitable to address the problem behaviour:

- Self-control boosting nudges that help drivers to take a break when drowsy;
- Nudges that activate the behavioural standard (i.e. take a break when drowsy);
- Nudges that drivers impose upon themselves voluntarily to help them to take a break when drowsy;
- Passive nudges that support drivers in taking a break when drowsy;

- Mindful nudges that help drivers to make more rational, cost-benefit decisions about (not) taking a break when drowsy;
- Mindless nudges that influence drivers to take a break when drowsy by taking advantage of well-established behavioural biases;
- Encouraging nudges that facilitate the driver to take a break when drowsy;
- Discouraging nudges that hinder or prevent not taking a break when drowsy.

7.6.4 Design considerations Stage 2

When final decisions have been made at Gate 1 regarding the overall approach and relevant types of interventions strategies and types of nudges, additional aspects needs to be considered so that a more specific intervention concept can be developed in Stage 2. These considerations must support decision making at Gate 2 regarding which specific intervention strategies that should be combined so that the intervention fits the addressed problem and its target group and context. Some aspects have already been identified during WP1 while additional ones need to be identified and explored in WP2. Aspects important to consider in WP2 which have been identified already at this stage include:

- *Who should be nudged by the intervention?* Tentative insights from WP1 suggest that the design of the nudge should be beneficial for all: young and old, men and women, inexperienced and experienced drivers. As the insights also highlight that drivers tend to drive drowsy more often in some situations, such as on return trips when the drivers just wants to get home, the intervention should be applicable for the people that most often drive i in such situations.
- *What information processing abilities does the target group have?*
- *What level of cognitive effort can be expected for drivers in situations when the addressed problem arises?* The insights from WP1 suggest that driving in general is a cognitively taxing activity and it affects the extent to, as well as the way in which people process information that is presented to them during

driving. For instance, incentives for taking a break risks being ignored when situational demands on the road are high and cognitive capacity is reduced. Hence, the design of the intervention must take drivers cognitive load into consideration.

- *Which types of biases can be predicted for the target group?*
- *Which of the relevant intervention strategies and types of nudges have potential to be effective for the target group?* The insights gained from WP1 suggest that drivers can be motivated, either unconsciously or consciously, to take a break by providing incentives that play on emotions, by reducing the perceived effort, and by increasing the benefits of taking a break. Inspiration and examples of intervention strategies for increasing drivers' motivation can be found in Appendix A.
- *What potential risks with introducing the nudge need to be considered?* Tentative insights from WP1 suggest that the nudge should not interfere with automatic 'good' routines; It is important to be aware of potential risks of interfering with automatic routines. Activating automatic reactions may interfere with other automatic responses, for instance by guiding attention to less relevant 'dangers'.
- *Does the intervention require any technology? If so, what type of technology is suitable to use?* As the intervention will build on the VCC's Driver Alert technology, the intervention requires technology that can link the app to the driver alert system. For instance, a cloud-based app can be used which will also provide the possibility to vary the presentation of the incentive so that is can be adjusted to fit individual drivers, as well as the location, time of day, and length of trip.

7.6.5 Design considerations Stage 3

When decisions have been made at Gate 2, additional aspects needs to be considered so that the intervention can be further developed and detailed in Stage 3. Some aspects have already been identified during WP1 while additional ones need to be identified and explored in WP2. Aspects important to consider in WP2 which have been identified already at this stage include:

- *How should the nudge be designed to have good effect and reduce potential risks?* Tentative insights from WP1 suggest that the nudge should be designed so that it does not increase mental workload in critical situations; it should not be distractive and not be confusing. As the overall idea is to explore this intervention in the form of an app (which in itself can be considered to give rise to a distraction), its design should be carefully considered and different alternatives for presenting the incentive should be explored.
- *At what level of driver drowsiness should the incentive be offered?*
- *How should the required technology be integrated and adjusted to provide a good basis for this specific intervention?*

7.7 Put good driving skills into practice

7.7.1 Addressed problem

The nudging interventions described so far are supposed to lead to an immediate increase in safe driving behaviour at specific locations and moments. However, MeBeSafe also aims to bring about long lasting safe driving habits, especially in HGV drivers. HGVs are defined as high goods vehicles of over 3.5 tonnes maximum permissible gross vehicle weight. Road traffic accidents involving HGVs tend to have more severe consequences because of their size and weight compared to other road users. Drivers of these heavy vehicles are all professional drivers. A challenge for HGV drivers is that they know how to drive safely and efficiently (e.g. how to reduce harsh braking, harsh cornering, speeding, and close following), yet do not always put their safe driving skill into practice to its full extent.

