# MODELLING DRIVER BEHAVIOUR ON BASIS OF EMOTIONS AND FEELINGS: INTELLIGENT TRANSPORT SYSTEMS AND BEHAVIOURAL ADAPTATIONS[1]

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## ABSTRACT

Intelligent Transport System (ITS) is a generic concept, which covers a wide range of systems. In this context the concept is applied on automotive systems and comprises systems generally defined as Driver Assistance Systems (DAS), Advanced Driver Assistance Systems (ADAS), In-Vehicle Information Systems (IVIS) and (roadside) telematics. The present paper focuses on Anti-Locking Brake Systems (ABS), which is used as an illustrative example of an IT-system with some unintended effects that calls for explanations by appropriate driver behaviour models. ABS, which aims to maintain the steering capacity during (heavy) braking by preventing the wheels from locking, is considered as a Driving Assistance System (DAS). ABS has become an increasingly standard equipment of new car makes. ABS has also been around for more than 15 years and several studies have evaluated the effect of ABS on behaviour and accidents. ABS is a case of special interest for several reasons: One is the demonstration of risk compensation associated with ABS, a second is several contraintuitive and even detrimental effects on traffic safety. Hence, with use of ABS as an example, several key issues can be extracted which are of special interest when considering ITS in a more generic sense.

To better understand and predict effects of ITS, a theoretical driver behaviour model based on emotions and feelings is presented and discussed. A new aspect in the development of the present model compared to previous driver behaviour models is its theoretical foundation on neurobiology, where concepts as emotions, feelings and the relationship and interplay between unconscious and conscious process are central.

It is postulated axiomatically that man's deepest motive is survival. It follows, likewise axiomatically that the organism must have an instrument, an organ, which enables it to survey its surroundings and the situations in which it acts. It is further postulated, that this organ is the organism itself, the complete body and its inherent physiology which has been refined by evolution through the developmental history of man where the identification of dangers has been of utmost importance. The organism taken as a whole is considered as a monitor, an organ for surveillance whose prime task is to monitor the interior, i.e. the state of the body, and the exterior, i.e. the surroundings and other actors, with whom the organism must interact. It is remarkable that man's inherent ability to handle risks is as effective and safe as it is in road traffic, while, on the other hand, this ability fails to recognize and cope with some dangers which, objectively speaking, really are dangerous. The inferiority of recognizing certain dangers is aspects that need discussion. Hence, inherent, (neuro)biological weaknesses of risk monitoring should be of special importance for developing ITS-solutions, because a given IT-system may offer better risk monitoring performances than the human organism itself.

Driving is a special case of living in which survival, risk perception, information processing and decision-making, are the main foci. Adopting the view of Damasio, his *Somatic-Marker Hypothesis*, and un-orthodox definitions of emotion and feeling, makes it possible to distinguish between unconscious and conscious processes that govern

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(driving) behaviour. The central concept in the proposed model is ***functional balance***, which is defined as the ***target feeling*** or ***the best feeling.*** The drive to achieve functional balance is regarded as a basic, predominantly unconscious knowledge, which the organism possesses about itself, and which the organism is actively seeking to restore or to maintain. Further, it is an assertion that this unconscious quest for functional balance becomes the steering principle in the model, and this also may constitute the basis for a deeper understanding of risk compensation.

Keywords: Driver behaviour models, Intelligent Transport Systems, emotions, risk compensation, behavioural adaptation, Damasio.

