

PROPOSING A RISK MONITOR MODEL BASED ON EMOTIONS AND FEELINGS: EXPLORING THE LIMITATIONS OF PERCEPTION AND LEARNING

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ABSTRACT

Recent achievements in neuroscience call for a new paradigm in many fields of human behaviour, not least behaviours of road users. One important contributor to this new paradigm is Antonio R. Damasio and the perspective he elaborates in “*Descartes’ error: Emotion, Reason and the Human Brain*”. Most prevailing driver behaviour models lack a neuroscientific basis, which requires revision of previous driver behaviour models, alternatively elaboration of new models. The present text proposes the Risk Monitor Model (RMM), which is explicitly based on Damasio’s paradigm. The RMM incorporates Reason’s model of information processing and decision-making, but takes Reason’s model a step further by integrating Damasio’s paradigm, which in turn provides an improved understanding of how perception and attention might operate in critical scenarios where the risk of accidents is salient. It is asserted that this revised model of information-processing and decision-making provides an alternative and better prediction of specific accident scenarios, which in turn call for measures that may be more effective in reducing the number of accidents.

KEYWORDS: Perception, emotions, feelings, driver behaviour, Damasio, The Risk Monitor Model

BACKGROUND

There is no doubt that recent achievements in neuroscience call for a new paradigm in many fields of human behaviour, not least behaviours of road users in road traffic. One important contributor to this new paradigm is the neurologist Antonio R. Damasio and the neurobiological perspective he elaborates in his book “*Descartes’ error: Emotion, Reason and the Human Brain*” [1]. Most prevailing driver behaviour models lack a neuroscientific basis, which requires revision of previous driver behaviour models, alternatively elaboration of new models. The present text proposes a new driver behaviour model, the Risk Monitor Model (RMM), which is explicitly based on Damasio’s paradigm [2]. The RMM incorporates basic elements of Reason’s model of information processing and decision-making [3], but takes Reason’s model a step further by integrating Damasio’s paradigm, which in turn provides, it is asserted, an improved understanding of how perception and attention might operate in critical scenarios where the risk of accidents is salient. It is asserted that this revised model of information-processing and decision-making provides an alternative and better prediction of certain accident scenarios, which in turn call for measures that may be more effective in reducing the number of accidents.

ACCIDENT SCENARIOS THAT CALL FOR REVISED ANALYSIS

In the present context, two accident scenarios which have puzzled me for years, are revisited: One is the accident increase at pedestrian crossings (figure 1):

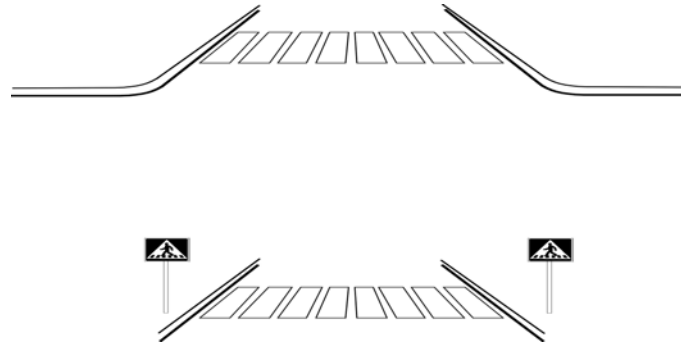


Figure 1. Ordinary marked pedestrian crossing with and without signposts

the other is the higher-than-expected involvement of MCs when cars do left-turns and a MC is on a crossing course (figure 4).

Scenario (1): The paradoxical effect of ordinary marked pedestrian crossings

In [4] the effects on accidents of several solutions of pedestrian crossings have been estimated. Here two other crossing solutions, depicted in figure 2 and 3, are compared with the one presented in figure 1:

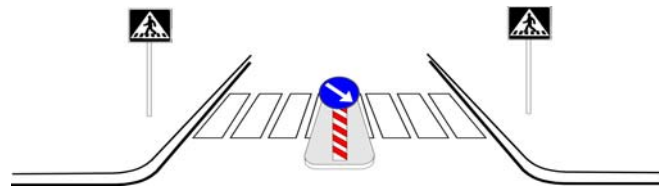


Figure 2. Marked pedestrian crossing with refuge

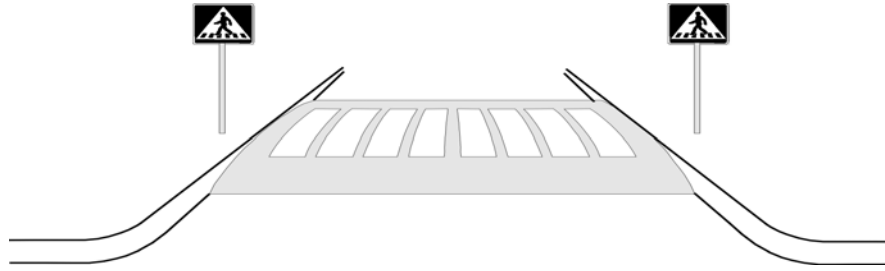


Figure 3. Raised pedestrian crossing

Table 1 shows the effects on accidents of these three types of pedestrian crossings [4]:

Table 1: Traffic control measures for pedestrians with statistically significant effects on accidents. Percentage change in the number of accidents. (from: Elvik and Vaa, 2004).

Percentage change in the number of accidents		Best estimate	95% confidence interval
Accident severity	Types of accident affected		
<i>Ordinary marked pedestrian crossings</i>			
Injury accidents	Pedestrian accidents	+28	(+19; +39)
Injury accidents	Vehicle accidents	+20	(+5; +38)
Injury accidents	All accidents	+26	(+18; +35)
<i>Refuges on pedestrian crossings</i>			
Injury accidents	Pedestrian accidents	-18	(-30; -3)
Injury accidents	Vehicle accidents	-9	(-20; +3)
Injury accidents	All accidents	-13	(-21; -3)
<i>Raised pedestrian crossings</i>			
Injury accidents	Pedestrian accidents	-49	(-75; +3)
Injury accidents	Vehicle accidents	-33	(-58; +6)
Injury accidents	All accidents	-39	(-58; -10)

One would expect that all these three measures would reduce the number of accidents, but, as shown in table 1, this is not the case. While pedestrian crossings with a refuge, and raised pedestrian crossings, reduce the number of accidents, an ordinary marked pedestrian crossing increases the number of accidents. Obviously, this paradox calls for an explanation. One simple attempt to explain the rise in accidents at an ordinary marked pedestrian crossing, would be that pedestrians, as a function of their knowing that cars are obliged to yield for pedestrians in this situation, enter the crossing, perhaps (very) abruptly in some cases, without checking if cars are approaching the crossing. However, if this is a prevalent pedestrian behaviour at a pedestrian crossing in general, one would expect that this behaviour would increase the number of accidents also at other types of crossings, as for example with pedestrian crossings with refuge, and with raised pedestrian crossings, but, as seen from table 1, it does not. One could argue that pedestrians behave differently by being more alert and vigilant with these two latter cases of crossings than with the former, but why should they? A Norwegian in-depth study of 36 accidents with pedestrians at pedestrian crossings, may throw some light on the interaction between car drivers and pedestrians [5]. The observations from this study shall be used to state hypotheses about accident causation:

- In 17 of the 36 accidents, the cause was attributed to pedestrian errors

- Pedestrians were hit by a car because they ran or “staggered” into the roadway without forewarning
- “To see a car is not the same as the driver sees me”
- In about 50% of the accidents, the pedestrian did not see the vehicle.
- Pedestrians involved in these accidents often belonged to subgroups who are more exposed than the average Norwegian also in other contexts, as pedestrians often were impulsive adolescents, mentally disabled, children, elderly people, intoxicated.

It is evident that a distribution of “accident-prone pedestrians” will prevail, in this sense the road system is “democratic”, it would be futile to educate marginal groups how to behave as pedestrians. As seen in table 2, the problem group of the four possible is and will still be when both the pedestrian and the driver are inattentive. The proposed solution must be to make the driver more vigilant at pedestrian crossings in order to reduce accidents with pedestrians at pedestrian crossings.

Table 2: Degree of attention distributed according to drivers and pedestrians

		The pedestrian	
		Inattentive	Vigilant
The driver	Inattentive	Problem	At risk, but may be saved by the other
	Vigilant	At risk, but may be saved by the other	No problem

The problem is twofold: Why is s/he inattentive and what can be done to increase the vigilance of drivers? The Norwegian study presents some clues regarding accident causation attributable to drivers [5].

