Determinants and consequences of drivers' emotions
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1. General introduction

“I was driving alone at night on a rural road. Over a length of 40 km, a continuous centre line indicated that overtaking was not permitted. When I had driven about 15 km, conforming to the speed limit of 80 km/h, I found myself driving behind an Audi 100. The driver was changing speed continuously: from 70 to 65 and back to 70 and so forth. I started overtaking where it was not allowed but necessary. Then the idiot speeded up when I was overtaking, so I had to speed up even faster. Eventually we were both driving at a speed of 110 where the speed limit was 80. As another car was approaching from the opposite direction, I was forced to stay behind him. He slowed down to a speed of 60. I almost exploded because I was so angry! Then he speeded up until he was driving 75, and suddenly hit the brakes heavily. I almost hit him from behind. I speeded up and finally overtook him, and hit the brakes as well. I wished I had time, and was not wearing a suit that could be damaged. Otherwise I would have forced him to a parking spot with violence, or chased him to his destination to hit him with the machete that I always carry with me in the car (for reasons of self defence). I was so angry I could have beaten up the bastard. He even started making hand gestures and light signals that he was ready to go to the parking lot, but I couldn't, because of a meeting, for which I was already 15 minutes late. I would have had no problems hurting a person who behaves like that! Like he could set the rules for all the drivers behind him at what speed they should drive. If I ever meet the guy again, I will pull him out from his car and beat him up. This is one of the two events that happened to me during the last 20 years.”

(from an anonymous respondents’ description of an aggressive driving incident)

1.1. Introduction

Car driving is in general considered an instrumental activity. Once the destination is set, the driving task is carried out rationally, until the goal of reaching the destination is accomplished. The example stated above indicates that this rational, instrumental behaviour is sometimes interrupted. Events may happen, either caused by another road user, by ourselves, or by a traffic situation, that produce intense emotions. We may be angered by another driver, become nervous when faced with a complicated intersection, or sad when passing a street that raises memories from our childhood. When being emotional, our judgement may be biased, and we may change our priorities to act. This thesis is about why and how often we become emotional on the road, and what happens to our driving behaviour when we do.
Every year, about 50,000 people die in road traffic accidents across Europe (IRTAD, 2004). Although the number of fatalities has been decreasing in the Netherlands and in some other European countries during the last few years, in other countries the number remained stable or even increased. Most of the fatalities fall in the category of car occupants. The causes of these car accidents can be diverse, but most researchers agree that the human factor accounts for most of the accidents. Estimates vary between 70 and 95% (Treat, Tumbas, McDonald, Shinar, Hume, et al., 1977; Treat, 1980; Rumar, 1985). Car driving is a complex cognitive task and even a small disturbance of the task performance can have severe consequences. The effects of alcohol, fatigue, and mobile telephone use on driving behaviour have already been demonstrated. Emotion is another factor that can be expected to affect cognitive functioning and therefore to increase task demand.

Although the emotional aspects of car driving received considerable attention during the last decade, it is still not clear whether emotions indeed constitute a serious problem for road safety. The evidence is mainly anecdotal and based on newspaper articles or interviews. Accident data does not provide enough information, because emotions are not registered as accident causes on standard accident registration forms in the Netherlands. Only severe cases of extreme violence on the road are systematically recorded. A link between emotions and road accidents can therefore not be made based on accident statistics. Some studies used other methods to investigate this issue. Questionnaire studies showed relations between self-reported (near) accidents on the one hand, and anger (Underwood, Chapman, Wright, & Crundall, 1999), angry and threatening driving (Wells-Parker, Ceminsky, Hallberg, Snow, Dunaway, et al., 2002) and interpersonal violations (Mesken, Lajunen, & Summala, 2002) on the other. A recent study (Vinson & Arelli, 2006), which used a case-control and case-crossover methodology, showed nonetheless that anger was not associated with traffic injuries. Empirical evidence on the relation between emotions and road safety is thus inconclusive and other emotions than anger have rarely been taken into account (see also Chapter 2).

In the remainder of this chapter, we will explain what emotion is, and why it would be relevant for driving. Furthermore, theoretical models on emotion and mood, and on driving, are discussed. Theories on emotions and moods will be evaluated in terms of their relevance for driving behaviour. Some theories are more useful than others because they make propositions about driving-related concepts, such as attention or risk, whereas other theories focus on processes less relevant for driving, such as memory or creativity. Theories on driving behaviour will be discussed in view of the question
whether the concept of emotion fits into the theory or whether the theory specifically mentions an emotion concept. This results in a theoretical framework from which the central research questions are derived. In Chapter 2, a review is given of empirical studies on emotion and traffic. This results in specific research questions on which the empirical Chapters 3, 4 and 5 are based. Chapter 3 discusses the role of personal interaction in the elicitation of emotion. In Chapter 4, the effects of emotions on cognitive processes relevant for driving are experimentally investigated. In Chapter 5, an on-road study is reported in which the theoretical concepts of emotion elicitation and consequences are demonstrated in a naturalistic environment. Chapter 6, finally, presents the conclusions of the studies and discusses the implications for both traffic research and traffic policy.