## INTRODUCTION

Intelligent Transport System (ITS) is a generic concept, which covers a wide range of systems. In this context the concept is applied on automotive systems and comprises systems generally defined as Driver Assistance Systems (DAS), Advanced Driver Assistance Systems (ADAS), In-Vehicle Information Systems (IVIS) and (roadside) telematics. The present paper focuses on Anti-Locking Brake Systems (ABS), which is used as an illustrative example of an IT-system with some unintended effects that calls for explanations by appropriate driver behaviour models. ABS, which aims to maintain the steering capacity during (heavy) braking by preventing the wheels from locking, is considered a Driving Assistance System (DAS) that has become an increasingly standard equipment of new car makes. ABS has also been around for more than 15 years and several studies have evaluated the effect of ABS on accidents. ABS is a case of special interest for several reasons: One is the demonstration of risk compensation associated with ABS, a second is several contra-intuitive and even detrimental effects on traffic safety. With ABS as a base, several key issues can be pinpointed when considering ITS in a more generic sense. Finally, to better understand and predict effects of ITS, a theoretical driver behaviour model based on emotions and feelings is presented and discussed.

## THE STRANGE CASE OF ANTILOCKING BRAKING SYSTEMS (ABS)

A German field study addressing the effects of Antilocking Brake Systems (ABS) on behaviour and accidents has become a classic study of risk compensation (Aschenbrenner et. al., 1987). Aschenbrenner et. al. applied Wilde's Risk Homeostasis Theory (RHT) (Wilde, 1982) to predict that risk compensation might be seen among drivers using cars equipped with ABS. As a conseqeunce, the suggested safety potential inherent in ABS, might be reduced or even cancelled out. To test this hypothesis Aschenbrenner et al designed an experiment to be performed within a taxi company in Munich. The taxi company equipped some of its cars with ABS, and let some of its cars remain without ABS. The taxis in two groups were similar, they only difference was the fitting with and without ABS. The drivers were randomly assigned to the two groups, and they were all told, which kind of brakes their taxi had. Driver behaviour was recorded by observers "camouflaged" as passengers. They all asked the taxi drivers to drive exactly the same trip. Data from a total of 113 trips were recorded, evenly distributed between taxis with and without ABS.

Driver behaviours were recorded on 18 variables. Of these, statistically significant differences were observed on four variables (Aschenbrenner et. al. 1987). These were:

- Drivers of taxis equipped with ABS were more often outside their lane than drivers of taxis without ABS
- Drivers with ABS "cut corners" more often than drivers without ABS
- Drivers with ABS predicted the traffic ahead to a lesser degree than drivers without ABS
- Drivers with ABS were more often involved in conflicts with other road users than drivers without ABS

Driving speeds were measured at four sites along the fixed trip. By one of these, in a 60 kmh speed zone, the driving speeds of ABS-drivers were significantly higher than among drivers without ABS.

Accidents were also recorded and analysed. The number of accidents was controlled for mileage and also for seasonal variations. It turned out that cars with ABS were involved in as many accidents as cars without ABS. Aschenbrenner et al conclude that driving behaviour of the ABS-taxis has been less cautious. In addition, there was no effect of ABS on the number of accidents (Aschenbrenner et. al. 1987).

So what happens to drivers who drive vehicles equipped with ABS? What lay behind the behavioural differences? Is it a matter of thinking differently than drivers of vehicles without ABS? Do they feel differently? Is behaviour governed by conscious processes, by unconscious processes, or both? Is it to be explained by vehicle characteristics, driver characteristics, or both? Aschenbrenner et als study is not the only one confirming behavioural differences between drivers of ABS-vehicles and drivers of vehicles without ABS. Sagberg et al found that (Norwegian) taxis with ABS had significantly shorter headways than taxis without ABS (Sagberg et. al., 1997), but found no relationships with driving speeds, possibly because dense traffic at the observation site may have prevented drivers from driving at their preferred speeds. No behavioural differences for drivers with cars with and without airbags were found. Sagberg et al conclude generally that there is more compensation found for accident-reducing than for injury-reducing measures.

