The role of emotions and moods in traffic

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Interim report of the first phase of a research project

Report documentation

Summary

This report describes the first phase of the project 'Emotions in Traffic' which started in January 2001 as a collaboration project between the University of Groningen and SWOV Institute for Road Safety Research.

Theoretical issues
The concept of emotion is closely related to other concepts: mood and affect. Affect is generally used as an umbrella term for all kinds of affective states. Moods are thought to be more non-specific than emotions, and are thought to last longer than emotions. Emotions are thought to be intentional, meaning that they are directed towards an object, whereas moods are not.
Emotions occur when a valued goal or concern is at stake. An event is cognitively evaluated or appraised by an individual, and it depends on this cognitive appraisal if, and if so, which emotion will occur.

Effects of affective states
Emotions may lead to thoughts and behaviour that affect performance on a range of tasks. Effects of emotions are shown in risk perception and risk taking behaviour, information processing, and memory.

Stress, emotions and performance
These effects of emotions on performance may be relevant for traffic participation, although research on this topic is limited. Some studies made a link between stress (an area closely related to the emotions) and task performance in traffic. However, the knowledge of the relations between stress and driving can be expanded if insights from the area of emotions are included.

Emotions and driving
The knowledge of the effects of emotions on thoughts and behaviour and the knowledge on the stress-performance relationship can be integrated to gain more knowledge of the relationship between emotions and task performance in traffic. Only a few studies focussed on emotion and traffic, and in most cases they were concerned with anger, and not with other emotions. These studies are reviewed.

Methodological issues
Research on emotions is complicated, not only because the concept is not clearly defined, but also because there are some methodological difficulties.
One problem is experimentally inducing emotions. Several methods can be distinguished (e.g. showing film fragments or asking subjects to recollect an experience that caused emotions in the past) but their efficiency varies and it is difficult to tell how long the induced emotion lasts. Another methodological issue is the measuring of emotions. Three different methods can be distinguished: observing overt behaviour, physiological measures and self-reports. Each has advantages and disadvantages, so it is recommended that a combination of methods is used.

Research plans
Four general research questions are formulated:
1.   Which are the determinants of emotions in traffic?
2.   To what extent do emotions affect cognition?
3.   To what extent do emotions affect the selection of action?
4.   To what extent do emotions affect driving performance?

Four experiments are designed to answer these questions. The first experiment is a questionnaire study in which possible determinants of emotions are studied. In the second and third experiment, emotional states are experimentally induced and the effects on cognitive processing and behaviour is studied in the laboratory. In the fourth one, experimental states are induced and the effects on actual driving performance are studied. In the last study (which is not a real experiment) written reports on aggressive incidents are qualitatively analysed.

Contents

1.   Introduction

This report describes the work that was done during the first year of the project 'Emotions in traffic'. The project started in January 2001 as a collaboration project between the University of Groningen and SWOV Institute for Road Safety Research. The project has its origins in two areas: traffic research and emotions research. In the context of traffic, the research that has been done on emotions has focussed mainly on anger and aggression. To a lesser extent, there have been studies on stress while driving and on mood states affecting driving performance. However, no systematic research has been carried out concerning the role of emotions, other than anger and aggression, in traffic.

Fundamental psychological research on emotions mainly focusses on origins, processes, and functions of emotions. Especially in recent studies extensive knowledge was gathered to construct a clear picture of what emotions are and how and why they occur. An area that until now did not receive much attention is the effects of emotions on performance, even though effects of other 'state factors' were considered (e.g. fatigue, stress etc.). Many studies dealt with the effect of moods on cognitive processing, but they focussed on positive versus negative mood, and not on specific moods and emotions. Also, these studies mainly used laboratory tasks concerning judgement, creativity or cognitive flexibility. An area that remains mainly uncovered, then, is how specific emotions (e.g. anger, sadness, happiness, pride, fear) influence complex and real life task performance.

The present project aims to shed light on this issue by constructing a series of experiments. The first experiment is a questionnaire study which focusses on the determinants of emotions in traffic. The following three experiments are concerned with the effects of emotions on traffic behaviour. The total running time of the project is four years, during which the results of the experiments will be integrated, and this will result in a dissertation.

During the first year of the project, three main activities were carried out. First, a theoretical background was written and suggestions for research were made. Second, a literature review was carried out on the methods to measure emotions in traffic. This paper was presented on a traffic safety seminar in Ankara, Turkey. Third, a theoretical introduction and research plan for the first study was written. This interim report includes the products of these activities. Also, a research plan for the remaining three years is added. The structure of the report is as follows: *Chapter 2* discusses some theoretical issues on the topic of emotions. *Chapter 3* gives an overview of studies that have been carried out on the effects of emotions, and moods. In *Chapter 4* the theoretical relationships between stress, emotions and performance are discussed. In *Chapter 5* an overview of studies on emotions in traffic is presented. *Chapter 6* deals with some methodological issues related to emotion research. In *Chapter 7*, finally, directions for future research are discussed.

2.   Emotions and moods: some theoretical issues

2.1.   Concepts and definitions

The concept of emotion relates to the occurrence of an event which is relevant to an important concern or goal. This concern or goal is not necessarily personally important for the person experiencing the emotion: sometimes the event violates social norms or values the person may have. Another characteristic sometimes mentioned is that an emotion will occur when goal-directed behaviour is interrupted. Two other elements of emotions are derived from Frijda (1986): action readiness and control precedence. Action readiness means that the event demands some kind of action: either to make the event stop (in case it causes 'negative' emotions) or to make it continue (in case of 'positive' emotions). Control precedence means that the event causing the emotion takes away all attention from other events or tasks: all senses are directed towards the one object or event causing the emotion.

Oatley and Jenkins (1996) summarize these elements in what they call: "a working definition of the concept of emotion":

- An emotion is caused by a person consciously or unconsciously evaluating an object or event as relevant for a personal 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, and actions.

A number of other terms is related to the concept of emotion, like mood, feeling and affect. The concept of 'affect' is often used as an umbrella term for feelings, emotions, and moods. Feelings, emotions, and moods then serve as sub-categories. Affect or affective responses are usually understood as being uni-dimensional: an either positive or negative affect is present. Feelings, according to Frijda (1986), form the core characteristic that differentiates affective from non-affective experiences. Feelings are usually seen as elements of experience that are irreducible to body sensations or cognition. Although emotions and moods are closely related concepts, most researchers insist on making a distinction between them (Ekman, 1994). The duration of the experience is often mentioned as a distinguishing criterion: emotional experiences are short (between a few minutes and a few hours) whereas moods can last for days, weeks, or even months. Some researchers claim that moods lower the thresholds for certain emotions to occur and also the other way around: the occurrence of a specific emotion may lead to a mood that will last for a longer time. Furthermore, emotions are intentional: they always have an object, whereas moods are non-specific.