- In 24 of 36 accidents the cause was attributed to the drivers
- Driving speeds were too high, and/or “too low awareness about risks although the circumstances called for something different”
- In 28 of 36 accidents drivers did not see the pedestrians “before it was too late”
- The two most pronounced explanations were: 1) Drivers do not check blind spots when needed, and 2) Drivers are more directed towards other road traffic than to spot pedestrians

It is obvious that accident causation is associated with being inattentive and two statements are regarded as especially interesting:

- “Drivers did not see the pedestrians before it was too late”
- “Drivers are more directed towards other road traffic than to spot pedestrians”

Given these statements, the following logical inference seems justifiable:

- Empirical base (I): Driver inattention is a prevalent characteristic which contributes to accidents at pedestrian crossings
- Empirical base (II): Pedestrian crossings with refuge, and raised pedestrian crossings, reduce the number of accidents with pedestrians, while ordinary marked pedestrian crossings increases the number of accidents with pedestrians

- Assumption (possibly also an axiom): Pedestrian behaviour does not differ significantly between crossing types, it remains the same across all types of pedestrian crossings listed in table 1 above
- Inference: Driver attention must operate differently in these three types of crossings: Attention is reduced in situation depicted in figure 1 and enhanced in situations depicted in figures 2 and 3.
- Problem statement: Why is attention reduced in situation depicted in figure 1 and enhanced in situations depicted in figure 2 and 3?

This is then *the* core problem to be focused: Is it possible to explain why the attention seems to be reduced when a driver approaches an ordinary marked pedestrian crossing? Or more precisely: Why do drivers have more problems with detecting pedestrians at ordinary marked pedestrian crossings than with other types of pedestrian crossings? This problem has puzzled me for some time to the extent that I some years ago started to count when a pedestrian actually was present or about to enter an ordinary marked pedestrian crossing. Table 3 presents the results of these ad-hoc counts:

Table 3: Frequenc of pedestrians observed in ordinary marked pedestrian crossings in an ad hoc-sample of Norwegian cities, suburb and villages and one week-end roundtrip in France. Number of trips, observations, and ratio between empty and "filled" pedestrian crossings (from [5])

Location	Category	Number of trips	# of pedestrians : # of crossings	Pedestrians : crossings (ratio)
Oslo	City	12	13 : 198	1 : 15
Jevnaker/Hønefoss	Village/City	28	28 : 703	1 : 25
Sokna	Village	105	9 : 314	1 : 35
Bærum	suburb	66	6: 355	1 : 59
Kongsberg	City	14	1 : 67	1 : 67
Rjukan	City	22	2 : 526	1 : 263
Round-trip Nancy-Colmar- Dijon-Paris	Several vil- lages/cities	1	0 : 116	0 : 116

As can be seen from table 3, it is considerably more likely that an ordinary marked pedestrian crossing is empty than "filled" with a pedestrian. The distribution varies from 1 in 15 times in Oslo, the capital of Norway with 578.870 inhabitants, to the city of Rjukan, a small city with some 3.365 inhabitants ca 200 km west of Oslo. A counting from a weekend-roundtrip between cities in eastern France is also listed in table 3 [5]. A question that could be asked is: What do drivers actually experience and *learn* from driving through a pedestrian crossing which for the most part are empty? Considering these experiences in terms of reinforcement theory several issues and hypotheses can be stated:

1. Assertion (1): What is actually learned – and reinforced – is that an ordinary pedestrian crossing normally is empty.

2. Assertion (2): Such a crossing does not provide any specific stimuli that makes it different from the road environment before and after the crossing has been passed.
3. Assertion (3): The experience is automated and does not cause any stimuli that are being consciously processed.
4. Assertion (4): As the number of accidents is reduced in raised pedestrian crossings, and crossings with refuge, and assuming pedestrian behaviour does not vary significantly across different pedestrian crossing types, driver attention must operate significantly different with the two former types of crossings than with an ordinary marked pedestrian crossing.
5. Assertion (5): Unlike an ordinary marked pedestrian crossing, where there normally are no feedback of potentially damaging stimuli, a raised pedestrian crossing represents potentials of damaging the car if the speed is too high. Likewise with a crossing with refuge: the lane width could be so narrow that the driver must consider his/her distance to the curbs on both sides of the car. Such damaging potentials do not exist in the situation of an ordinary marked pedestrian crossing, there is no bump in the car, and drivers do not need any appraisals of his/her lateral position as lane widths are ample.
6. Assertion (6): These appraisals of car damaging potentials, and/or in combination with reduced driving speeds, is what make perception and attention work differently from the situation of an ordinary marked pedestrian crossing, and hence, reduce the number of accidents. That is possibly why accidents are reduced by these two solutions.