### 1.2. What is emotion?

#### 1.2.1. Concepts and definitions

The concept of emotion is used for a wide range of phenomena, but there is substantial disagreement about which phenomena to include and which to exclude (Frijda, 1986). Most researchers, instead of providing a definition, present a set of necessary elements for the concept of emotion. This results in a prototypical definition: a phenomenon is considered an emotion if it conforms to most of these elements (Russell, 1991). Frijda (1986) considers the relevance of an event for personal concerns and goals as one of the key elements of emotion. Other important elements are, according to Frijda, action readiness, and control precedence. Action readiness is the tendency to act, as a response to the emotion-evoking event. When a person is faced with a negative event, e.g. a car on collision course, he will wish to end or escape this event, e.g. by hitting the brakes. In case of a positive event, the person will wish to continue or to prevent the stopping of the event. This does not imply that action is always undertaken: sometimes there are circumstances, for example our norms and values, or external situations, that makes it impossible to follow up on the action tendency. An important characteristic of action tendencies is that it focuses all attention to the event that causes the emotion. The action tendency interrupts ongoing activity and pushes other issues that are currently requiring attention, to the background. Frijda calls this phenomenon “control precedence”.

Oatley and Jenkins (1996) summarise the necessary elements in what they call a working definition of emotion:
• An emotion is caused by a person consciously or unconsciously evaluating an object or event as relevant for a personally important concern.

• The core of an emotion is readiness to act and the prompting of plans.

• An emotion is usually experienced as a distinctive type of mental state, sometimes accompanied or followed by bodily changes, expressions, or actions.

Emotions thus can be considered as a process that promotes adaptation to the environment and prepares the person for adaptive action (Lazarus, 2001). This mechanism is often accompanied by subjective feelings, by physiological changes such as increased heart rate, and by expressions, such as voice, face or gestures. The emotion process starts when we perceive an encounter as being relevant for an important goal or concern. Then, we evaluate this event and decide whether it is positive or negative. What follows is the tendency to act, and possible accompanying physiological reactions. The emotion process may result in actual behaviour change, although this is not a necessary step. In all phases of the emotion process, regulation may occur: the emotional reaction may for example be inhibited by beliefs about social desirable behaviour. Appraisal theory (Lazarus, 1991; Scherer, 2001) describes the emotion process in detail. This theory, which is the most influential contemporary emotion theory among psychologists, is discussed in Section 1.3. Thus, emotion may contain different elements, and these elements are related to each other; they can be considered to be a process. These two issues are combined in a definition provided by Fischer (1991): "emotions are specific reaction patterns that develop as a process and may contain different components".

A number of other terms is related to the concept of emotion, such as affect, feeling, and mood. Affect is most often used as an umbrella term for emotions, feelings and moods. Feelings form the core characteristic that differentiates affective from non-affective experiences (Frijda, 1986). Feelings are usually seen as those elements of experience that cannot be reduced to bodily sensations or cognitions. Moods are affective states for which the cause or object is not clear. Whereas emotions are intentional in the sense that they are always related to an event or object (we are afraid of something, angry at someone, sad about something), moods are not; they are diffuse and might refer to the world in general. Moods also last longer in general compared to emotions: moods may last days, weeks or even months, whereas emotions usually last between a few minutes and a few hours. As the present research
is about the relation between specific traffic events and affective experience, it takes emotions, and not moods, as a focus. This does not imply that moods are not relevant for traffic. Many traffic researchers indicated the relevance of mood for driving performance. These studies are reviewed in Chapter 2.

1.2.2. Functions of emotions

Why do we experience emotions? Zeelenberg and Aarts (2001) give an overview of the functions of emotions. The first is the adaptive function: emotions are adaptive in the sense that they promote behaviour that fits the demands of the environment. The emotion of fear, for example, causes action tendencies to avoid or escape, which is beneficial when being faced with a physical threat. When a car driver is confronted with another car suddenly coming from a side street, the fear or startle response causes the driver to brake instantly. This reaction is much faster than a more cognitive response in which the advantages and disadvantages of possible actions are carefully evaluated. A second function is a social or communicative function. By observing others’ emotions, we can make predictions about the other person’ intentions, needs, and actions. The crying of a baby is an example of the signal function of emotions: it indicates that action is needed from its caretakers. During driving, it is difficult to observe the emotions of other car drivers. This is why other methods are used to express our emotions during car driving, such as hand gestures or horn honking. A third function of emotions is related to strategy. People may use their emotions, or exaggerate them, to accomplish their goals. This can be seen in politics, for example, where in public debates the “functional anger” is used to gather support for the politician’s opinion. Also, a driver who is slow in parking and thus blocks another drivers’ progress, may make a hand gesture of apology, as a strategy to avoid an aggressive reaction.

1.2.3. Determinants and consequences of emotion

According to most current approaches, emotions are caused by a person evaluating an event or encounter, in terms of his or her personal goals or concerns. Thus, an interaction is needed between the person and the environment. This means that the same event may elicit intense emotions in one person, and none whatsoever in the other. Likewise, different events may elicit similar emotions. The notion that an emotion results from an interaction between person and event, implies that especially in the driving context, emotions may arise frequently. As driving is considered goal directed behaviour, and as driving involves a constantly changing
environment with many events happening which might block or promote our goals, the driving task could become a rather emotional task.

As we saw before, emotions are believed to have an adaptational value and thus are functional. But it is possible that they have adverse effects in a task environment in which one mistake may have severe consequences. Lazarus (1991, p. 416-417) discusses three mechanisms through which emotions may have maladaptive effects on task performance. One is interference: the emotion raises responses and thoughts that are irrelevant for the task. This is for example the case in a driving test situation, where the student driver finds himself paying more attention to his raised heartbeat, and to worries whether he will pass the examination or not, than to the actual driving task. Another mechanism is conflict of motives: emotions always imply some sort of action tendency, and this tendency may be in conflict with the task requirements. This mechanism was especially visible in the example from the beginning of this chapter. The car driver had an important meeting, but the anger that was elicited led him to forget about that for a moment and get involved in a competition. The third mechanism that Lazarus mentions is cognitive coping processes: when a person is worried that he will not succeed on a task, he might devaluate the task, or invest less effort to it. Thus, if task performance is poor, he can blame the lack of effort or claim that the task was not important.