2.2. The emotion process: appraisal theory

The most influential emotion theory among psychologists is appraisal theory. The first researchers to use the concept of appraisal were Arnold (1945) and Lazarus (1966). Although Lazarus' 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. In *Chapter 4* we will say more about the relations between stress and emotions.

The general idea behind appraisal theory is that emotions are elicited by evaluations (appraisals) of events and situations (Roseman and Smith, 2001). It depends on the interaction between an event and an individual whether an emotion takes place. Appraisal theory does not see an emotion as a distinct phenomenon, but rather as a process. Within this process several steps or phases can be distinguished.

The process starts with an event. This is not necessarily something happening in the outside world: a person can also suddenly remember something or realise something, which is then called 'event' as well. The first question that is asked by the person perceiving the event, is: How important is this for me? Something that bears absolutely no relevance for the person, is not likely to elicit an emotion. The next step is the evaluation of the event in terms of congruence or incongruence with one's own concerns. Events that are congruent with the person's concerns will elicit positive emotions; events that are incongruent with one's concerns will elicit negative emotions.

Next, there are a number of hypothetical questions a person might ask himself. Generally speaking, these questions are similar in the appraisal theories proposed by Lazarus (1991), Frijda (1986), and Scherer et al. (2001). The answers to these questions may determine the type of positive or negative emotion that is experienced. For example:

- Who is responsible for this event?
- How well can I cope with this?
- What is the significance of this event for my self-concept and social norms and values?
- What are the outcome probabilities?

Each emotion is different because the answers to the questions mentioned above are different. Appraisal is the process of 'going through' these questions. For example, anger is likely to be induced if:

- the event is relevant for one's concerns;
- the event is incongruent with one's goals;
- someone else is to blame;
- the event relates to one's self concept or norms and values.

By appraisal, people scan the environment for events relevant for their well-being, so the correct response to the event can be selected (for example, fight, in the case of anger). Therefore appraisal also has an adaptational value. Sometimes, however, the emotions elicited by appraisal processes

are maladaptive, such as in anxiety disorders, or the behaviour caused by emotions is maladaptive, such as in aggression. In *Chapter 5* we will get back to the question when emotions are adaptive and when they are maladaptive.

3.   Effects of affective states

Emotions can cause behaviour, thoughts, or experiences which have a direct relationship with the emotion. Sometimes however, behaviours occur which are not specifically related to the emotion but do occur as an effect of it. This distinction may be especially relevant for traffic situation: when people get angry they may start swearing or making gestures (behaviours related to the emotion), but they also may suffer from attention loss or decrease in reaction times as a result of anger. Perhaps the kinds of behaviour that are not so clearly related to the emotion at hand are even more important in traffic situations, since the effects might do their work unconsciously. For example, one may not notice that reaction times are longer when being angry.

A large number of studies investigated the effects of various affective states on human performance. Memory, judgement, risk perception, attitude change, impression formation, attention, and creativity: these are all topics that have been studied in relation to affect. However, research has been limited in two ways. First, in most studies the focus was on mood or on general positive or negative affect. The effects of specific emotions received less attention. An area that remained mainly uncovered, then, is how specific emotions (e.g. anger, sadness, happiness, pride, and fear) influence complex and real life task performance.

A reason why emotion researchers have not been concerned so much with the effects of emotion, was recently proposed by Siemer (2001). It may be that we are dealing with two distinct research traditions, one which is 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. When considering the effects of affective states on driving performance, a third relevant line can be distinguished, which focusses on the effects of various state factors (like stress and fatigue, and recently also moods) on task performance. Another reason may be that while emotions are believed to have a clear object, research on the effects of emotional states is more directed towards the question of how emotional states alter cognition unrelated to the original object of the emotion (Parrot and Spackman, 2000).

In the previous chapter, insights on emotion processes and theories were discussed. In the present chapter we will review studies that concern the effects of affective states on performance. Most of the studies focus on cognitive processes but some discuss task performance as well.

3.1.   Mood and risk

Johnson and Tversky (1983) investigated the relationship between mood and risk perception in a series of four experiments. In the first and the second experiment, subjects in the experimental condition had to read newspaper articles concerning a death of a young undergraduate. It turned out that subjects in the experimental condition were in a more negative mood than subjects in the control condition. Furthermore, subjects in the experimental condition made more pessimistic judgements about the risk of

getting killed than subjects in the control condition: they gave higher risk estimates. This effect was a global effect, meaning that it extended to all causes of death and not only the ones that were similar to the cause of death mentioned in the newspaper article. In the third experiment, subjects in the experimental condition were asked to read depressing stories unrelated to risk of death. Results showed that these subjects also gave higher ratings of risk of death, supporting the hypothesis that it is the bad mood, rather than the information in the stories, that cause the more pessimistic judgements. In the final experiment, subjects read positive stories and again made judgements on the risk of death by several causes. Subjects in the experimental condition showed lower levels of perceived risk of getting killed by various causes than subjects in the control condition.

Wright and Bower (1992) also showed that people in a positive mood are optimistic: they report higher probabilities for positive events and lower probabilities for negative events. People in a negative mood (sad, in this case) are pessimistic: compared to controls they report lower probabilities for positive events and higher probabilities for negative events.

These results suggest that a negative mood leads to a higher risk perception whereas a positive mood leads to a lower risk perception. In other words, people in a positive mood are optimistic and may therefore take risky decisions. This was shown by Armitage, Conner and Norman (1999), who found that a positive mood promotes risky decision making and more heuristic decision strategies, whereas negative moods instigate a more problem-focussed approach. The explanation provided is that people in a positive mood try to maintain that state, and too thorough processing can interfere with that goal. People in a negative mood, on the other hand, see many more problems and try to 'repair' their negative mood by elaborating, in other words, by thinking things through carefully.