On the other hand, several questions about learning mechanisms should also be raised:

1. Question (1): Given that a pedestrian from time to time either will be in the crossing, or about to enter it, probably in a variable ratio pattern, how will such single experiences make changes in drivers' information processing and behaviour?
2. Question (2): Will single experiences reinforced at a variable ratio be extinct because it is followed by (numerous) experiences of empty crossings or will such experiences be reinforced to make driver expectancies of crossing pedestrians because the reinforcement schedule is variable?
3. Question (3): Given that incidents of almost hitting a pedestrian in a pedestrian crossing would have a more salient impact on the information processing, cognition, and behaviour of the driver: How will one narrow escape be generalised in time and space?
4. Question (4): Will one incident be generalised to other crossings at all?
5. Question (5): Given an incident, how long will the increased vigilance at a particular crossing last before it becomes extinct?
6. Question (6): Remember the statement above: "Drivers are more directed towards the other road traffic than to spot pedestrians." What exactly does represent a "danger" to a driver in contexts where pedestrian crossings appear?
7. Question (7): An experience of injuring or killing a pedestrian would naturally be a devastating experience for any driver, but it is threatening to the driver more in psychological terms, not in physical terms as a collision with another car potentially would be. Do drivers look more for dangers that are potentially life-threatening in physical terms, than in psychological terms? And more specifically: Are drivers more concerned about damage to their cars than to other people, simply because the probability is much higher, because it is more frequent?

Could “the rank order of threatening events” be like this:

1. Threats to being hit by another driver?
2. Threats to damaging the car?
3. The possibility of injuring a pedestrian?

Do drivers rank threats and dangers in this rank order, and, if they do, is this rank order done consciously or through automated and unconscious learning processes?

This “looking for dangers” in terms of which dangers drivers actually are looking for, is a major issue that involves how different models of information processing and decision-making, and hence, driver behaviour models, understand and predict driver behaviour. Scenario (2) describes a situation which involves issues that may be analogous to those described in scenario (1).

Scenario (2): The higher-than-expected involvement of MCs when cars do left turns before an MC on a crossing course

Compared to cars, motorcycles and mopeds are overinvolved in accidents in intersections [7], for example in the accident scenario depicted in figure 4. A possible explanation for this overinvolvement is that car drivers fail to notice two-wheeled vehicles. The Norwegian literature survey discusses several hypotheses that might explain this overinvolvement of two-wheelers:

- An eventual difference in conspicuity would show up in daytime, but not in nighttime because the use of running lights in darkness would equalize the conspicuity.
- Another line of analysis focused on who is the guilty party in collisions between cars and motorcycles. For intersection accidents, studies have shown that car drivers are overrepresented as the guilty party [7].
- Riders of two-wheelers are more vulnerable than drivers, and may be more careful when entering or leaving an intersection. For that reason they are more often the innocent than the guilty party.
- Motorcycles are smaller than cars and may more easily be hidden behind obstructions. However, studies that take this possibility into account, still find that drivers failed to notice the motorcycle in a considerable proportion of accidents [7].
- Drivers may underestimate speed and overestimate distance to motorcycles and for that reason enter into small gaps when the approaching vehicle is a motorcycle.

Although these alternative explanations seem plausible, they were not supported by empirical evidence. A plausible explanation for collisions between two-wheeled vehicles at intersections. Glad discusses several hypotheses. One is that drivers, because they have met cars far more frequently than two-wheelers at intersections, have established a “visual set” for what-to-look-for, i.e. cars, and for that reason fail to notice two-wheeled vehicles.