Broughton and Baugha (2002) found in a postal survey that ABS does have the potential of reducing the number of accidents, but also that many drivers have little or no knowledge of ABS and its effects. They found an overall accident reduction tendency of 3% (insignificant at confidence level of 90%), a tendency to increase the number of accident by 10% (insignificant) among men aged 56+, a 16% accident reduction among men aged 17-55 (significant), and a tendency among all women of increasing the number of accidents by 18% (insignificant). One reason that the number of accidents may increase among females, and among men aged 56+, may be that some drivers have little or no knowledge of ABS and its effects. One hypothesis is that the way in which many women and older men use the ABS may tend to increase their risk of accidents (Broughton and Baugha, 2002).

In a comprehensive meta-analysis of accident studies on ABS it was found that the overall effect of ABS for personal cars was a marginal, although statistically significant accident reduction of 3,5% (Elvik and Vaa, 2004). However, the effect on fatal accident went in the opposite direction as they were increased by 6%, also statistically significant (table 1):

*Table 1: Effects of ABS on accidents. Percentage change in the number of accidents. Results from meta-analysis (Source: Elvik and Vaa, 2004).*)*

| | *Percentage change in the number of accidents* | | |
|---|---|---|---|
| ***Level of injury*** | ***Accident types that are affected*** | ***Best estimate*** | ***95% CI*** |
| **ABS – brakes on personal cars** | | | |
| All vehicles | All | -3,5 | (-44; -2,6) |
| Injury accidents | All | -5 | (-8; -2) |
| Fatal accidents | All | +6 | (+1; +12) |
| **Effects on specific types of accident** | | | |
| Unspecified (All) | Overturning accidents | +22 | (+11; +34) |
| Unspecified (All) | Single acc. without overturning | +15 | (+9; +22) |
| Unspecified (All) | Intersection accidents | -2 | (-5, +1) |
| Unspecified (All) | Rear-end collisions | -1 | (-5; +3) |
| Unspecified (All) | Collision with fixed objects | +14 | (+11; +18) |
| Unspecified (All) | Collision with turning vehicles | -8 | (-14; -1) |
| Unspecified (All) | Pedestrians/cyclists/animals | -27 | (-40; -12) |

*) The meta-analysis is based the following evaluation studies: Aschenbrenner et. al. (1987), Kahane (1993 and 1994): Hertz et. al. (1995A and 1995B): Evans and Gerrish (1996).

What are even more compelling are the effects on different accident types. On the one hand, ABS seems to reduce collisions with turning vehicles and accidents with pedestrians, cyclists, and animals. A reduction of accidents with moving objects is what would be expected, as an effect of ABS is the ability to maintain the steering capability during braking.

However, on the other hand, the number of overturning accidents, single accidents without overturning, and collision with fixed objects, are all accident types that significantly increased. The effects on intersection accidents, and rear-end collisions, were practically zero, no change in the number of accidents regarding these accident types were documented (Elvik and Vaa, 2004).

ABS also reduces stop lengths. Personal cars with ABS on all wheels have considerably shorter stop lengths on wet surfaces than personal cars without ABS (Robinson and Duffin, 1993). ABS may reduce stop lengths by 20% at speeds over 80 kmh and at same time maintain stability. But doubts have been raised that ABS may have failed or lost its effect in critical situations. American traffic police have addressed this question (Brandt, 1994). The situation they wanted to investigate would probably be rare for the common driver, but more prevalent for police patrols during an alarm, chasing a criminal or the like. Suspicions arose among American traffic police forces to the extent that they decided to investigate and measure stop lengths in critical avoidance manoeuvres. The suspicions were confirmed, stop lengths did increase when drivers were braking in avoidance manoeuvres. The explanation to this phenomenon is uncertain, but consider the difference between braking with ABS and with ordinary brakes: Heavy braking with ordinary brakes in a critical situation would lock the wheels, i.e. all friction will be used to reduce speed to the disadvantage of loosing steering control, while braking with ABS the braking forces would be split between reducing speed and maintaing steering capacity. In other words, some of friction forces between wheel and road surface is utilized for steering, resulting in less friction for reducing the speed of the car (Brandt, 1994).