Research by Isen (see Isen, 2000 for a review) also shows that positive moods lead to more risky decisions, but only if the situation which subjects are presented with is hypothetical. When confronted with a situation where subjects indeed could win or loose something, subjects in a positive mood made less risky decisions than those in a negative mood. Leith and Baumeister (1996) found that a bad mood was associated with more self-defeating (risk-taking) behaviour, but only in a high arousal - bad mood condition like anger. Sad subjects did not show any higher levels of self-defeating behaviour. Angry subjects did also show lower risk-perception in a study by Lerner and Keltner (2000), as opposed to fearful subjects.

These results seem to point in the direction that sad and fearful subjects are likely to perceive risks as higher and have lower inclinations to take risks than angry subjects. The opinions about subjects in positive mood are less clear: are they risk-averse because they want to maintain the positive mood, or are they more likely to take risks because of an illusion of control? It needs to be said that all reported studies were carried out in the laboratory, using lottery games, pencil-and-paper risk estimations, and so on. We do not know of studies linking positive and negative mood, or even

specific emotions to risk perception and risk taking behaviour, in real life situations like traffic.

3.2. Mood and information processing

People in a good mood tend to process information in a less systematic way and rely more on heuristic cues than people in a bad mood. This was shown first in relation to attitude change (Mackie and Worth, 1991; see Eagly and Chaiken, 1993, for a review on mood and persuasion) and later also in relation to social judgement (Bodenhausen et al., 1994). Sinclair and Mark (1995) showed that happy subjects were less accurate in estimating correlation coefficients from scatter plots than sad subjects. Several explanations have been offered for this phenomenon, the most important being that mood has a signal function: a bad mood means something is wrong and something has to be done about it, and a good mood means all is well (Armitage et al., 1999). Sinclair, Mark and Clore (1994) extended this hypothesis by arguing that the more elaborate processing of sad subjects is caused by misattribution. When people are in a bad mood, they tend to perceive their mood as a reaction to the situation which then means that something is wrong and something needs to be done. Therefore elaboration will be high. This is called the 'mood as information hypothesis'. However, Sinclair et al. (1994) showed that people who attribute their mood to an external cause (e.g. the weather) do not show greater elaboration when being in a bad mood.

The different processing styles of happy and sad subjects lead to different levels of performance on different tasks. Performance on tasks that require detailed processing are facilitated by a negative mood. Performance on tasks that require creative and 'playful' processing is facilitated by a positive mood. However, Hirt et al. (1997) claimed that if the effects of moods are caused by misattribution (mood as information), then the mood effects should be eliminated if subjects are made aware of their mood and the fact that the mood has been caused by something else. They did an experiment in which they cued half of the subjects on the true source of their mood. The other half of the subjects were not cued. It appeared that cuing the subjects on the source of their mood had an effect on quantitative measures of performance. However, cuing did not affect creativity. The authors conclude that the mood-as-information view does not apply to creativity. It is not exactly clear yet through which processes positive mood does affect creativity, but explanations must be sought (according to the authors) in theories of mood management or affective priming. Mood management refers to the phenomenon that people want to maintain their positive mood and are unwilling to engage in activities that include careful systematic processing. Affective priming means that affect is linked to similar concepts in the brain.

Dibartolo et al. (1997) showed that subjects with a generalised anxiety disorder showed poorer task performance of a laboratory task than normal comparison subjects. However, this difference was noted only during baseline trials and not during experimental trials. One explanation that is provided is that anxious subjects become aware of the interfering role of their anxiety with the task, and allocate an extra amount of effort to the task at hand during the experimental trials. Therefore, the final performance is

equal to the performance of normal comparison subjects. It should, however, be noted that mood effects might be different for people with mood disorders than for non-clinical subjects. People who are afraid of driving might show different behavioural responses in traffic than those who are suffering from anxiety disorder which is not related to traffic.

3.3. Mood and memory

Parrot and Spackman (2000) give an extensive review of studies investigating the effect of emotional states on memory. First of all they note that in these studies, no consistent distinction has been made between mood and emotion. This is a general problem of studies on the effects of emotional states on performance, as we have seen before. In their review chapter, Parrot and Spackman use the terms 'emotion' and 'mood' interchangeably, as we will do in this paragraph as well.

Emotions can influence memory in three ways. One applies to the emotional valence (positive or negative value) of the material to be remembered. The second applies to the emotional state of the person at the time the material is encoded in memory. And the third applies to the emotional state of the person at the time of retrieval of the material. Most studies considered the interaction effects of emotional states during retrieval and emotional content of the material. Early studies mostly showed mood-congruent recall, that is, persons in a happy mood recalled positive information, whereas persons in a sad mood recalled negative information. This phenomenon was first explained by the associative network theory. According to this theory, human memory can be modelled as a network of concepts, linked together to describe an event. Emotions are thought to be represented in the network and are related to emotional events and concepts. The activation of an emotion leads to activation of related emotional concepts and events, and therefore facilitates memories that are similar in emotional valence.

The need for other explanations for mood-memory relationships became obvious when other studies started to show incongruent recall as well: remembering negative events when being in a positive mood and vice versa. This led to the development of motivational theories, which claim that persons' moods are important for the memories they recall. Memories can be retrieved to maintain or change a person's plans, goals, or moods.

A study by Levine and Burgess (1997) showed the distinct effects of specific emotions on memory. Subjects were brought in a happy, angry or sad emotional state and were then presented with a positive or negative narrative. Each narrative contained information on setting, goal, agent, outcome, and consequence. Results showed that happy subjects showed better memory of the narrative as a whole. Angry and sad subjects showed better recall of only parts of the information in the narrative: angry subjects recalled more information related to goals, whereas sad subjects recalled more information related to outcomes.

The research that has been reviewed in this chapter concerns mainly laboratory studies, which deal with cognitive processes rather than with real life task performance. Also, most studies in this area focus on general

positive or negative affects or moods. What is lacking is theoretical knowledge about how specific emotions affect complex and real life task performance, and to be more specific, in which cases emotions are beneficial to driving performance and in which cases they are destructive. Therefore, in the next chapter we will turn to a topic which is closely related to emotions but where a much broader theoretical background exists on the effects on performance: the area of stress.

4.   Stress, emotions and performance

4.1.   Definitions of stress

The concept of stress is complex and vague. Not only are there a number of different definitions, but also the processes that have been studied under the umbrella term of stress are of a very different nature (Buunk and Gerrichhauzen, 1993). However, the definitions that have been proposed over the years can be broadly summarised in three viewpoints. In the earliest views, stress was seen as a characteristic of the environment: a load that was put on the subject. Later on, the emphasis was put on the subject who reacted to an external threat. Nowadays, stress is usually defined from an interactionist point of view. It is not just the environment that is causing stress, because equal situations cause stress reactions in one person but not in the other. Neither is it a personality characteristic, because the same person might respond differently to different stressful stimuli. Instead, stress is a result from a dynamic interaction between person and environment. Specifically, in interactionist definitions stress results from environmental demands and personal capabilities that are not in congruence with one another.