Whereas the above indicates that emotion may have adverse effects on task performance, research on the effects of affective states has focussed on moods rather than on emotions. This might be because, as we will argue later in this chapter, research on emotions and moods developed along two fairly distinct research lines, one concerned with cognitive causes and constituents of affect, like research on emotion and appraisal, and the other dealing with the effects of affective states on various cognitive processes (Siemer, 2001). In the next sections, these research lines will be discussed.

1.3. Emotion theories

The development of psychological theories about emotion started more than a century ago. In the end of the 19th century, William James and Carl Lange, independently of each other, developed about the same ideas about emotions. Their claim was that events cause bodily sensations, which are labelled by the person as an emotion. Each combination of bodily sensations implies a different emotion: we feel frightened because we tremble, angry because our heart beats rapidly, happy because we smile etc. The emotional experience, then, is actually nothing else than the bodily changes. Since we
can differentiate between different emotions (we know when we feel happy or sad or angry), there must be specific patterns of arousal for each emotion.

The James-Lange theory does not explain how the bodily sensations are caused by events: why is it that rude behaviour causes an angry expression? Also, arousal patterns are actually not so distinct for each emotion, as was put forward as criticism by the Cannon-Bard theory (developed by Walter Cannon in 1927 and modified by Philip Bard). The same bodily changes (e.g. increased heartbeat) may be a result of both fear and anger, for example. According to the Cannon-Bard theory, an event causes bodily sensations and emotional experience at the same time: they do not affect each other. The bodily sensations are in this viewpoint just side effects of the emotional experience. Neither the James-Lange theory nor the Cannon-Bard theory was able to account for different emotional responses to the same event by different people or at different moments of time or in different context. Also, they do not explain which emotions are elicited under which circumstances.

The argument of the Cannon-Bard theory that emotions cannot be distinguished by physiological patterns, was taken over by Schachter (1966). His Two-Factor theory also claims that physiological activity is the same for each emotion. However, Schachter's theory differs from Cannon-Bard theory in the notion that which emotion is experienced, depends on cognitive evaluation. The theory is based on experiments by Schachter and Singer (1962) in which subjects were injected with epinephrine: some were informed about the effects of this, others were not, or were misinformed. Subjects were then exposed to one of two situations, one in which they meet a happy person, and one in which they meet an angry person. It turned out that the subjects that were most affected by the emotional state of the person they had met, were those who were misinformed about the effects of epinephrine. According to Schachter, the results of the experiment show that the pattern of arousal may be unspecific for a particular emotion, but which emotion is experienced depends on the situational circumstances. In other words, arousal determines the intensity of emotional experience, but interpretation determines the type of emotional experience.

The Two Factor theory was the most influential theory in the area of emotions for many years. It was the first theory to take the viewpoint that cognitive evaluation of the outside world is an important factor. This became the central concept of contemporary appraisal theories (Parkinson & Colman, 1994). The first researchers that used the concept of appraisal were Arnold (1945) and Lazarus (1966). Although Lazarus’s ideas were originally developed within the area of stress, in 1993 he made an argument to
integrate the two areas, or rather, to see stress as a part of the emotional domain. Stress, according to Lazarus, is experienced when a person evaluates an event as harmful (primary appraisal) and evaluates the personal capabilities to deal with the event as insufficient (secondary appraisal). The negative emotions associated with stress result from a person-environment relationship that is harmful or threatening for the individual. However, there can also be beneficial person-environment relationships, contributing to the well-being of the individual, which lead to positive emotions. Thus, in the understanding of how individuals adapt to the environment, Lazarus concludes that stress theory is too restrictive and actually covering only half of the topic. Instead, he proposes that any person-environment relationship can lead to any emotion, depending on a range of appraisal components. Appraisal components are the subsequent steps in the appraisal process. These components can be divided in two categories: primary appraisal and secondary appraisal. Primary appraisal is related to the relevance that an event has for a person’s goals and identity; secondary appraisal is related to the coping process, or how a person responds to an event. This is similar to the primary and secondary appraisal from the area of stress. The event is not necessarily something happening in the outside world: a person can also suddenly remember something or realise something, which is called ‘event’ then as well.

The primary appraisal components are goal relevance, goal congruency and type of ego involvement. Goal relevance refers to the extent to which the event is relevant to the person’s goals. It determines whether or not an event will elicit any emotion: if an event is not relevant for a person’s goals, there will not be any emotion. Goal congruence determines whether or not the event will elicit positive or negative emotions: if an event is congruent with a person’s goals, positive emotions will occur; if an event is incongruent with a person’s goals, negative emotions will occur. Type of ego-involvement refers to any aspects of the event that are relevant to a person’s identity, like aspects that affect self-esteem, moral values etc. The secondary appraisal components are blame or credit, coping potential and future expectations. Blame or credit is related to whether or not another person or “the self” is held responsible for the event. Coping potential refers to the extent to which a person believes anything can be done about the situation. Finally, the future expectations that a person has refers to whether or not a person expects the situation is about to change for better or for worse in the future. The combination of these six specific appraisal components defines which emotion occurs. Sometimes different terms are used by different emotion researchers: whereas Lazarus speaks of appraisal components, Roseman (2001) uses the concept of appraisal dimensions and Scherer (2001) Stimulus
Evaluation Checks. Appraisal theory does not require that a person goes through the appraisal components consciously and sequentially\(^1\). Still, for each event that one encounters, implicitly the questions are asked: Is this relevant? Good or bad? Does it involve my identity? Is someone to blame? Which are the future expectations? And what can I do about it? The answers to these questions determine the type of emotion: for example, anger will arise after the appraisal of an event as relevant, goal-incongruent, and involving someone else who is to blame.