7.7.2 Overall idea of the proposed intervention

The initial idea proposed in the MeBeSafe project plan is to develop coaching schemes to stimulate HGV drivers to put their safe driving skills into practice to its full extent, i.e. reduce unnecessary harsh braking, harsh cornering, speeding, and close following.

The proposed plan is to develop two types of coaching interventions. The first type is online self-coaching, i.e. the coached HGV drivers does not interact with a human coach, they receive feedback through a technology interface (e.g. app, web portal, dashboard) instead. The second type of coaching concerns providing drivers with behavioural feedback through interaction with a human coach.

7.7.3 Design considerations Stage 1

The addressed problem, i.e. that HGV drivers not always put their safe driving skills into practice, has been analysed in relation to the insights gained in WP1 in order to: i) confirm that the overall coaching approach initially proposed for the intervention is suitable to address the problem, and ii) to identify relevant types of interventions strategies and types of nudges that the intervention can be based on.

Tentative insights, summarized in Figure 7.8, map out some of the characteristics of the addressed problem. As illustrated in the figure, a number of different aspects have been considered to identify the underlying causes to why HGV drivers do not always put their safe driving skills into practice. Even though these aspects were discussed during the workshop in The Hague, WP4 members should further investigate this problem. The initial analysis suggest that the drivers do not refrain from putting their safe driving skills into practice intentionally, but do so because they are not motivated to utilising the skills and because utilising them do simply not come to mind in situations when they would be beneficial. Therefore, an overall coaching approach that focuses on *increasing drivers' motivation* seems most fitting to address the problem. Furthermore, as the driving context does not to any higher extent support the drivers to utilise their skills, an additional opportunity is to improve the driving context, e.g. improve the in-vehicle communication by providing online coaching schemes, so that it better supports the drivers to put their skills into practice.