Lazarus and Folkman (1984) proposed a definition of stress that is still widely used nowadays. According to them, stress occurs when:
a) someone judges a stimulus or event as harmful, and b) doesn't see (enough) possibilities to handle the stimulus or event. As a result of stress, stress reactions may occur, such as physical illnesses, disruption of behaviour, and negative emotions. According to Lazarus en Folkman's viewpoint of stress, appraisal is a central theme. Appraisal means the continuous evaluation of the external environment by the person. Thus, during the occurrence of stress, two different kinds of appraisal take place: the evaluation of a stimulus as harmful (primary appraisal) and the evaluation of personal capabilities as being insufficient (secondary appraisal). The stimulus or event that is evaluated is not called the stressor, because it depends on how it is appraised by the individual whether it causes stress or not.

4.2.   Stress and the emotions

The area of stress is closely linked to the area of emotions. However, the literature on stress and the literature on emotions have mainly been treated separately. Therefore, Lazarus (1991, 1993) proposed an integration of the two theories. In fact, he claims that current interactional theories of psychological stress come very close to a theory of emotion. An interactional theory of stress defines the appraisal process that leads to negative emotions. The negative emotions 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 the stress theory is too restrictive and actually covers only half of the topic. Instead, he proposes a theory which

he calls a cognitive-motivational-relational theory of emotion. According to this theory, each emotion has a 'core relational theme', this is what the emotion is all about. Which emotion occurs as a result of a specific person-environment encounter, depends on a range of appraisal components, divided in two categories: primary appraisal and secondary appraisal. Note that these terms are used a bit differently in emotion theory than in stress theory (see *Paragraph 4.1.*). The primary appraisal components are goal relevance, goal congruency, and type of ego involvement, whereas the secondary appraisal components are blame or credit, coping potential, and future expectations. The combination of the specific appraisal components define which emotion occurs. Stress, in the viewpoint of Lazarus, is therefore seen as a particularly harmful, threatening or challenging person-environment relationship, and it depends on the specific appraisal components which (negative) emotion occurs.

An example may shed some more light on this theory. Consider a situation on a highway, where a car driver is driving in the right lane. From a merging lane on the right, another car is approaching. The car driver moves to the left lane, just in front of the first car driver, who has to hit the breaks heavily to avoid a collision. The first driver may appraise the event as follows. There is goal relevance, since the goal of the driver is to avoid a collision. There is goal-incongruence, since the event may actually cause a collision, so the goal is threatened. The ego-identity is affected if the event is seen as an assault. These are the primary appraisal components. Secondary appraisal components are blame (the other driver is responsible), coping potential (it is possible to attack, for example by close following, as a reaction to the offence) and future expectations (the expected consequences of the attack are positive, e.g. the other car is not a police car).

4.3. Performance

The relationship between stress and performance has been studied thoroughly. Perhaps the earliest insight in this area came from Yerkes and Dodson (1908). They showed that the relationship between arousal and performance can be seen as an inverted U-curve: under moderate levels of arousal the level of performance increases but when the level of arousal gets too low or high, performance decreases. The optimum level of arousal is reached earlier when the task is complex than when the task is easy. Although the Yerkes-Dodson law has been criticised heavily, it still remains one of the most cited insights in performance literature. It must be noted however, that the concept of stress is not used in the original publication, but the concept of arousal has been interpreted as stress level by other scientists in later years.

One of the criticisms of the Yerkes-Dodson law was that it focuses on arousal, whereas there are other ways in which stress may affect performance, for example by distraction or by changing perception (Matthews et al., 2000). Therefore, cognitive scientists have tried to identify the mechanisms through which stressors have an effect on performance. Many of these effects have been established. Hockey (1986) summarises the effects of various stressors such as noise, heat, fatigue, and anxiety on performance indicators, such as selectivity of attention, speed, and

accuracy. His analysis shows that different stressors can have similar effects on task performance. Also, the same stressor can have different effects on different components of task performance. Hockey does see stressors as independent factors influencing performance, independent of appraisal, whereas Lazarus thinks appraisal is needed before one can speak of stress. However, the concepts are not very clear here, as can be seen from the collection of stressors. From Lazarus' point of view, for example, anxiety is not a stressor but something that may occur as a result of stress.

The integration of stress and emotion, or, if you will, the capturing of stress theory in emotion theory, offers a lot of possibilities for explaining the stress-performance relationship. The reactions that people show under the influence of task environment, can be extended with reactions or action tendencies (Frijda, 1986) to emotions. In other words, the task environment may lead not only to negative emotions as a result from stress, but also to other negative and positive emotions. Lazarus describes about 15 different emotions, each with their own theme or story, and each emotion can lead to different action tendencies. So, when applying Lazarus's emotion theory to the topic of task performance, two issues are important. First, it is likely that performance is not only affected by anxiety, anger, and frustration etc. (the typical stress reactions), but also by joy, pride, sadness, and other emotions. Second, it is not the stress itself that causes changes in performance, but the emotions that result from the person-environment relationship. Unfortunately, the concept of stress and the concepts of emotional reactions to stress (like anxiety) are often used interchangeably in performance literature, making it difficult to differentiate between the concepts.

5. Emotions and driving

Generally it is believed that emotions are functional, that 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. However, sometimes emotions are maladaptive. This happens when specific action tendencies which occur as a result of the emotion, are not fit for the demands of the environment at that very moment. Also, sometimes certain behaviour occurs as a side-effect of the emotion, (for example narrowed attentional focus when being angry) which may turn out to be maladaptive. In this chapter we will try to integrate the viewpoints of the earlier chapters and apply them to the area of traffic. In particular, we will elaborate on the question when emotions are adaptive (beneficial) and when they are maladaptive (harmful) for performance on the driving task.

5.1. Driving stress and emotions in traffic

Keeping in mind the links that exist between stress and emotions, studies on stress and driving can, for several reasons, be viewed in a new perspective. First, the studies assume a direct link between stress and driving. However, as was shown before, the existence of stress leads to stress reactions such as negative emotions. It can be assumed then, that it is not the stress itself (the mismatch between task demands and personal capabilities) that leads to a change in driving performance, but the negative emotions that result from it. Consequently, emotions can be seen as a mediating variable between stress and driving performance.