According to Lazarus (1991), the combination of the appraisal components may lead to up to 15 different emotions. Each emotion has its own "theme" (what the emotion is about) and reaction (or action tendency). The emotions are believed to be functional; they promote adaptation to the demands of the environment. The emotion of fear, for example, causes action tendencies to avoid or escape, which is beneficial when being faced with a physical threat. Under the influence of emotions, behaviours that serve our goals are given priority over other behaviours. However, sometimes emotions are maladaptive: for example when people suffer from anxiety disorders or are so overwhelmed with grief that they can't concentrate on anything else. Levelt (2003a) states that all emotions have the capacity to be maladaptive for the task of driving, because they drag the attention away from the task. Also Lazarus (1991) mentions several mechanisms through which emotions may be maladaptive for performance: interference, conflict of motives and cognitive coping processes. Interference refers to the fact that under the influence of emotion, many (task-irrelevant) cues need attending to, like emotion-related thoughts and physiological changes. This is comparable to what Frijda (1986) calls the "attentional capacity hypothesis". A conflict of motives arises when the task requires one activity, whereas the emotion requires another. This is comparable to Frijda’s "response competition hypothesis": Frijda states that when the task and the emotional response are incompatible, task performance might be interrupted. If they are compatible, task performance might improve. Finally, cognitive coping processes imply that people will try to cope with the emotion, possibly by performing behaviour that is not necessarily beneficial for task performance. For example, a person whose self-esteem may be threatened might try not to expect too much and therefore not put an optimal amount of effort to the task.

\(^1\) Appraisal theorist have different assumptions about sequentiality. Lazarus, although proposing some kind of decision tree, does not assume that people go through the appraisal process sequentially, but Scherer (2001) does: he considers appraisal as a process of sequential checking.
In sum, appraisal theory is able to explain why different emotions may occur as a result of the same event. Also, the theory accounts for different events evoking the same emotional response, and is able to explain the interaction between event and person to elicit emotions. The emphasis that appraisal theory places on the event-person interaction makes it especially useful for studying the role of emotions in driving behaviour. While driving, events follow each other with a higher speed than during other activities, and this requires the driver to constantly assess the changes of the environment. Appraisal theory is able to describe these processes of assessing the changed environment for one’s well-being. Furthermore, appraisal theory is the most commonly used emotion theory in contemporary emotion research. As a result, appraisal theory is the most useful theory to explain the elicitation of emotions in traffic, as was also put forward by Levelt (2003a, 2003b).

Although appraisal theory might explain the elicitation of emotions in traffic, it is much less specific in explaining the consequences of emotions. The theory stops when the emotion is present: Lazarus states that appraisal is both sufficient and necessary for the experience of emotion, but he does not make propositions about emotions that may affect cognition. Lerner and Keltner (2000) propose that people in a certain emotional state are inclined to appraise events according to that emotional state. In Section 1.5 a more detailed discussion of this viewpoint will be presented. Roseman and Smith (2001) also state that appraisals may well be causes as well as components and consequences of emotions, but they also conclude that appraisal theory is a theory on the elicitation of emotion. The two main theses of appraisal theory are: appraisal is responsible for the elicitation of emotions, and appraisal is responsible for the differentiation of emotions (Frijda & Zeelenberg, 2001).

Thus, appraisal theory does not make predictions about the effects of emotions, other than describing responses and actions that 'belong' to the emotion from an adaptational point of view (for example: flight, in the case of fear). The other emotion theories described above also put more emphasis on emotion elicitation rather than emotion effects. For the area of road user behaviour, it is relevant to address not only at the action tendencies belonging to the emotion, but also more indirect effects on task performance. Affective theories that do address these types of consequences can be found in the area of moods.
1.4. Mood theories

Whereas emotions theories are concerned with the elicitation of specific emotions, mood theories address the effects of general affective states on cognitive processes. The development of these theories started with studies of mood effects on memory. Moods can be a factor in memory in three ways. First, the material to be remembered can be associated with a certain affective value. Second, at the time the material is encoded in memory, the person may be in a certain affective state. And third, also at the time of retrieval of the material, the person may be in an affective state. Most studies considered the interaction effects of affective states during retrieval and affective content of the material (Parrott & Spackman, 2000).

Two studies that were published at about the same time showed effects of mood-congruent recall (Isen, Shalker, Clark, & Carp, 1978; Bower, Monteiro, & Gilligan, 1978). These findings were the basis of the associative network theory (Bower, 1981). According to the theory, human memory can be modelled as a network of concepts, linked together to describe an event. Mood is thought to be represented in the network and is related to affectively valued events and concepts. The activation of a mood state leads to activation of related affective concepts and events and therefore facilitates memories that are similar in affective valence. In this way, the theory explains mood effects on memory, but also the fact that mood-congruent stimuli are more easily recognised and attended to than mood-incongruent stimuli. This principle is also referred to as affective priming. The associative network theory was developed to explain memory effect and, to a lesser extent, attention effects. It also makes propositions about (social) judgement, to the extent that judgement is influenced by recall. When asked to judge a person, while being in a positive mood, positive concepts are likely to be activated in the brain, leading to a positive judgement. Later studies showed that mood affects not only the outcome of cognitive processing, as in memory, but also the nature of processing (Forgas & Bower, 1987). Associative network theory was not able to account for these effects. Also, the theory could not explain results of studies that showed mood-incongruent effects. These findings instigated the development of new theories, that were more adequate to explain mood effects on cognition than associative network theory. In the next section, two of these theories will be discussed: Affect Infusion Model and Mood as Information theory.
1.4.1. Affect Infusion Model

The Affect Infusion Model (AIM; Forgas, 1995a) was developed to explain affective influences on social judgement. It aimed to explain mood effects on both the content of judgement tasks (e.g. does a person evaluate another person as positive or negative) and the process (e.g. does mood have an effect on the way people construct these judgements). Also, it aimed to account for both congruence effects and incongruence effects. In this sense the theory provides more differentiated predictions of mood effects than associative network theory.