## BASIC ISSUES OF RELEVANCE FOR INTELLIGENT TRANSPORT SYSTEMS (ITS)

Why describe a system like ABS to such detail? Is it of relevance for ITS in a more general and broader sense? Indeed it is. Several issues can be extracted from this "strange case of ABS" that would be of interest to elaborate and discuss further:

1) Drivers with ABS-cars seem to behave differently than drivers in cars without ABS. ABS seems to affect speed choice, headways, lateral position, and conflicts with other road users. ABS seems "to do something" with drivers, it affects the driver in certain ways. What is this "something", what exactly does ABS do with the drivers?

2) The findings of Broughton and Baugha indicate that drivers' knowledge of the system, or rather lack of knowledge, affects the way drivers understand and operate ABS. Anecdotal evidence suggests that some drivers, when imposing all their powers on the brake pedal in a situation of emergency, experience that the pedal "strikes back", the pedal "shakes". This feedback is normal from an ABS, it is a property of the ABS when sensors prevent the wheels from locking, but some drivers may experience this feedback from pedal as "something is wrong" (with the brakes or other), which in turn may make the drivers lift the pressure off the pedal, the braking powers is then reduced, and it may result in an accident.

3) The third issue to be discussed is the Brandt hypothesis, i.e. that stop lengths may be increased because steering in critical avoidance manoeuvres may lead to less friction for reducing the speed of the car. This could then be a case of which the engineers that developed the ABS-technology in the first place, did not foresee every possible outcome of the effect of the system, which in turn suggests that the initial risk analysis of the system has been insufficient.

With ABS as an illustrative example, these three issues could be of relevance in a more basic and generic sense, i.e. of relevance for Intelligence Transport Systems (ITS) in general. Four hypotheses can then be extracted from the issues 1) - 3):

- The suggested effects of ITS may be counteracted and compensated by behavioural changes among drives. If so: Why do (some) drivers change their behaviours as a function of a given ITS? And second: What kind of properties is it that may result in behaviour changes among drivers?
- A more self-evident hypothesis is that the effect of a given ITS would be dependent upon driver knowledge of the system. Improper or insufficient knowledge of a given system may lead to a reduction of the potential effect of ITS, or even to detrimental effects.
- The scenarios incorporated in the risk analysis preceding the development of a given ITS may be incomplete, i.e. some outcomes of an ITS may be unforeseen. Given the large variation of driving situations, driving tasks, and drivers, (some) drivers will hit the occasions where the effects of a given ITS are reduced, unforeseen, and/or detrimental.
- Technology can be defined, at least in some cases, as an extension of the human organism, which can bring humans to situations where the organism is poorly suited for mastering. In principle, any ITS could have the potential of carrying a driver to situations which he is unable to cope with.

## EVOLUTION, ADAPTATION AND NEW TECHNOLOGY

Human beings try to adapt to whatever environment she or he is exposed to. Adaptation is a necessary prerequisite for survival, it is an integral part of the survival mechanism of the human organism. Survival is regarded as the most basic motive of human beings (Damasio, 1994), and adaptation is a tool of necessity for survival. Piaget has at times simply defined intelligence as the ability to adapt (Hoff, 2002). A driver adapts to whatever car he/she wishes to use. A car transports a driver to situations he/she would not have been exposed to without the car. A car somehow ***extends*** the organism, the car has the potential of eliciting propensities in humans that may otherwise have been hidden, repressed, not seen, unless he/she had been "extended by the car". Driver aggression and elciting hostility towards other road users is one example, the feeling of status in another, the transition from powerlessness to status/power is a third. Some drivers are even tempted to frighten people: Varhely (1996) has shown that some 1/6 of drivers (17%) accelerate when they see a pedestrian entering a pedestrian crossing. There are numerous cases of drivers using the car as weapon and as a means to hurt or even kill people (Vaa, 2000). Humans bring with them fylogenetic abilities and propensities developed by evolution over a time span of say 10,000, 100,000 or even 1 million years into new environments by means of technologies that have not been part of the evolution history of the human organism. Then, as a consequence, these dispositional propensities may be limited regarding ability of humans to cope with certain situations created and promoted by todays' technology, which also means that he/she is misguided, misled, and not adequately warned, when they enter situations brought to them by new technology, because the ability to monitor and judge risk is not adapted to experiences into which technology has "transported" him or her. The expansion of spaces to act, an expansion which is provided by technology, is not fully accompanied with the tools the organism need for coping adequately with the risk of situations brouhght to the organsim by new technology. Given the enormous death tolls and personal injuries, the car is probably the most unprecedented example of the mismatch and maladjustment between humans and technology of any time.