Second, when restricting oneself to stress and driving performance, the focus is on negative emotions resulting from stress. However, one then neglects the effects of positive emotions, resulting from other causes, which may affect driving performance as much as negative emotions. For example, many studies showed a relationship between positive mood and risk taking behaviour (e.g. Armitage, Conner and Norman, 1999; Isen, 2000; see also *Chapter 3*). Also, research by Levelt (2001) showed that an emotion occurring regularly in traffic is pride about ones own abilities to drive fast in a safe way.

Thirdly, as a more methodological point, the concepts of stress and emotion are confused in studies on stress and driving. Quite often, anxiety or anger is measured, and considered to indicate the level of experienced stress. However, if one would want to measure stress, one would have to measure first how the task demands are appraised by the individual, and second how the individual capabilities to cope with the task demands are perceived. The anxiety and anger are just the emotional reactions that *result* from stress.

Because of these reasons, the focus of new studies should be more on the emotion-driving performance relationship than on the stress-driving performance relationship. The stress and driving studies offer interesting insights, but the picture is not complete.

5.2.   **Results from earlier studies**

As early as 1967, a study was carried out about the effects of mood on performance in a driving simulation task (Heimstra et al., 1967). Subjects filled out the Mood Adjective Check List (MACL) prior to the driving simulation task. The MACL consists of a list of mood adjectives, such as anxious, sad, or relaxed etc. After each adjective four symbols are placed, for example:

Anxious vv v ? no

When the subject was sure to feel anxious, he had to draw a circle around the 'vv' symbol, if he was to feel slightly anxious, he had to mark the 'v' symbol, if he wasn't sure hoe he would feel he had to choose '?' and if he would not feel anxious all he had to mark 'no'. Only four mood factors were considered: aggression, anxiety, concentration, and fatigue. Results from the study showed that correlations between mood factors and task performance measures were low. Subjects' mood did not seem to relate to a large extent to task performance. However, when high scores and low scores on the mood factors were compared, subjects scoring high on aggression, anxiety, and fatigue performed poorer than subjects scoring low on these factors.

In 1980, a similar study was carried out by Appel and colleagues, but this study linked mood and performance in a real life driving situation: the performance of driving school students on a driving task on a slippery road. In this study as well, a mood adjective checklist was used. The adjectives form six dimensions, four of which were used in this study: pleasantness, activity, calmness, and confidence. Results from the study showed that pleasantness, calmness, and confidence were negatively related to error scores on one of the subtasks: subjects who felt more pleasant, more calm, and more confident made less errors.

Until now, research on emotions (as opposed to moods) in traffic mainly focussed on aggressive driving (see for example Levelt, 1997, Lajunen et al, 1998; Hennessy & Wiesenthal, 1999; Lajunen & Parker, 2001). Results from a survey carried out by the British Automobile Association (Joint, 1995) showed 90% of all respondents reported to have been involved in an aggressive incident in traffic during the previous year. It should be noted, however, that 'aggressive incidents' were defined very broadly in this study, including people sounding the horn or giving light signals. Although it is generally assumed that aggression in traffic is preceded by anger, not all studies reporting aggressive driving relate aggression to anger. Hartley and Hassani (1994) for example, view aggression as part of a range of state factors, which together constitute the concept of driver stress. Sometimes a distinction is made between instrumental and affective aggression: instrumental aggression is assumed to be related purely to 'getting ahead' whereas affective aggression involves an anger component and is directed to other road users. However, it is also possible that emotions play part in instrumental aggression, but to what extent is as yet not clear.

Some studies focussed specifically on anger while driving. Deffenbacher et al. (1994) developed a driving anger scale, which yielded 6 sub-scales:

anger provoked by hostile gestures, illegal driving, police presence, slow driving, discourtesy, and traffic obstruction. Lajunen et al. (1998) carried out factor analysis on responses to the items by a British sample, resulting in a scale with 21 items and 3 subscales: progress impeded, direct hostility, and reckless driving. Arnett et al. (1997) conducted a study during which they asked 59 adolescent drivers to keep a log of their driving episodes over a 10 day period. One finding of the study was that an angry mood (but not other moods) was related to speeding behaviour.

Only a few studies report on emotions other than aggression in traffic. Myrtek and colleagues (1994) made a distinction between increased heart rate due to physical activity on the one hand, and increased heart rate due to emotional load on the other. They measured muscle activity and heart rate for train drivers, and compared the values for any given minute with the values of the previous minutes. If the heart rate of a given minute exceeded the rate of the previous minutes without an accompanying increase in physical activity, an emotional/mental heart rate increase was assumed. Results indicated that when speed was less than 100 km per hour, no changes in heart rate occurred compared to a standing still position. When speed was between 100 and 200 km per hour, a decrease in heart rate occurred, presumably due to monotony effects. Starting the train and coming to a halt showed greater emotional workload as compared to moving.

Carbonell et al. (1997) investigated how anxiety and stress in certain traffic situations can lead to traffic accidents. They suggest that, for professional drivers, anxiety combined with time pressure can lead to carrying out dangerous manoeuvres, thus increasing accident risk. Groeger (1997) studied the relationships between drivers, their moods, and their driving performance; both as they themselves believe it to be, and as observed by an experienced observer. Three mood indices were considered: anxiety, depression, and hostility. In general, those who are more anxious perform less well than less anxious subjects. Also, when hostility increases during the test, performance seems to deteriorate.

Jessurun (1997) used electromyography (EMG) to measure drivers' appraisal of two different road environments. She showed slides of the two road environments to subjects and measured activity of the corrugator supercilii (the muscle above the brow, used in frowning). A difference in EMG activity was shown, the more monotonous road causing more activity of the corrugator supercilii than the less monotonous road. So, the more monotonous road caused more negative feelings. This was also reflected in self-report measurements in which the subjects rated the monotonous road as less pleasant than the other road.

Levelt (2001) studied emotions and moods in car drivers and lorry drivers. Moods were described in terms of two factors: calm-energetic and agitation-irritation. It was shown that drivers who agree that they are often in a agitated or irritated mood, also agree that often speeding is the consequence. Furthermore, enjoying driving fast and being proud to drive fast in a safe way were reported by a quarter of the drivers. They were related to violations of speed limits and overtaking prohibitions, as well as the number of fines. Irritation, caused by a slow driver, causes

hooting/flashing and close following, and is related to violations and the number of fines.