Affect Infusion refers to the process through which affective states have an effect on reasoning and judgement and colour the outcomes. According to the model, affect infusion is more or less prominent depending on the information processing style that is adopted. Four processing styles are distinguished: direct access processing, motivated processing, heuristic processing and substantive processing. Direct access means that a response to a particular object is already stored in the brain and is easily retrieved. This is for example the case when one is asked to state an opinion about someone who is very close to the subject. It is unlikely that a judgement about this person is influenced by affect. Motivated processing means that one deliberately searches for information that support a held view or opinion. This may be done for a variety of reasons. Affect infusion is also unlikely when this processing style is adopted. Heuristic processing means people rely on simple cues or heuristics to form their opinion. In this case mood may serve as a cue and therefore affect infusion is more likely. Also in the fourth processing style, substantive processing, affect infusion is likely, because all provided information is consciously and carefully processed to form an opinion or response.

Thus, affect infusion is most likely under conditions that promote elaborate, open information processing, and less likely if information processing consists of the direct retrieval of already existing information. However, AIM explains not only how affect influences judgement for each processing strategy, but also how affect has an effect on the choice of processing strategy. Each strategy differs in the amount of attention that is directed to various features and thus, according to AIM, mood affects attention through processing choices. Three effects on processing choices are distinguished. First, mood has an effect on processing capacity. Both for positive and negative mood it has been demonstrated that mood consumes processing resources, which means that fewer information sources are attended to. Second, there are functional effects of moods on processing strategy. Positive
and negative moods differ in the adaptational function they have for the individual: a positive mood means all is well; and no special actions need to be taken. A negative mood means something is wrong and action is needed, which means that negative mood instigates more elaborate processing of information than a positive mood. A positive mood, but not a negative mood, therefore reduces the amount of information sources that a person is attending to. Third, mood may cause a person to be especially motivated to process information by using a specific strategy. This may be the case when a person is in a positive mood and wishes to keep it that way (mood maintenance) or when a person is in a negative mood and wishes to change it (mood repair). A person in a negative mood is therefore more likely to process information in a controlled, motivated way, and attend to more information, than a person in a positive mood.

The differential mood effects that AIM predicts were shown on a number of behaviours. In a study on the judgement of typical and atypical stimuli, Forgas (1995b) found that subjects in a positive mood differentiated less between the two types of stimuli than subjects in neutral or negative mood. Atypical stimuli (in this case 'mismatched' couples) generally have more characteristics that need to be attended to make a judgement, but this was obviously done only by sad or neutral mood subjects and not so much by happy subjects. These results demonstrate a differential effect of positive and negative mood (negative mood leads to the attending of more information than positive mood). Also, Forgas (1999) showed mood effects on language use in formulating requests. Sad subjects were more polite and used more complex ways to express themselves than happy subjects. This effect was strongest when substantive processing was needed (when the request was difficult). Other interaction effects of affect and processing style were shown on judgements of relationship quality, consumer items, members of in- and outgroup, and on strategic behaviours like negotiations (see Forgas, 2000 for a review).

1.4.2. Mood as Information

The Mood as Information model is also known as the misattribution hypothesis. It was developed by Schwartz and Clore (1983) to explain mood effects on evaluative judgements. According to this model, when a person is in a certain mood while making a judgement about an object, the mood may be (falsely) perceived as a reaction to the object. The mood is used as extra information to evaluate the object. For example, when I am asked my opinion about a person, and I am in a good mood (because of something else, for example the weather), I might ask myself: "how do I feel about this person".
When the answer is "positive", my mood may have affected my judgement, even though it was caused by something else. The misattribution effect is strongest under several conditions (Schwartz & Clore, 1987). First, the object or situation under evaluation should be ambiguous, that is, vulnerable to several explanations. Second, the real cause of the mood should not be salient. Third, it is possible that the evaluation task is being perceived as a question about the subject’s feelings and therefore the person uses nothing but his own feelings towards the object. For example, when asked to judge a future outcome, people might interpret this question as “how would you feel if this would be the outcome” and therefore use only their feelings to make the judgement. And last, in complex and demanding tasks, the use of mood as information may serve a facilitating task. Instead of weighing all attributes of the object under evaluation, the own feelings are used to make the evaluation. Where AIM makes propositions about mood effects on evaluative judgements about objects, the Mood as Information theory proposes that our feelings provide information about the state of our environment (Schwarz, 2001). Being in a negative mood would mean something is wrong in our environment and this would trigger us to make risk averse judgements and decisions.

The Mood as Information theory also makes propositions about the effect of mood on attention. All affective states require some kind of attention. If the affective state does not have a salient object, as is the case in moods, attention is directed to whatever is in the attentional space at that moment. For example, a person who is in a negative mood sitting in the waiting room of the dentist may feel his attention to be directed towards the sound of the drill even if this is not the cause of the mood, but just because that sound happens to be in the attentional space at that moment. This is referred to by the Mood as Information Model as the immediacy principle.