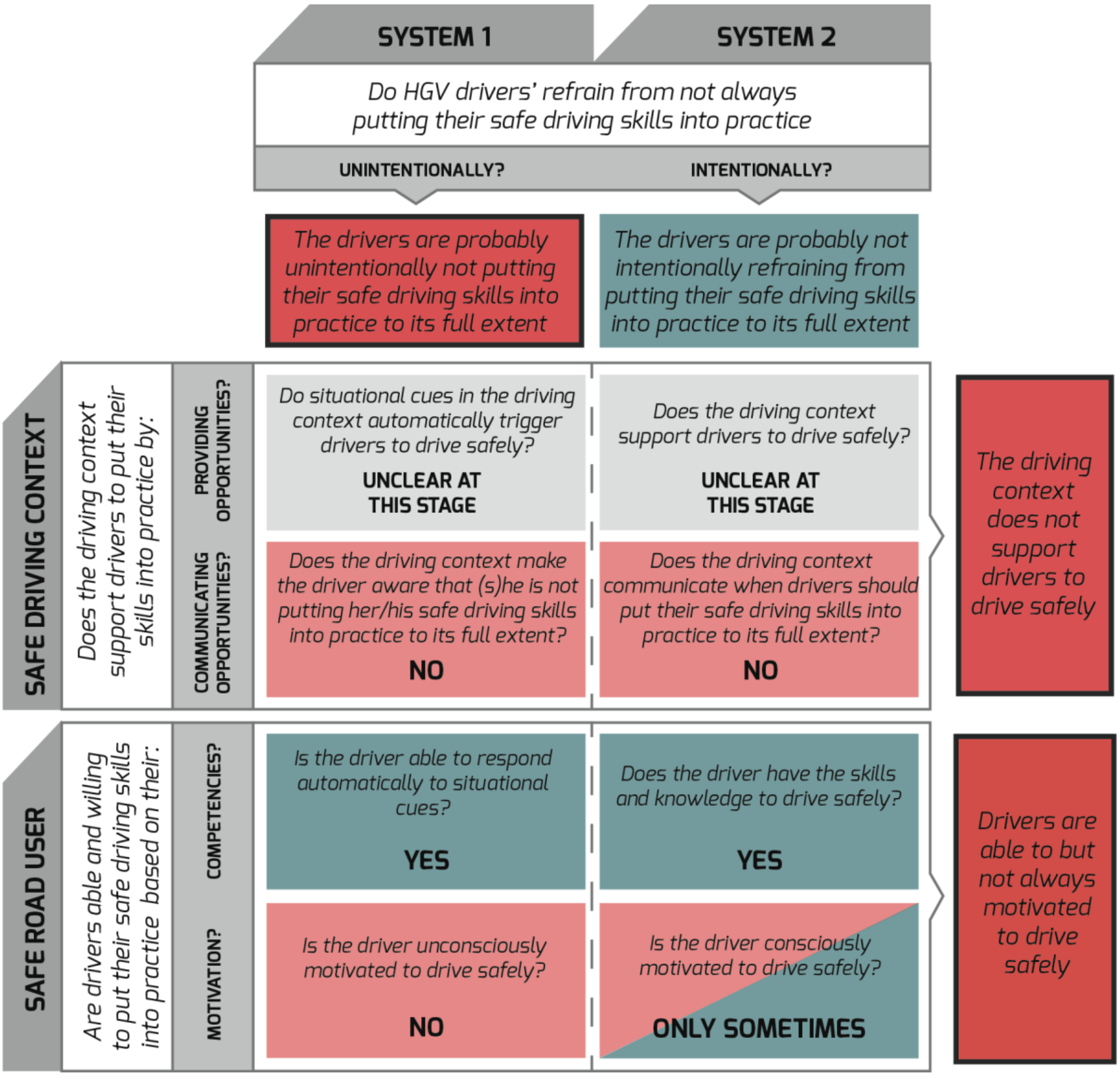


Figure 7.8: An overview of design considerations and tentative insights gained in Stage 1 addressing why HGV drivers do not put their safe driving skills into practice

7.7.4 Design considerations Stage 2

When final decisions have been made at Gate 1 regarding the overall approach and relevant types of coaching schemes, additional aspects needs to be considered so that a more specific intervention concept can be developed in Stage 2. These considerations must support decision making at Gate 2 regarding which specific intervention strategies that should be combined so that the intervention fits the addressed problem and its target group and context. Some aspects have already been identified during WP1 while additional ones need to be identified and explored in WP4. Aspects important to consider in WP4 which have been identified already at this stage include:

- *Who should be coached?* Insights from WP1 show that coaching will only work for people that show interest, willingness and actually have the possibility to change.
- *Who should the coach be?* Insights from WP1 suggest that in the off-line coaching schemes the HGV driver should be coached by a peer, not by an external professional coach or internal supervisor.
- *Which of the relevant intervention strategies have potential to be effective for the target group?* Insights from WP1 suggest that coaching based on a combination of objective feedback and evaluation of the information can be beneficial; subjective evaluation should be avoided. Positive feedback is essential, as is collaboration between coach and coachee. The coaching intervention should not be about teaching new skills, but rather guiding drivers towards new goals and helping them to directs their resources by increasing awareness and reminding them of existing knowledge. Inspiration and examples of intervention strategies for increasing drivers' motivation can be found in Appendix A.
- *How frequent and how long should the coaching sessions be?* Insights from WP1 suggest that peer-to-peer coaching fits best within a long-term relationship, so the number of coaching sessions and the duration of the coaching intervention must have to fit this. Feedback should be presented at least once a week, but due to individual differences and different working hours etc., a flexible and interactive feedback schedule is preferable.
- *When should the coaching take place?* Insights from WP1 suggest that advice based on feedback should probably be presented just before a trip. Pure informative feedback, on the other hand, should preferably be available after each trip.
- *What potential risks with introducing the coaching schemes need to be considered?*
- *Do the interventions require any technology? If so, what type of technology is suitable to use?* Insights from WP1 suggest that coaching relies on reliable data

on actual driving behaviour so instead of self-observation, telematics systems documenting data seems to be a better alternative. Therefore, MeBeSafe wants to make full use of the data gathered by vehicle-based sensors and In-Vehicle Monitoring Systems (IVMS). For the online self-coaching intervention, technology for providing feedback and advice that is linked to each journey is also necessary.