5.3. When are emotions (mal)adaptive in traffic?

To answer the question in which cases emotions are maladaptive in traffic, it is necessary, first, to take a stand in the discussion about whether emotions should be seen as categories or as dimensions. In Lazarus's view emotions can be fitted in categories, each with their own relational theme. Other scientists: Plutchik, (1980), Watson and Tellegen, (1985) have taken a dimensional approach, in which all emotions fit on a circumplex defined by two dimensions, e.g. positive and negative affect or valence and arousal. Especially when studying the effects of emotions on task performance, it is important which viewpoint is taken, since the predictions of the two viewpoints would be quite different. Take, for example, anger and anxiety. In an arousal-valence dimensional approach, these two emotions would be placed close together on the circumplex and have similar effects on task performance. But in a categorical approach, the underlying appraisal themes of anger and anxiety are totally different from each other, leading to different effects on task performance. Lerner and Keltner (2000) put the two approaches against each other and tested whether anxiety and anger have different effects on risk perception. Their study showed that fearful people made pessimistic judgements about future events, whereas angry people made optimistic judgements.

This study is also relevant for traffic research, since risk and risk perception are important factors in driving. Based both on this study and on Lazarus's theory of emotion, it seems legitimate to favour the categorical approach over a dimensional approach when studying the effects of emotions on driving performance. We assume that each emotion has its own specific effects on driving performance. The question is then, through which processes these effects occur, and when the effects are beneficial (adaptive) or harmful (maladaptive), that is, promoting traffic safety or endangering it.

Frijda (1986) reviews a number of hypotheses on emotional disturbance and energizing. One of these is called the response competition hypothesis. According to Frijda, it depends on the relevance of a particular behaviour for the task at hand, whether this behaviour improves or deteriorates under the influence of emotion. Frijda gives an example of a football team, made angry at the opposing team by the coach just before the start of the match. The anger may result in running and kicking with force, which is especially adaptive in this situation. Likewise, anxiety in traffic will be adaptive if the task is, for example, keeping at a safe distance from the lead car, since the behaviour resulting from anxiety has to do with avoidance or escape. On the other hand, if the task at hand is following another car with high speed, anxiety will be maladaptive because the behaviour resulting from anxiety is incompatible with the task. Related to this is what Wickens (1992, p. 419) says about stress and decision making: "The effects of stress on decision making depends on the components of the decision making which are relevant: since different decisions may involve varying dependence on such components as working memory, attention and long-term memory retrieval,

each decision will be affected differently by stress as a function of the components on which it depends."

This also means that positive emotions such as happiness and pride may have averse effects on task performance. Likewise, negative emotions like fear can have positive effects. All depends on whether emotional responses coincide with task-relevant responses.

Other hypotheses on the emotion-performance relationship can, in my opinion, be summarised by the term 'cognitive bias'. It refers to those instances in which emotions cause changes in judgement, attentional focus, information processing, distraction, etc. These effects are not so much concerned with the primary function of the emotion, but are, in a way, unintended consequences.

Consider, for example, a study by Matthews et al. (1998). They considered anxiety to be a central part of the driver stress dimension 'dislike of driving'. Anxiety, they claimed, has two effects on driver performance. First, anxiety may lead to a diversion of attention, leading to more driving errors. Second, anxiety may increase the perceived danger of the task, leading to a decrease in risk taking behaviour. The concept of anxiety can, according to Lazarus (1991), be described as an uncertain, existential threat. The action tendency belonging to anxiety would be avoidance or escape. The response competition hypothesis would predict that performance will decrease if emotionally motivated behaviour and behaviour required by the task are conflicting. In this case (assuming that the task in this case would be safe driving), the action tendency of avoidance does not conflict with the behaviour required from the task (risk avoidance). Therefore in this case performance does not decrease. However, from the cognitive bias hypothesis point of view, anxiety also leads to unintended consequences, like distracting thoughts or cognitive interference, leading to more driving errors. Thus, the same emotion, in this case anxiety, can have both positive and negative effects on performance and these effects can actually occur at the same time in the same task environment.

To establish, then, the effects of each emotion on driving performance, one should specify the action tendencies that result from the emotion, specify the task (components) in which one is interested, and establish the cognitive biases that may occur as a result of the emotion.

6. Methodological issues

In this chapter we will address some methodological issues that are relevant when studying emotions in traffic. We will discuss respectively the issue of inducing emotions in the laboratory, and the issue of measuring emotions.

6.1. Inducing emotions

A large variety of methods has been used to induce emotional states in the laboratory. Generally, no distinction is made between the concepts of moods and emotions, although there are exceptions (Philippot, 1993). For example, in a review by Gerrards-Hesse et al. (1994) a footnote is made: "Here as well as in the following; emotion, emotional state, mood, and mood states are used as synonyms". When studying the effects of specific emotions on performance, inducing a positive or negative emotional state is not enough. One has to be sure that a specific emotional state is present, because it is believed that each emotion has different adaptational functions, and that the effect of each emotion on performance is dependent on these functions.

In the next section an overview is given of studies using emotion induction procedures and their effectiveness. For each procedure, the type of intended emotional state is mentioned (general or specific, moods or emotions). Where possible, something is said about the duration of the emotional state induced.

Video

Hirt et al. (1997) studied the effects of mood on cognitive laboratory task. A happy or a sad mood was induced in subjects: subjects in the 'happy' condition watched videoclips from films like 'Pretty Woman' and 'Mrs. Doubtfire'. Subjects in the 'sad' condition watched clips from films like 'Ordinary People' and 'Sophie's Choice'. Both before and after the task, the mood was measured and both showed significant effects of the mood manipulation. There is no information about how long the effect lasted.

Asuncion and Lam (1995) studied the effects of mood on memory. A happy mood was induced by having subjects watch comedy video clips. A sad mood was induced by having subjects watch videoclips showing a Ronald McDonald house where children with cancer were interviewed. Mood manipulation checks were carried out right after the manipulation but not after the task. The mood manipulation was effective: both mood states differed statistically significant in the expected direction from a control group. Mood state was not measured after the task, so no knowledge exists about the duration of the mood state.