Similarly as people use their mood as information about to which attention should be directed, they also use their affective state as information to judge the possibly dangerous or threatening environment. This implies that when someone is faced with a difficult situation, and at the same time is feeling anxious for whatever reason, the person may (mis)attribute the anxious feeling to the difficult situation and thus judge this situation as risky. The effect occurs only when the feeling is in some way relevant to the situation: the feeling of fear is related to risk and threat and thus fear might affect the judgement of risk, but not, for example, the judgement of blame. Likewise, a feeling of anger might affect the judgement of blame, but not the judgement of risk. Similar to the effect of affective states on attention, the effect is more clear for moods than for emotions, because in the case of emotions there is a
salient cause or object. An implication of the theory is that emotions do not affect unrelated judgement directly after they have been elicited, but later, when the cause is further back in the past and not salient anymore, leaving the subject with a feeling that is more like a left-over from the emotion.

1.5. Linking emotion determinants and mood effects: The appraisal tendency approach

In the field of emotion research, appraisal theory seems the most relevant theory to explain the elicitation of emotions in traffic. It specifies which specific emotion will occur under which (personal or situational) circumstances. The Affect Infusion Model and the Mood as Information theory both provide useful information about how feelings affect cognition. AIM is most extensive in providing ideas about the effects of mood on both content and process of evaluative judgements. However, AIM is focussed primarily on social judgements and on processing styles, whereas Mood as Information applies to the way we perceive objects, and the general state of the environment. It assumes that our feelings guide us to direct our attention and filter information that is relevant for our well-being and safety. Since driving is a dynamic activity in which people are constantly evaluating the state of the environment, these insights are necessary to explain mood effects on driving performance. Therefore, the Mood as Information theory is more useful for research in the area of driving behaviour.

It was noted before that the research on emotions and moods has been carried out in different research lines, and therefore in the previous sections, the theories have been described separately. The problem remains how insights from appraisal theory and Mood as Information theory, which seem to be the most adequate theories to explain driving behaviour, can be combined. First it should be noted that recently there have been attempts to bring together information about moods and emotions. Smith and Kirby (2000) developed a process model of appraisal and emotion, in which the concept of affective priming was included. Clore and Gaspar (2000) discussed effects of moods and emotions in the same chapter, and concluded that it is mainly their difference in intentionality why they have different effects. Emotions have an object; moods don’t, and this is the main difference between the two. Clore and Gaspar therefore believe that mood effects on cognition are stronger than emotion effects on cognition, because in the case of emotions, the real cause of the emotion is salient, leaving no space for misattribution. Another interesting observation is that earlier editions of social cognition textbooks discussed moods and emotions in different
Still, studies on emotion deal mostly with specific emotions, whereas theories on moods emphasise general positive or negative affect. When considering a real-life task domain like traffic, it is relevant to know what happens when a person is experiencing a specific emotion. For example, when someone gets angry behind the wheel, it is possible that the response is (a tendency to) aggressive behaviour; which is predicted by appraisal theory. However, it is also possible that judgements of risk are affected by the negative mood state, as predicted by affect-as-information theory. In order to account for emotion-specific influences on judgement, Lerner and Keltner (2000) introduced the concept of appraisal tendencies. Assuming first that each emotion is defined as a set of appraisal components, and second that each emotion has an adaptive value (in the sense that it should promote chances of survival), they hypothesised that “(...) each emotion activates a predisposition to appraise future events in line with the central appraisal dimensions that triggered the emotion” (p. 477). Lerner and Keltner (2000) state that the process through which different emotions influence judgement might well be that the affective state is used as information about the state of the world, as affect-as-information theory suggests. Thus, angry drivers might judge traffic situations as less risky, because anger is associated with appraisals of control (Lazarus, 1991).

Although the concept of appraisal tendency was not meant as an alternative term for the concept of mood, the mechanisms through which it influences cognition are comparable. Frijda (1986) stated that a quick and intense emotion may develop in time to a more global, less intense state of mind which could be considered a mood. When time passes, the object of the emotion becomes less salient, but some of the affective valence is left. So, if the effects of appraisal tendencies can be considered similar to moods, the whole emotion process, from causes to effects, can be described by appraisal theory and Mood as Information theory.

In order to explain the determinants and effects of emotions in the applied context of traffic, in the next section we will discuss some influential models on driving behaviour. For each theory or group of theories, the relevance of emotions will be evaluated.
1.6. Models of driving behaviour

1.6.1. Introduction

In explaining the role of emotions in traffic, two general questions can be distinguished. First, which are the characteristics in the driving task and the driving situation that are able to elicit emotions, and second, which are the characteristics of emotions and emotional states that are likely to influence driving performance. Ideally, one would like to have one overall theory or model describing road user behaviour, that includes both the causes and influences of emotions. However, such a model does as yet not exist: there is not even a single model of driving behaviour that incorporates all aspects of the driving task and influences on driver performance (Ranney, 1994; Huguenin & Rumar, 2001). In the last decades, a number of driving behaviour models have been developed. Some of these refer to an affective concept or can be linked to a theory of emotion. In the next section, these theories will be discussed and their usefulness in explaining the role of emotions in traffic will be evaluated.