7.7.5 Design considerations Stage 3

When decisions have been made at Gate 2, additional aspects needs to be considered so that the intervention can be further developed and detailed in Stage 3. Some aspects have already been identified during WP1 while additional ones need to be identified and explored in WP4. Aspects important to consider in WP4 include:

- *How should the coaching schemes be designed to have good effect and reduce potential risks?* Insights from WP1 suggest that information, feedback and advice need to be simple, objective, relevant (i.e. understandable and pertaining to driving) and come from a respected and trustable source. Information fed back to drivers should be simple and consist of only a few variables. The level of detail of the information provided to drivers must be determined in relation to the target group as the optimal level varies with the person, problem and situation. Feedback on individual behaviour should only be made available to the coaching pair. Only overall (mean) results for the whole company should be available to all drivers and supervisors. Providing context specific coaching seems appropriate.
- *How should the coaching schemes be designed to ensure a good social relationship between the coach and the coachee?*
- *How should the required technology be integrated and adjusted to provide a good basis for the coaching scheme?*

7.8 Comparison of the proposed MeBeSafe interventions

Figure 7.9 provides an overview of how the proposed interventions relate to each other based on the integrated framework presented in Chapter 4. As shown in the figure, the majority of the interventions will take on a nudging approach focused on re-designing the driving context in order to both improve opportunities for safe driving and to better communicate those opportunities. These interventions will address System 1 thinking and unconsciously support users to drive more safely. The WP4 coaching interventions and two of the WP2 nudging interventions will address the road users and their motivation and skills. While all the interventions that take on a nudging approach will address specific situations and aim to influence behaviour during a momentary or short time frame, the coaching interventions will address a longer time frame and aim to influence behaviour not only during specific situations but also prior to and after.