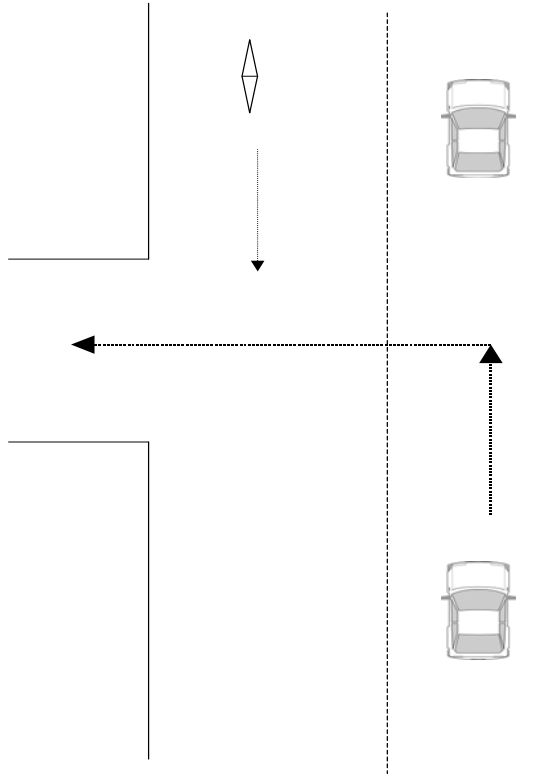


Figure 4. Car turning left before an MC on a crossing course

Understanding perceptual “visual sets” in scenarios (1) and (2): Reason vs Damasio

The hypothesis that car drivers fail to notice two-wheel drivers because of “visual sets” can be understood and explained by Reason’s model of information processing and decision-making [3], which is outlined in figure 5 [8]: .

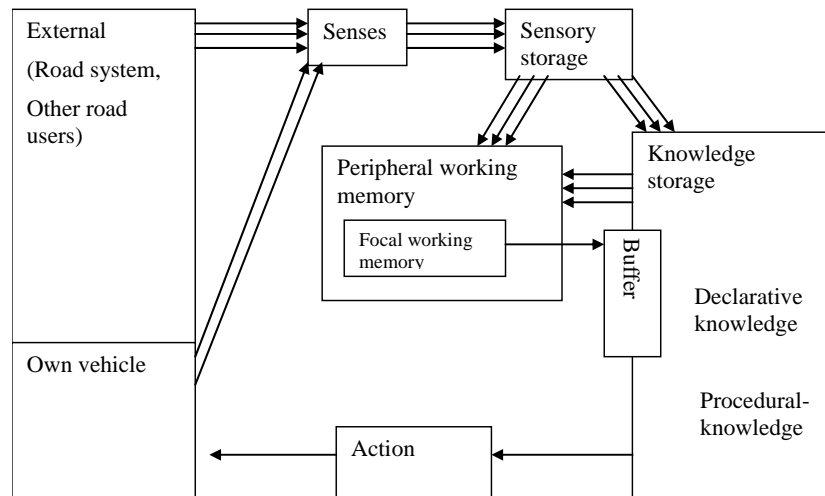


Figure 5: Reason's model of information processing [3], [8]

Reason's model describes and explains elements and interactions between factors involved when drivers perceive elements of the road environment in the continuous and dynamic change of stimuli which characterize the process of driving. In short, the inexperienced and novice driver has to deal with constantly changing time windows of changes of road geometry parameters and movement of and conflicts with other road users. In the beginning, these ever-changing windows represent problems that the driver has to perceive, understand and solve in order to escape accidents. The underlying entity for the perception and solving of problems is denoted a scheme, which represent the identification of scenarios that resemble each other and that more or less have identical solutions regarding speed choice, braking, steering, etc. As a start, these identification and solving of problems are regarded to be handled by conscious processes, but, as a function of time and frequency, they are overlearned and automated, which basically means that they are handled by unconscious processes, ie. that cognitive, conscious appraisals of a given problem no longer are needed. Reason denotes these processes and decisions as similarity matching and frequency gambling.

One disadvantage, however, with Reason's model, is that it is "mechanic" and not "organic", ie. that it is not based upon neurology and in broader terms, achievements in neuroscience. That does not imply that Reason's model is wrong, but rather that it appears as somewhat "shallow", meaning that it could be enhanced by taking neurological processes into account and then provide a more satisfactory understanding of driver behaviour. Hence, it is asserted that Damasio provide a more profound understanding of the underlying mechanism which are involved in the accident scenarios (1) and (2) [1].