Models of driving behaviour may be contrasted on several dimensions, for example functional versus motivational models, models which focus on the driver versus models that focus on the task environment, and models that focus on cognitive, motivational, emotional or social aspects (Huguenin & Rumar, 2001). Michon (1985) proposed a classification along two axes: taxonomic versus functional models and input-output models versus psychological models. Taxonomic models are inventories of facts that are important for the driving task, whereas functional models describe relations between elements in a model. Input-output models are also referred to as stimulus-response models: given a certain stimulus, the response is fixed, in all circumstances. They do not presume an internal state that is responsible for a choice of action. Psychological models do make presumptions about the mental processes that take place in the head of the driver. Van der Hulst (1999) states that when considering driving behaviour as an adaptive task, in which the driver adjusts the behaviour to the demands of the environment, only psychological, functional models are sufficient. To consider driving an adaptational activity is useful for discussing the role of emotions in driving as well, since emotions are considered to have an adaptive function (Lazarus, 1991). Therefore, in the next section, the focus will be on functional, psychological models. These models can be categorised into three classes: Risk models, performance models and social psychological models.
1.6.2. Risk models

Three well-known risk models of driving behaviour are Wilde's risk homeostasis theory (Wilde, 1982), Näätänen and Summala’s zero risk theory (Näätänen & Summala, 1976) and Fuller’s threat avoidance theory (Fuller, 1984). Risk homeostasis means that drivers are motivated to reach an optimal balance between target risk and perceived risk. Target risk is not the same as minimal risk, but is the risk a driver is willing to accept, given the other goals that are relevant while driving (e.g. arriving at the destination at a certain time). If the level of perceived risk is higher than the target risk, behaviour is changed to reduce the perceived risk by driving more safely. If the level of perceived risk is lower than the target risk, the opposite will happen: driver behaviour is changed in a less safe manner. The zero risk theory differs from the risk homeostasis theory in drivers' motivations towards risk level: zero risk theory assumes that drivers are always motivated to avoid risk, whereas according to risk homeostasis theory drivers are motivated to reach an optimal level of risk. Zero risk theory furthermore assumes that most of the time, drivers do not perceive any risk; only when risk level reaches a certain threshold, they will perceive risk and adjust their behaviour.

The zero-risk theory was revised by Summala (1997). In his hierarchical model of driving behaviour, he refers to emotion as an “extra motive” for road user behaviour. Events in the task environment that elicit emotion, may temporarily shift motivation. This is similar to what Frijda calls "response competition": the task requires one response, but the emotion requires another (see also Section 1.3). The theory however does not specify the processes through which these extra motives exert an influence on driving.

The threat avoidance model assumes that drivers are motivated to avoid aversive stimuli, or threats. Drivers anticipate to the potential threats that may arise in the traffic situation. When they believe a certain threat is present, they might take avoiding actions. This belief may be triggered by certain features of the traffic situation, like warning signs, weather circumstances etc. However, the driver may also choose to "face the challenge" and if needed, undertake avoiding actions at a later moment.

The concepts of risk and threat are central to risk theories. These theories all assume that when risk or threat increase, drivers adapt their behaviour to cope with the situation. Behavioural adaptation may thus, in terms of appraisal theory, be considered an action tendency belonging to the emotion of fear.
1.6.3. Performance models

Performance models emphasize the individuals’ processing of information. According to the cognitive scenario viewpoint, behavioural choices are not based on judgement processes of risk or threat, as in the above described risk models. Instead, the present situation is evaluated by using an earlier stored image of a similar situation. This knowledge is then used as a key to what kind of behaviour is needed in the present situation. Important aspects in this viewpoint are memory and experience: the behaviour in the present situation is dependent on what one can remember from earlier experiences. Production systems, on the other hand, present driver behaviour as a set of "if-then" rules that need to be followed. They are also referred to as rule-based models. Multiple sets of rules may be active at the same time and they may involve complex priority setting (Michon, 1989). That is, a rule may be "if the road is slippery, then drive slowly" while another may be "if being in a hurry, then speed up". Whereas production systems assume that the decision of which rule to follow takes place in a rational way, appraisal theory states that emotions indicate the importance of an event for one’s personal concerns. Emotions may thus serve as a selection criterion as to which rule to follow in case of conflicting rules.

A recent performance model is the task-capability interface model (TCI; Fuller, 2005). This model states that drivers try to maintain a constant level of task difficulty (instead of a constant level of risk). This is done by evaluating the demands of the task and the personal capabilities. When task demands exceed personal capabilities, the task is (too) difficult; when personal capabilities exceed task demand, the task is easy. The interaction between demand and capabilities is also central in the concept of mental workload (De Waard, 2002), which is, according to Fuller, a different name for a similar concept (p. 468).

The data presented by Fuller show that task difficulty is highly related ($r = 0.97$) to experienced risk, or feeling of risk. Feeling of risk is furthermore considered as almost synonymous with feeling of fear or anxiety. Anxiety, Fuller suggests, thus serves as a mechanism to assess task difficulty. This signalling function of emotions is similar to the adaptive function of emotions as described in Section 1.2.2: emotions inform us about the state of the world, and trigger us to take action (e.g. reduce speed) if needed. Another aspect of the TCI in which emotions play a role is in personal capabilities. Personal capabilities are, according to Fuller, not stable. Instead, they are affected by all kinds of state-related variables, such as distraction, alcohol, emotions and stress. Emotions thus might increase task difficulty in
those instances when they reduce personal capabilities, while task demand remains stable.

1.6.4. Social psychological models

Whereas risk models and performance models are domain-specific models of driving behaviour, social psychological models are general models applied to the area of road user behaviour. The most commonly used model is the Theory of Planned Behaviour (TPB; Fishbein & Ajzen, 1975). This attitude model describes behaviour intention as a function of attitude, belief and social norm. It has been applied widely to explain different traffic-related behaviours, such as speeding (Elliot, Armitage, & Baughan, 2005), seat belt use (Budd, North, & Spencer, 1984), traffic law violations (Rothengatter, 1994) and aggressive violations (Parker, Lajunen, & Stradling, 1998). The TPB is a rational model in the sense that a course of action is selected after careful consideration of the different options and their consequences. As such it has been applied to road user behaviour as well. Later studies indicated that decisions to commit violations are not determined by rational motives alone. Lawton, Parker, Manstead, and Stradling (1997) extended the TPB by adding the factor of anticipated affect. They showed that road traffic violations, such as speeding, can be associated with positive emotions, such as pride or excitement, or negative emotions, such as fear of being involved in an accident. Violations were more likely when drivers expected to experience positive emotions while performing that kind of behaviour than when they expected to experience negative emotions (see also Chapter 2). The notion that both instrumental and affective motives determine road user behaviour, proved to be a useful extension of the TPB (Levett, 2003a; Yagil, 2005).