Who is responsible for the mismatch between man and technology? Is man responsible? Is technology responsible? Should we demand that human beings, by their ability to think, of being conscious of what he/she is doing, should detect, stop, and refrain from situations, which he/she is at danger? Or has the consciousness, and its ability to assess and discover risk, a limited ability to detect danger in those situations of danger?

## THE ENTITY TO BE STUDIED SHOULD BE THE "EQUIPAGE": "THE-DRIVER-IN-A-CAR"

It is obvious that a car "do something" with drivers in terms of compensation mechanisms and in terms of bringing the driver into situations, which are difficult to handle. A car represents a tool that enhances the possibilities and acting space of the human organism. There is a difference between a VW 1200 1974-model which accelerate from 0-100 kmh in about 30 seconds and a 2004-model Mercedes 200 SLK Kompressor which accelerates from 0 to 100 kmh in some 7,5 seconds. The Mercedes sports car can realize potentials of overtaking and speeding behaviours that are impossible to realize in a VW 1200 1974-model. As a consequence, the basic entity to be studied should not be the driver as such, but rather "the-driver-in-a-car", because a car represents different potentials of driver conduct. Further, there is also a difference between:

- "Drivers being brought into dangerous situations by technological systems". The car is obviously one such system.
- "Improving the ability of drivers to avoid or handle dangerous situations".

ITS have potentials of avoiding or handling difficult situations. Route guidance is one ITS-example that could prevent or eliminate "searching behaviour" that may put the driver searching for the right exit and surrounding road users at risk. In a generic way, Intelligent Transport Systems do have potentials of counteracting or limiting dangerous driver behaviour by improving risk monitoring in situations where the human organism is at enhanced risk either because of the organism's limited ability to assess risk in given situations or by preventing drivers from entering dangerous situations.

## UNDERSTANDING ITS AND BEHAVIOURAL ADAPTATIONS: A DRIVER BEHAVIOUR MODEL BASED ON EMOTIONS AND FEELINGS

Keeping in mind the example of ABS above, several issues are essential when considering effects of ITS on driving behaviour:

- How will drivers adapt to ITS?

- To what extent can behavioural adaptations of ITS be predicted?
- To what extent will predicted effects of ITS be counteracted and/or compensated by behavioural changes among drives?
- To what extent is a given ITS based on a model of driver behaviour?

The scope of the present paper is not to answer all these issues, but rather to present a model of driver behaviour that may have a potential of understanding and predicting behavioural effects of certain Intelligent Transport Systems.

A new aspect in the development of the present model compared to previous driver behaviour models is its theoretical foundation on neurobiology, where concepts as emotions, feelings and the relationship and interplay between unconscious and conscious process are central (Vaa 2003a).

Antonio R. Damasio and the neurobiological perspective he elaborates in his book,"*Descartes' Error: Emotion, Reason and the Human Brain"* (Damasio 1994), provides a more basic understanding of humans that may serve well as a basis for a model of driver behaviour. The basis for the model is three simple axioms:

- ***Axiom 1:*** Man's deepest and most fundamental motive is ***survival.***
- ***Axiom 2:*** Man must possess a specialized ability to detect and avoid dangers that threatens his/her survival. Hence, man must possess an organ that takes care of the necessary monitoring of potential threats.
- ***Axiom 3:*** Evolution has developed and designed the human organism to be this monitor which prime objective is detection of dangers and securing survival. ***The body is the monitor***.