Figure 6 depicts the Risk Monitor Model (RMM) [2] which is heavily based on Damasio [1]. A disadvantage with previous driver behaviour models is that most of them do not include aspects of physiology and neurology. Only Taylor, by proposing GSR-constancy as a governing principle, includes such an aspect [9]. Antonio R. Damasio and the neurobiological perspective he elaborates in his book, "*Descartes' Error: Emotion, Reason and the Human Brain*" [1], provides a more basic understanding of humans that may serve well as a basis for developing a model of driver behaviour. 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. The base for what is labelled “The Risk Monitor Model” is three simple statements, which all are extracted from Damasio [1] [2]:

- **Axiom:** Man’s deepest and most fundamental motive is survival.
- **Deductions:** Humans must possess a specialized ability to detect and avoid dangers that threatens his/her survival. Hence, humans must possess an organ that provides the monitoring of potential threats.
- **Assertion:** 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 monitor 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 environment and other actors with which the organism interact. 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” [1].*

A central concept in the above citation is the **functional balance**. This functional balance is defined as the target feeling. This target feeling is a kind of state that drivers are seeking to achieve and/or maintain while driving. The drive to achieve a functional balance is regarded as a central, predominantly unconscious knowledge, which the organism possesses about itself, and which the organism is actively seeking to maintain or to restore. Damasio states his model by saying that something important happens before thinking and reasoning. 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 emotion is knit to the body, Damasio labels it **somatic** (‘soma’ is Greek for ‘body’) and **marker** because the emotion 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....

Damasio separates between emotion and feeling and limits the concept of **emotion** to what goes on in the body of the organism, i.e. the myriads of changes in the state of the body that is induced autonomously in all its parts and organs when the organism is exposed to a given, external event. Damasio distinguishes specifically between emotions and feelings and limits **feeling** to processes of consciously experiencing, consciously sensing, the changes of the body and the mental states. Damasio distinguishes between several levels and defines emotions and feeling as follows:

- **Primary emotions:** Emotions that are innate and unconscious, corresponds to the neurobiological apparatus of the newborn infant
- **Secondary emotions:** Emotions that are learnt and based on individual experiences, accumulated by the individual – i.e. as they develop into “the emotions of the adult”. Predominantly unconscious or pre-conscious.
- **Feelings:** The process of “feeling an emotion”, the process of “making an emotion conscious”, to feel and transform changes in body states into conscious experiences.

In short, there are two paths to information processing and decision-making, one path predominantly unconscious through primary and secondary emotions, and one predominantly conscious through the path of feelings (figure 6). The orienting reflex bridges the connection between emotions and feelings when appropriate stimuli is provided, and always in this direction as there is no such thing as “deciding to drive in automated mode” which is done by the organism itself, without any preceeding cognitive/conscious appraisals.