1.7. Towards a theoretical framework

Models of driving behaviour describe the driving task from one perspective: either from a perspective of risk or threat, from a performance perspective or from a social psychological perspective. For the area of emotions it is not only necessary to describe the relations with cognitive concepts like judgement or memory, but also the relations with other cognitive factors like attention, and social psychological factors. Therefore insights from one of these perspectives do not suffice. What is needed is information from both the risk, performance and the social psychological perspective (Huguenin & Rumar, 2001; Rothengatter, 2002). Groeger (2000) made an attempt to integrate these factors. He proposed a four-facet framework in which four basic processes of driving are considered. The first process, implied goal interruption, detects changes which imply that currently active goals will not
be achieved or will be less likely to achieve. Elements belonging to this process are for instance spatial judgement and hazard perception. The second process, appraisal of future interruption, appraises or evaluates these changes. This process may be affected by personality characteristics like extraversion, but also by susceptibility to stress and level of confidence. The third process, action planning, selects and constructs the most appropriate form of action in the circumstances, and the fourth process, implementation, is responsible for the implementation of these actions. Although developed in a cognitive tradition, this model takes perceptual, cognitive, personality and social factors into account. Groeger does not attempt to make a model of driving behaviour: the framework is mainly a description of the factors (clustered in 4 "main" elements) that are relevant for driving.

The four facets explain how drivers adapt to changes in the task environment: an event may happen that implies an interruption of the drivers' goals, the driver evaluates whether this event has consequences for the future and for future goals, and depending on that, he decides on action planning and implementation. The facets appraisal of future interruption and action planning are quite similar to elements of the appraisal theory of emotion. Apparently, for driving in general, the same processes occur as in the emotion process: events are evaluated in terms of their adaptational value, and if this evaluation results in a need for action, action is prepared. A difference is that actions that derive from emotions are not carefully planned and implemented, as is the case in action planning in Groeger's model.

Emotions may affect two facets of driving behaviour. First, emotion may affect the facet of action planning. The discussion of social psychological models shows that motives for behaviour are not always rational; sometimes emotions show to be a stronger motivation. The discussion of appraisal theory states that emotions imply a need for action, which might take precedence over other actions. These discussions show that under the influence of emotions, a driver might select a different action than was planned before. This is also mentioned by Groeger (2000) in his description of action planning: “A threat that is appraised as very important will cause a reallocation of attention and the interruption, perhaps the forgetting, and consequent need for re-planning of the goals currently operating.” (p. 196). Second, a driver may intend to perform the planned action, but turns out to be incapable to implement this action. Groeger suggests (p. 198) that sometimes the implementation phase requires the combination of different actions as resulted from the action planning phase. This might lead to an increased demand on processing capacity, which consequently requires more conscious control, where actions would have been implemented more
automatically otherwise. Emotions may further increase this demand. Support for this comes from the discussion of the Task-Capability Interface model. Personal capabilities are not stable and when they are affected by emotions, they increase task difficulty, assuming that task demand remains stable.

The emotion process can thus be placed within the four facet framework of driver behaviour. The transition from the facet *appraisal of future interruption* to the facet *action planning* may imply that emotions are elicited; namely, when events are evaluated as relevant for a person’s important concerns and goals (see Figure 1.1).

![Figure 1.1. Emotion linked to the four facet model of driving behaviour.](image)

The actual processes through which emotions are elicited and through which they influence driving behaviour, are not described by the four facet framework. In Section 1.5, it was argued that by combining appraisal theory with the appraisal tendency approach, the entire emotion process, from emotion elicitation to emotion effects, can be accounted for. Thus, the four facet framework of Groeger can be connected to the emotion process, which is in turn described by appraisal theory and the appraisal tendency approach.

### 1.8. Conclusions

Let us return to the account of drivers’ aggression at the beginning of this chapter. The example indicates that when investigating the role of emotions in driver behaviour, a number of factors play a role. The example describes the elicitation of anger: in line with appraisal theory, the driver evaluates the
event (the other drivers’ continuous speed changing) as an interference with his personal goal. The driver blames the other driver, which is an important appraisal component for the elicitation of anger. Besides elicitation of emotion, the example also provides evidence for the effects of emotions. The driver strongly feels the need to do something about the event (force the other driver to a parking spot), although he does not follow through his plans because of an important meeting. Furthermore, the driver does not seem to perceive any risk, although at least two near-accidents are reported, which indicates that the angry state may have influenced his risk perception. When focussing on the drivers’ task performance, the example also indicates that a number of subtasks may be influenced by the emotional state e.g. reaction (braking) time, judgement of overtaking gaps, the commission of violations, etc.

The current thesis aims to clarify the role of emotions in traffic. Two central research questions can be distinguished: first, through which processes are emotions elicited during driving, and second, which are the consequences for driving-related performance. In order to answer these questions, different theoretical frameworks are needed. In the current chapter, we have tried to connect these theoretical perspectives to each other, in order to indicate the relevance of the traffic context for emotion and mood theories, and the relevance of emotions for models of driver behaviour. In the next chapter, the question is whether these connections have been made in empirical studies. An overview will be given of experiments on emotions in traffic, and special attention will be directed towards the use of a theoretical framework. Theoretical notions and empirical findings will be compared, in order to develop specific research questions for the remainder of this thesis.