It follows axiomatically from the assumption that man's deepest motive is survival, that the organism must have an instrument, an organ, enabling it to survey its surroundings and the situations in which it acts. This organ is the organism itself, the complete body and its inherent physiology developed by evolution through the history of man where observation and identification of dangers have been of vital importance. The organism taken as a whole is considered as a monitor, an organ for surveillance whose prime task is to monitor the interior, i.e. the state of the body, and the exterior, i.e. the surroundings and other actors with which the organism interact.

It is remarkable that man's inherent ability to handle risks is as effective and safe as it is in road traffic, while, on the other hand, this ability may fail to recognize some dangers realized through new the use of new technology. The inferiority of recognizing certain dangers is, hence, also aspects that need discussion.

Damasio postulates a relationship between internal states and external behaviour when the human organism is exposed to certain strain and emotional stress, which forms:

> *"…. a set of alterations [which] defines a profile of departures from a range of average states corresponding to a functional balance, or homeostasis, within which the organism's economy probably operates at its best, with lesser expenditure and simpler and faster adjustments " (Damasio, 1994).*

A central concept in the above citation is the ***functional balance***. This functional balance is considered and defined as the ***target feeling*** or ***the best feeling***. It is this ***functional balance*** which is retained as one of the central principles in the model. The drive to achieve functional balance is regarded as a central, predominantly unconscious knowledge, which the organism possesses about itself, and which the organism is actively seeking to restore or to maintain. Further, it is an assertion that this unconscious quest for functional balance becomes the steering principle in the model, which also may constitute a basis for a deeper understanding of risk compensation. This view is presented as an alternative to Wilde's RHT and especially also to his concept "target risk" (Wilde 1982), i.e. drivers are not seeking a certain risk level other than zero, as in Näätänen and Summala's "Zero-Risk Model"(1974). In conclusion, drivers are seeking a target ***feeling*** rather than a target ***risk.***