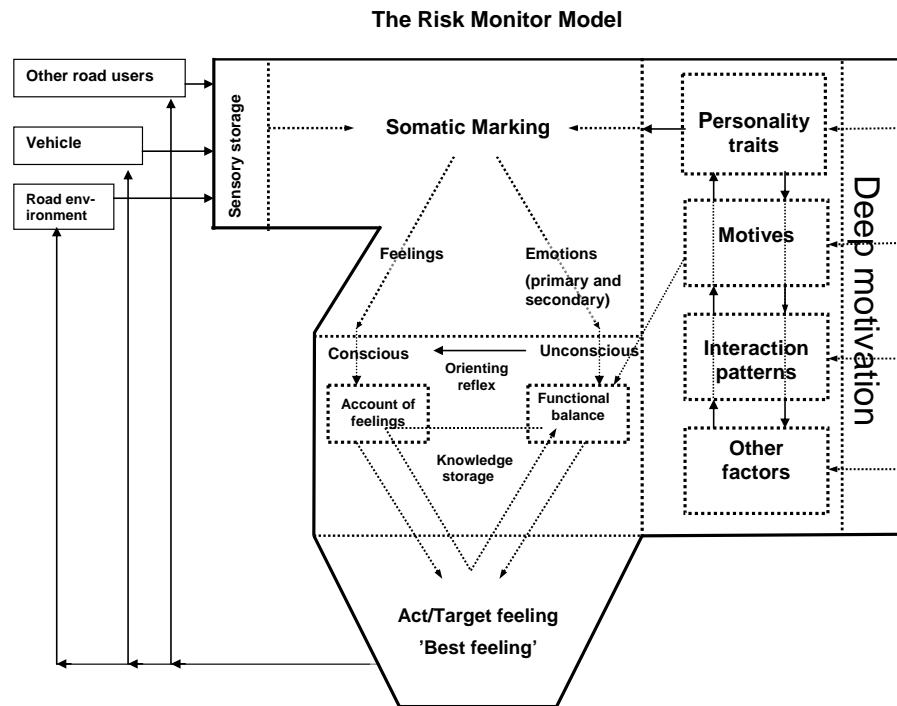


Figure 6: The Risk Monitor Model (RMM) [2]

While primary emotions are exclusively sub-cortical and directed towards the body, secondary emotions also include activation of numerous prefrontal cortices, which means that secondary emotions, in addition to the sub-cortical responses of primary emotions, also include cortical, but still unconscious responses activated by the external stimuli. It is assumed that the cortical loop in prefrontal cortices that is involved in secondary emotions, may give access to schemes formed and accumulated by the learning history of the individual and that this loop enables the body to react without involving conscious processes. And further, it is this “loop of secondary emotions” that enables the organism to act automatically in behaviours that are “over-learnt” – as often experienced by drivers in driving tasks [10]. Secondary emo-

tions is also regarded as be analogous and identical to what is labelled *schemes* in Reason's model of information processing.

Finally, to feel an emotion, it is necessary, but not sufficient, that neural signals from the viscera, muscles, joints, neurotransmitter nuclei, i.e. all body organs that are emotionally activated, are redirected towards the neo-cortex and certain sub-cortical nuclei. The signals from the body back to cortex go through endocrine and other chemical routes and reach the central nervous system via the bloodstream. The feelings, i.e. the conscious experience of body states impinged by external stimuli, then establish an association between an external object, say a given situation in traffic, and an emotional body state. Hence, by the processes of feeling and emotion, the individual is able to evaluate, consider and choose between alternative acts in a situation that demands action. The consciousness needs a continuous update of "here-and-now", of what the body does and what it experiences. Feelings are then the conscious experience of what the body does, - by representations of emotional body states. Or, as Damasio puts it,

"That process of continuous monitoring, that experience of what your body is doing while thoughts about specific contents roll by, is the essence of what I call a feeling" (Damasio 1994 : 145).

The main point, however, is the concept of *primary emotions* as it offers an improved understanding of the concept of "*visual sets*": The organism is predisposed to look for dangers governed by reflexlike, innate, neurobiological properties that limit perception and information processing, and, as a consequence, also may limit learning of appropriate schemes in the accident scenarios (1) and (2) described in the present context. In these scenarios, the "looking for dangers" may make drivers overlook two-wheelers because these are not perceived as threats to survival, which make them perceptually and neurobiologically different from the configurations of cars.

Predictions of the Risk Monitor Model

One might hypothesize that the accident scenarios (1) and (2) is a function of low-frequency exposure of these scenarios, making the establishment of appropriate schemes to avoid accidents slow, ie. that both perception of these scenarios, and the learning of appropriate schemes, are bounded by limitations constituted by the inherent neurological apparatus of individuals that make perception and the learning of appropriate schemes especially slow and hard to achieve, because it is dominated by primary emotions that search for threats of survival. If it is correct that we, as drivers, unconsciously and reflexlike look for other cars because it is these objects that represents threats to survival, and not two-wheelers as MCs, mopeds and bicycles, then one should look for measures that have potentials of "boosting" perception and learning in these two accident scenarios. The options that the RMM provide and predict, would be through a more effective exploitation of the orienting reflex:

1. Scenario (1): In the case of an ordinary marked pedestrian crossing: Blinking, amber lighting in when pedestrians are about to enter the crossing in a configuration that is comprehensive from left to right hand road-side/pavement (the alternative would be removal of this type of pedestrian crossing)
2. Scenario (2): In the case of an MC as continuous use of high-beam running lights should be mandatory as low-beam or triangular light configurations are considered to too weak in providing sufficient perception stimuli.

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