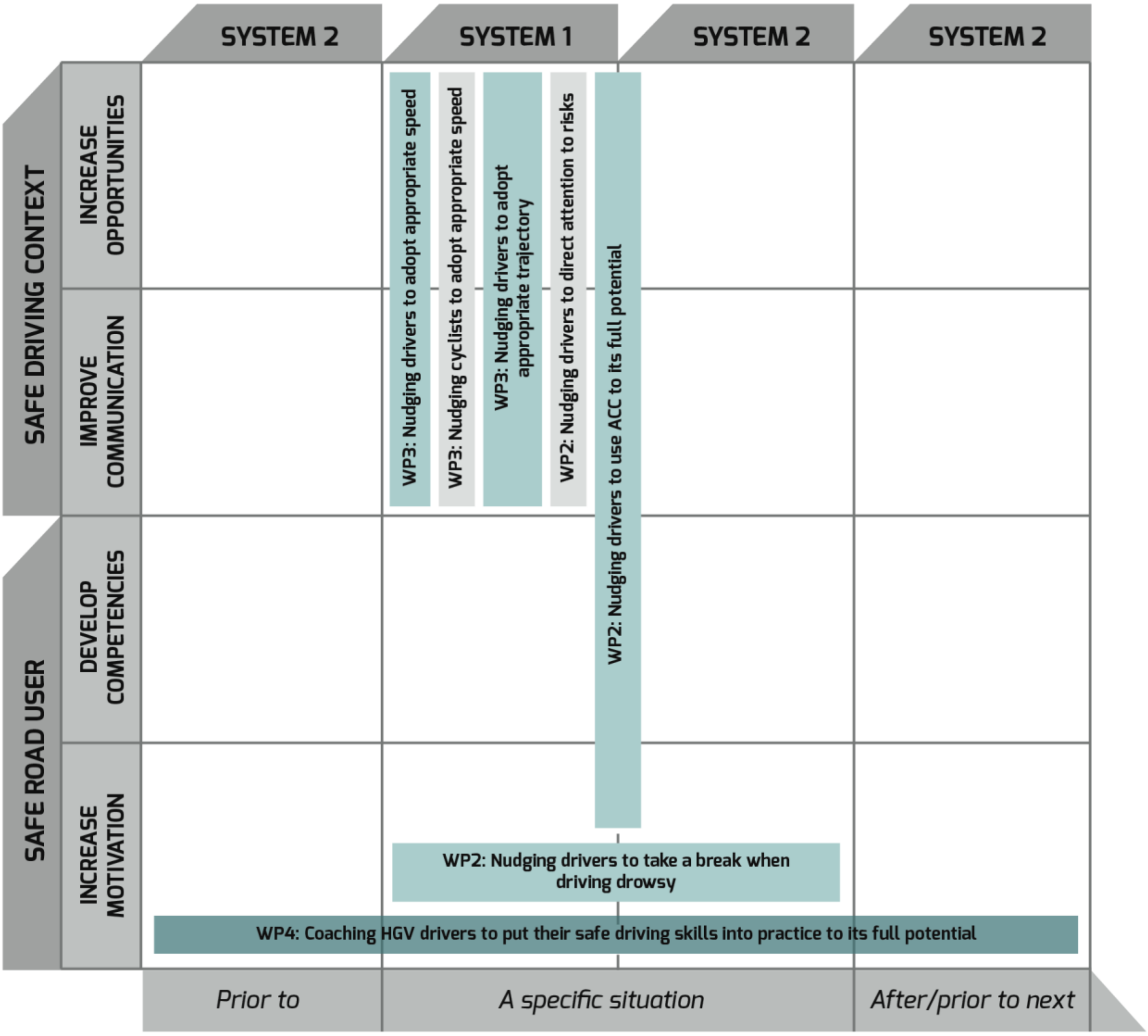


Figure 7.9: Overview of the proposed MeBeSafe interventions

8 Deviations from Workplan

There are no deviations to the workplan.

9 Conclusion

WP1 has resulted in the following:

- The key characteristics of nudging and coaching respectively have been identified and described.
- A framework has been developed that attempts to integrate the principles of nudging and coaching, taking into consideration time and frequency.
- Fundamental, underlying theories and models of relevance for understanding road user behaviour have been described and related to the principles of nudging and coaching.
- Road user profiles or characteristics of relevance for the project have been addressed and considerations have been proposed for the design of the interventions (in WP2, WP3, and WP4), as well as the design and interpretation of the outcome of the field trials (in WP5).
- Based on the literature studies, the available data from interviews with different experts, and workshop activities, design considerations have been extracted. These are intended to help improve the initial ideas for the respective interventions and are to be taken into consideration when designing the nudging and coaching interventions in WP2, WP3, and WP4 respectively.

In designing the respective interventions, the design considerations need to be developed further into more detailed design requirements.

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Annex

A. Examples of Intervention Strategies

Examples of intervention strategies for

1) *(re)designing the driving context so that opportunities for safe driving increases and are better communicated*
2) *influencing the road user to drive safely by developing competencies and by increasing motivation*

SAFE DRIVING CONTEXT	INCREASE OPPORTUNITIES	Design the road system in a way so that all components jointly facilitate safe behaviour
		Add components to the road system in order to increase opportunities for safe behaviour
		Add functions to the road system to facilitate performance of safe behaviour
		Add functions to the road system or components to restrict risky behaviour in certain situations
		Add functions to the road system or components to eliminate risky behaviour
		Design the interaction with components in a way so that safe behaviour is scripted/guided
		Design the interaction with components in a way so that errors are prevented
		Make the interaction with the components easy, effortless, and convenient
		Make use of opt-out default options so that safe behaviour requires little effort
		Make use of prompted choice so that the consequences of behaviour is made conscious
		Provide reminders to make drivers aware of opportunities for safe driving
		Provide warnings to make drivers aware of potential risks
	IMPROVE COMMUNICATION	Communicate safe driving opportunities either explicitly or implicitly
		Make use of different types of stimuli to communicate safe driving opportunities
		Enhance consequences of behaviours to make it easier to evaluate opportunities and outcomes
		Structure and group complex options to make it easier for the driver to choose between them
		Provide information in a way that match conventions and the driver's previous experiences
		Ensure that a stimuli's associated outcome match the driver's expectations
		Adapt the format through with information in provided so that it suits the driving situation
		Simplify information to reduce the driver's cognitive burden in a specific situation
		Frame information from a certain perspective to influence perception and evaluation of outcomes
		Prime information to influence the processing and responses of subsequent stimuli
		Anchor information to a specific starting point to facilitate interpretation
		Schedule information to provide information only when needed to reduce cognitive burden
SAFE ROAD USER	DEVELOP COMPETENCIES	Provide the driver feedback and data on the driver's behaviour and its effects
		Provide the driver general information about risks associated with the behaviour
		Provide the driver information about the benefits and costs of action and inaction
		Tell the driver how to perform a behaviour or preparatory behaviours
		Have an expert or peer show the driver how to correctly perform the behaviour
		Teach the driver to identify environmental cues that remind the driver to perform the behaviour
		Set easy tasks for the driver and increase difficulty until the target behaviour is performed
		Prompt the driver to rehearse and repeat the (preparatory) behaviour
		Help the driver to identify and manage situations likely to result in re-adopting risky behaviours
		Prompt the driver to identify barriers to the behaviour and to plan for how to overcome them
		Prompt the driver to monitor/keep a record of the behaviour
		Support drivers in self-evaluating their own behaviour
	INCREASE MOTIVATION	Provide the driver praise, encouragement or material rewards that are linked to the behaviour
		Prompt the driver to compare performance to a pre-set standard or to others performance
		Provide the driver information about others (dis)approval of the behaviour
		Prompt the driver to observe others' performance e.g., in a group class or using video
		Indicate how the driver may be a good example to others
		Arouse emotions to trigger motivation for safe driving
		Prompt the driver to formulate self-motivating statements
		Prompt the driver to use self-instruction and self-encouragement (aloud or silently)
		Prompt the driver to decide to set a general goal
		Prompt the driver to make a detailed plan of what (s)he will do
		Prompt the driver to sign a resolution (contract) specifying the behaviour to be performed
		Prompt the driver to review previously set goals or intentions