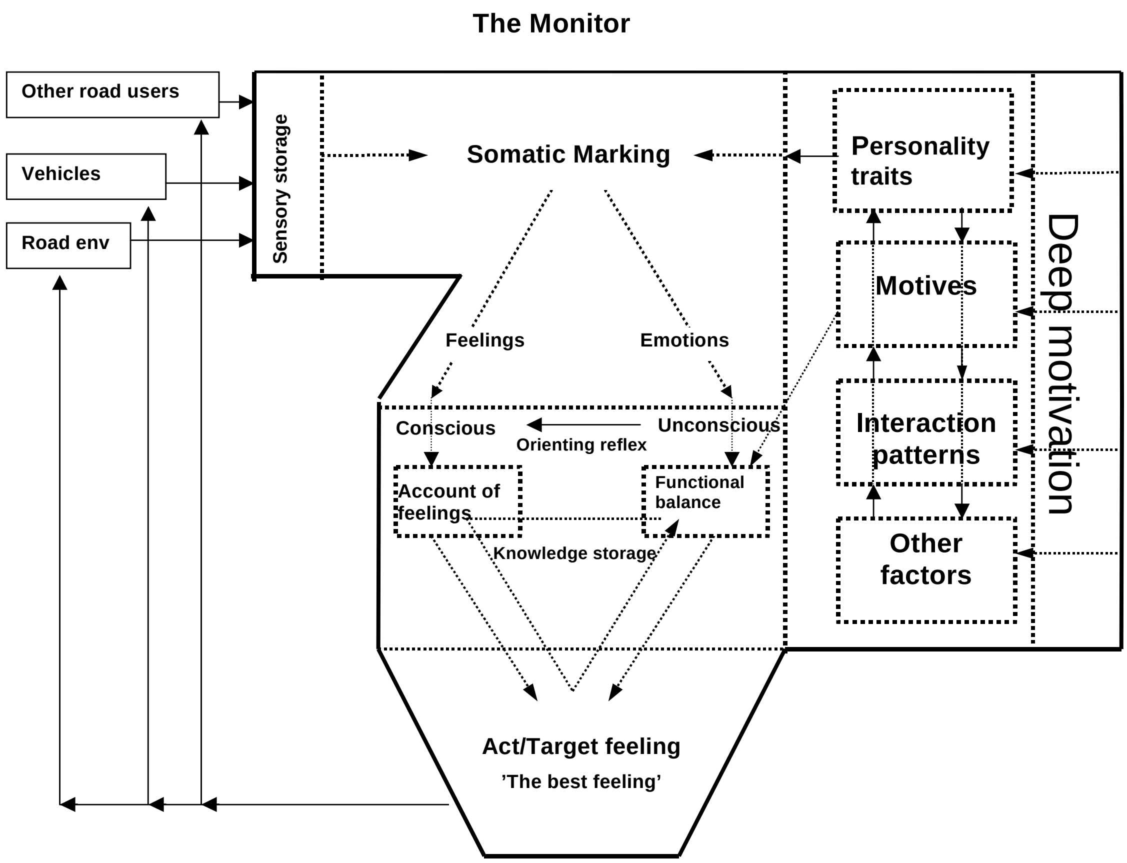
Damasio states his model by saying that something important happens before reasoning, before the application of a cost-benefit analysis of the inner scenarios. If, for example, a situation seems to develop into something threatening or dangerous, a feeling of unpleasantness will enter the body, an unpleasant 'gut feeling' may be under way. Because this feeling is knit to the body, Damasio labels it ***somatic*** ('soma' is Greek for 'body') and ***marker*** because the feeling marks the picture or the scenario. Damasio describes the consequence of this ***somatic-marker*** in the following way:

> *[A somatic marker.].."forces attention on the negative outcome to which a given action may lead, and functions as an automated alarm signal which says: Beware of danger ahead if you choose the option which leads to this outcome….*

*…. The automated signal protects you against future losses, without further ado, and then allows you* ***to choose from among fewer alternatives*** *(Damasio 1994, page 173).*

The second central concept of the model is then the ***account of feelings***, a concept which is used to describe a conscious process and defined as a cognitive ‘weighting’, or “cost-benefit analysis” of conscious, internal scenarios against each other (Damasio 1994; Overskeid 2000).

The introduction of a monitor is justified by the Damasio model and his assertion that emotions and feelings are fundamental mechanisms which are involved in the organism’s perception and evaluation of dangers. The concept is also adopted from Näätänen and Summala’s “Zero-Risk Model” (1974). Hence, the monitor is then both a concept and a principle, as well as a model for organising processes that influence sensing, processing of information and decision-making that will affect factors outside the organism. Figure 1 presents the basic structure of the monitor.




Source: TØI report 666/2003

*Figure 1: Basic Structure of the Monitor Model (Source: Vaa 2003a)*

The monitor is nothing less than the whole of the body, the whole organism. The boundaries of the monitor (solid line) correspond to the boundary of the body. The internal components are all elements and processes enclosed by the solid line: Somatic marking, personality traits, motives, interaction patterns, other factors. Deep motivation serves as a base and will potentially influence other components through personality traits, motives, and interaction. Personality traits influence motives and dispose for interaction patterns that are idiosyncratic for each driver. The interaction pattern of the individual driver can in turn elicit new, latent motives as a consequence of other road users’ responses on the initial act(s) of the driver.