Rosselli et al. (1995) studied the processing of rational and emotional messages. Either a happy or a neutral mood was induced. Subjects in the 'happy condition' viewed a 5 minute video clip from a comedy series. Subjects in the neutral mood condition watched a 5 minute videoclip about wine. Mood manipulation checks were carried out after watching the

video's. Subjects in the happy mood condition rated their moods as more positive than subjects in the neutral mood condition.

Video / experimental manipulation

Leith and Baumeister (1996) used different techniques to induce positive and negative moods. In study 2, for positive mood, videoclips were used. For negative mood, subjects were told that they were supposed to sing aloud the lyrics of a song: "I did it my way" by Sinatra. This was supposed to evoke feelings of embarrassment and anxiety. The mood manipulation check showed that all subjects gave reports that corresponded to the mood manipulation. However no average scores or significance levels are given. In study 3, good mood and angry mood were considered. It was believed that merely watching a videotape would not evoke sufficient levels of anger in respondents. Therefore, to induce anger, an experimental manipulation of the situation was used. Respondents were encouraged to recall an episode in which they had been very angry, but in the middle of this recollection (which involved actual expression of the anger on an audio tape, for example shouting and swearing) the procedure was interrupted several times by the experimenter. Manipulation checks showed that the mood manipulation was successfull. Study 4 used the same anger induction procedure as study 3. In study 5, sad mood was evoked by showing videoclips. All manipulations were successful.

Experimental manipulation

Levine and Burgess (1997) studied the effects on specific emotions (happiness, anger, and sadness) on memory. Happiness and negative emotions were induced in undergraduate students by randomly assigning a low (D) or high (A) grade on a surprise test. It was expected that the subjects who received a 'D' would experience a broader range of emotions than subjects receiving an 'A'. Because of this, the group of students receiving a 'D' was bigger than the group receiving an 'A'. Manipulation checks (a question after the memory task, asking how the subject felt right before the memory task) showed that subjects receiving an 'A' were more happy than subjects receiving a 'D'. Subjects receiving a 'D' were more sad and more angry than subjects receiving a 'A'. Questions were directed at the 'primary emotion'. Therefore, in later analyses, distinctions could be made between subjects who felt mainly angry, and subjects who felt mainly sad after receiving a 'D'.

Video / success / failure

Forgas (1995) studied the effects of mood on judgement and memory about prototypical and atypical targets. In experiments 1 and 2, video fragments were used to induce either a happy or a sad mood. Experiments 3 and 4 used a false feedback mood induction procedure. The mood induction procedure was introduced as a test of verbal abilities. A set of 33 questions was presented. On average, people completed 19 questions in 5 minutes. Subjects in the positive mood condition were told that the test was difficult and few people completed more than 10 questions in 5 minutes. Performance between 7-13 questions completed within 5 minutes was described as 'average' and over 13 as 'above average', indicating superior

verbal ability. Subjects in the negative mood condition were told that the test was easy and that most people completed the test in 5 minutes. For this group, average performance was described as 27-30 items completed, with more than 30 items as 'above average'. Performance below 27 items was labelled as 'below average'.

Both the manipulations in experiment 1 and 2, and the one in experiment 3, were effective: subjects in the 'happy' condition rated their mood as more positive than controls and subjects in the 'sad' condition rated their mood as more negative than controls. The manipulation check was carried out after the manipulation, but before the judgement task. Subjects had to rate their mood on 7-point scales: happy-sad, good-bad and satisfied-dissatisfied. It seems that possible emotion blends were disregarded here: it could be expected that subjects who scored below average were not only sad but angry as well.

Success / failure

Hockey et al. (2000) studied the effects of mood on risk taking behaviour. In study 1 and 2, mood was measured but not manipulated. In study 3, a mood manipulation procedure was used: one group of subjects had to work in a group on a difficult task which could not be completed because of unexpected problems. The other group spent the time in private study and unstructured group discussions. The main goal of the manipulation was to induce fatigue. Manipulation checks showed that subjects in the experimental group were more tired and anxious, but not more depressed than the control group. Manipulation checks were carried out after the 'risk task', but it is not clear how much time it took for subjects to finish the task. Therefore it is not clear how long the induced mood had lasted.

Imagine / music

Siemer (2001) makes a distinction between moods and emotions. In the study, the effects of mood on emotion judgement were investigated. Mood (angry, anxious, or sad) was induced using the autobiographical recollection method (asking subjects to recall an event which caused anger, sadness or anxiety) and a mood induction method in which pieces of music which are known to induce certain moods, were used. Whereas differential effects were clearly demonstrated for the sadness and anger induction procedure, the differential effectiveness of the anxiety induction was less clear, at least when compared to the sadness condition. That is, rather than a specific anxious mood, the anxiety induction method seems to have induced a general negative mood state of unhappiness. The mood manipulation check was carried out immediately after the mood induction procedure, but not after the judgement task, so it cannot be stated with certainty whether the effects lasted throughout the task.

Imagine

Sedikides (1992) studied the effects of happy and sad mood on self-focussed attention. Happy and sad moods were induced using a guided imagery task. Subjects in happy mood were asked to imagine for 2 minutes that they had won a free cruise in the Caribbean. They were given brochures with pictures of cruises to help the imagination, and they were

given 3 minutes to write about the event. Subjects in the sad condition were asked to imagine for 2 minutes that they had been burnt in a fire and seriously disfigured. They were given photographs of burnt victims and were given 3 minutes to write about it. Manipulation checks showed that the procedure was effective.

Music

Byrne and Eysenck (1995) used two different pieces of music to induce a neutral or anxious mood. State anxiety was measured before and after the mood induction. In the anxious mood condition, subjects felt significantly more anxious after than before the mood induction. However in the neutral mood condition, there was also a small difference in state anxiety: subjects reported to be slightly more anxious after the mood induction procedure than before.

Velten

Bartolic et al. (1999) studied the effects of experimentally induced emotional states on frontal lobe cognitive performance. Mood was induced using the Velten mood induction procedure. In this procedure, subjects are presented with a series of self-referent statements, visually (written on cards) and orally (played from an audio tape). Subjects are asked to read or listen to the statement carefully, and try to experience the mood suggested by the statements. Statements vary from relatively neutral ("Today is no different from any other day") to elation ("I really do feel good") or depression ("Every now and then I feel so tired and gloomy that I'd rather just sit than do anything"). Subjects in the positive emotion condition reported more euphoric affect than those in the negative condition. Subjects in the negative condition reported more dysphoric affect than those in the positive condition.