B. German In-Depth Accident Study (GIDAS)

The creation of the road traffic user profiles with European statistics is very limited, because the European road traffic statistic only considered traffic fatalities. However, these statistics only reflect a small proportion of road users in the EU. Due to a lack of detailed information, an overview of the road traffic users is to be given with the help of the "German In-depth Accident Study" (GIDAS).

GIDAS is a cooperative project between the Federal Highway Research Institute (BASt) and the German Association for Research in Automobile Technology (FAT). The investigation of real traffic accidents is supported by the Medical University Hanover (MHH) and the Technical University Dresden (VUFO). In both investigation areas (Hannover, Dresden) more than 2,000 accidents per year are recorded. Each case is then encoded in the database with about 3,000 variables.

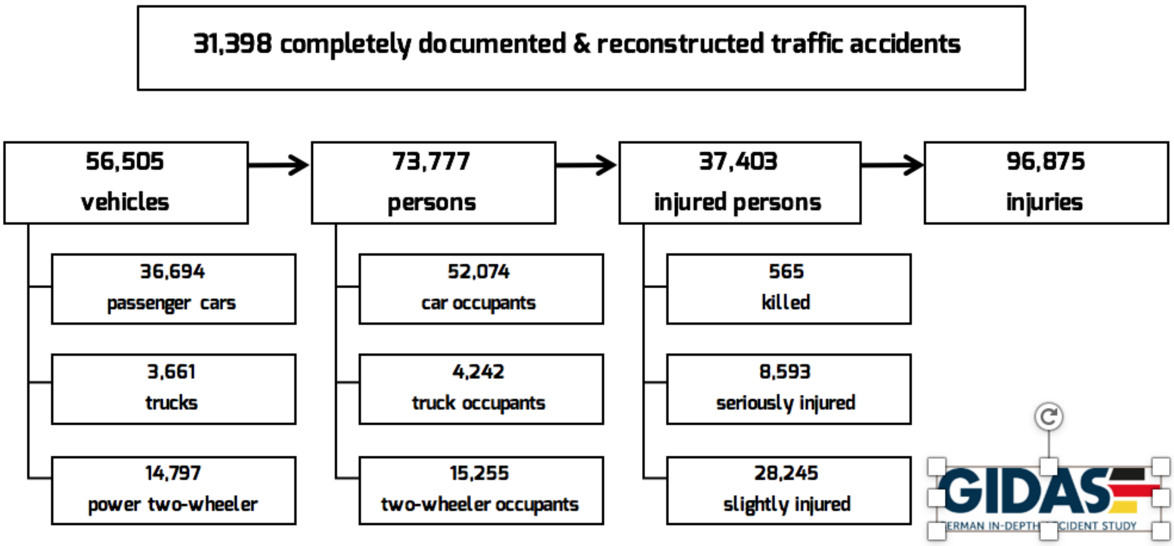

Figure A1: Scope of GIDAS database (last update 07/2017).

At the beginning of the MeBeSafe project, the GIDAS database (July 2017) contains nearly 31,400 complete documented and reconstructed road traffic accidents more than 56,000 involved vehicle drivers.

Due to the facts that

- the research areas (Dresden and Hannover) represent the average German topography very well,
- the investigation follows an exact statistic-sampling plan and
- the number of cases is fairly high,

the GIDAS database can be weighted towards the official German road traffic accident statistic to get representative results.