There are two routes or modes of information processing and acting, one predominantly conscious through feelings and account of feelings, and one predominantly unconscious (automated) through emotions and functional balance. Both modes aim at maintaining or restoring a functional balance of the organism, which is achieved by the act that realizes the target feeling, either by conscious route or automated route. The orienting reflex bridges the gap from automated mode to conscious mode and further to account of feelings if necessary. The organism will prefer and seek to be governed by automated mode if possible, as this mode is less costly, i.e. the organism wants to economise with its cognitive (mental) resources (Reason 1990; Damasio 1994). However, the organism does not decide (consciously) to go to automated mode, this "decision" should rather be regarded as a property of the organism itself, i.e. to be governed by automated mode whenever possible.

One superior motive, alongside with the motive of survival, is then to establish or maintain the functional balance of the organism. During automated behaviour, there is identity between target feeling and functional balance. Hence, there is a direct impact from motives to functional balance and to target feeling (Vaa 2003a).

## IS IT SAFE TO DRIVE IN ROAD TRAFFIC? THE RELATIVE SUCCESS OF RISK MONITORING

According to the most recent calculations of accident risks in Norway (Bjørnskau, 2003), the risk of a personal injury accident among drivers is 0,18 person injury accidents per million kilometres, i.e. one driver must drive some 5.5 million km before he or she, on the average, would be injured in an accident. Let us suppose that a driver drives from 18 – 83 years of age, i.e. for 65 years. The Norwegian average driving distance is ca 14.000 km per year. One driver will then drive a total of approx 910.000 km in 65 years. Hence, it takes 5.5 : 0.910 ≈ nearly 400 years, or a group of 6 drivers of which only one, on the average, will experience one injury accident during a lifelong carrier as a car driver. Then, individually speaking, it is quite safe to drive. Further, it illustrates the relative success of risk monitoring, which is remarkable taking into account that the ability to monitor risk has been developed, through evolution, for a different time, and for different environments, than for the system of road traffic.

Inherent in this perspective, is the question of whether road traffic accidents could be viewed as deviance, as consequences of deviant states or certain behaviours in marginal driver groups. Such an assertion can be justified when considering high relative risks of accidents associated with drink driving, fatigue, drug abuse, certain medical conditions, young drivers, elderly drivers, and drivers with certain personality traits (Vaa 2003a, Vaa 2003b)

## WEAKNESSES OF RISK MONITORING AND POTENTIAL BENEFITS OF ITS

One basic question to be asked is whether a given ITS would alter the functional balance of the driver. Obviously, ABS has done just that, as shown by ABS-drivers driving faster and with shorter headways than drivers without ABS. A second basic question would be whether a given ITS addresses aspects where the organism's ability to monitor risk is weak or inadequate. No doubt, drivers' ability to monitor risk is far from perfect. The monitor is not an infallible machine, it has weaknesses regarding monitoring of dangers, even if some of its functions can be modified and improved by experience. Some important examples of monitor weaknesses that theoretically could be improved by ITS would be:

- Preventing excessive speeds, especially among young, inexperienced drivers who underestimate the dangers of high driving speeds
- Drivers' appraisal of their ability to stay awake while driving is inadequate. Systems that monitor and warn drivers of falling asleep could hence, in principle, be beneficial
- The ability to detect speed changes of the car in front is poor, which calls for alarm systems that warn drivers of speed changes and/or changes of time headways
- Alarming drivers attempting to overtake when there is a moving object in the dead angle of the side mirror
- Warnings of cyclists and MCs on a crossing course: Some drivers are unable to detect 2-wheeled road users on opposite course especially in left turns at crossings
- Warnings of crossing vehicles at junctions, especially among elderly drivers who are overrepresented in accidents at junctions
- Warning systems that warn drivers of pedestrians at pedestrian crossings

The general issue illustrated with the above examples is the recognition that drivers have difficulties with detecting dangers in specific situations, i.e. difficulties that possibly can be attributed to neurobiological limitations of the organism's ability to monitor risk.

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