Armitage et al. (1999) also used the Velten mood manipulation procedure in two studies on mood effects on information processing. In both studies, the mood manipulation was effective with subjects in the positive condition reporting a more positive mood than subjects in the negative condition.

Sinclair and Mark (1995, study 1) induced happy, neutral, and sad moods using the Velten method. In study 2, using the same method, both affect and arousal were induced independently. In both studies the manipulation was effective.

Pictures / story

Forgas (1998) carried out a field study investigating the effect of mood on helping behaviour. Students who came to study in the university library found an envelop on the desk containing either positive (humourous cartoons) or negative (pictures of car accidents) images. They were then approached by a confederate asking for a favour (giving some sheets of writing paper). Responses were recorded and immediately afterwards the subjects were told that this was a social psychology experiment and asked whether they would answer a few questions. Mood manipulation checks were part of these questions. Subjects were asked to rate their mood at that

moment and immediately after viewing the images. In both cases, subjects in the negative condition rated their mood as worse than those in the positive condition. A second study used approximately the same procedure, but instead of images, written texts were used to induce either a happy (comic episode), sad (narrative about death from cancer), and neutral (library information) mood. Again subjects were asked to rate their mood immediately after reading the text and after the experiment. The effects were similar to the first experiment and lasted throughout the experimental episode.

Gift

Isen (2000) carried out a series of studies on positive affect and its effect on cognitive processing. In many of these studies, positive affect was induced by giving subjects a small bag of candy just before they had to perform several tasks. In one study (Nygren et al., 1996), the order of the tasks were varied because affect inductions of this sort usually last not longer than about half an hour. However, analyses revealed no order effects, meaning that the mood manipulation was effective throughout the experiment.

Gerrards-Hesse et al. (1994) made a review of experimental inductions of emotional states and their effectiveness. Experimental mood induction procedures (MIPs) can be categorised in five groups:

1. MIPs based on the free mental generation of emotional states;
2. MIPs based on the guided mental generation of emotional states;
3. MIPs based on the presentation of emotion-inducing material;
4. MIPs based on the presentation of need-related emotional situations (manipulating the situation in a way that it induces emotion);
5. MIPs aiming at the generation of emotionally relevant physiological states.

Most effective MIPs seem to be:
For positive mood: Film/story MIP, Gift MIP;
For negative mood: Imagination MIP, Film/story MIP, Success/Failure MIP, Velten MIP.

The authors conclude that if one wants to use the same MIP to induce both positive and negative moods, the film/story MIP should be the first choice. It should be noted that in this review, only studies inducing positive (elated) and negative (depressed) mood were considered. Also, the words emotion, emotional state, mood, and mood state are used as synonyms.

Conclusion

Several methods are effective in inducing different kinds of emotional states. A rough distinction can be made between directly manipulating experimental situations to produce real-life emotions (like the A-D method of Levine and Burgess), and techniques that use imaginary or recollection tasks (film fragments, music, autobiographical recollection etc). Philippot (1993) states several advantages and disadvantages of both groups. The direct manipulation of experimental situations, he claims, depends too

much on deceiving subjects, which is ethically and methodologically problematic. He doesn't specify the methodological problems. But moreover, the direction of the emotions is difficult to predict: it is likely that, especially in the case of negative emotions, a mix of emotions will occur. Film fragments, according to Philippot, if categorised a priori on the basis of the emotion they supposedly evoke, can induce specific emotions. However, from this study it appears that also in procedures using film fragments, a mix of emotions may occur: it was especially difficult to find fragments that evoke anger and disgust independently. A further disadvantage of using video clips, is that the effects of emotional states are likely to be mild, and it is not clear that the emotional states will last long enough to have an effect on task performance.

Levine and Burgess induced specific emotions by experimental manipulation. Although they did induce (as expected) a mix of negative emotions, they were able to distinguish between them by asking subjects what there primary emotion was. Then the subjects in the negative emotion group were grouped based on this primary emotion and by doing so, the effects of different emotions could be compared.

To establish the effects of emotion on driving performance, the most promising way to induce emotions is by experimental manipulation of the situation. This method will be most likely in inducing real emotions that last throughout the whole task and will be most likely to affect cognitive processing. Under the condition that situations are used that people most probably encounter on the road every day, this procedure is also ethically acceptable.

6.2. **Measuring emotions**

Once the emotion induction procedure has been carried out during the experiment, manipulation checks should be carried out to see whether the induction procedure did indeed produce the intended emotions. In other words, the emotional state of the subject has to be measured. Methods to measure emotions can roughly be divided into three categories: overt behaviour, physiological measures, and self-reports.

6.2.1. *Overt behaviour*

Overt behaviour is concerned with observable actions or action tendencies. Examples of this category are voice characteristics, facial expressions, and body movements and positions.

Emotions expressed by voice can be inferred by judges with an accuracy which is much better than chance, as was shown by Banse and Scherer (1996). However, the differences in vocal patterns are often related to arousal and not to the specific quality of the emotion. But Johnstone and Scherer (2000) say that even though, until now, no clear acoustic patterns of discrete emotions have been found, this does not mean that they don't exist. The fact that people can recognise emotions so well from voices means that there should be specific acoustic patterns. Johnstone and Scherer give two reasons why these patterns have not been found clearly until now. First, until now, only few acoustic parameters have been used.

Second, the emotional states have not been defined precisely enough. For example, irritation and anger were seen as similar emotions with different intensity and therefore given the same label, but they appear to have very different acoustic patterns. The study by Banse and Scherer showed that taking a wide range of acoustic variables, and clearly defining emotional states, can clearly increase the discriminating power of acoustic patterns.

Recently, facial expressions of emotions are sometimes considered as resulting from social motives rather than the experience of an emotion. A Dutch newspaper cited from a study on professional bowlers' facial expressions. Results showed that when the bowlers scored a strike, they immediately felt happiness, but they didn't start smiling until they turned back towards the audience. Facial expressions are in fact easy to manipulate: people smile when they do not feel joy, and people are angry but do not show it. However, facial expressions do seem to correspond with other indicators of emotions, like self-reports and activity of the central nervous system.

Several programs have been developed to code different facial expressions, like MAX and AFFEX by Izard and FACS by Ekman (Oatley and Jenkins, 1996). The coding is done after facial expressions have been photographed or videotaped. Several facial muscle contractions receive a coding, and each facial expression is a combination of several muscle contractions. For example, a happy smile consists of contraction of the muscles encircling the eye, contraction of muscles causing the corners of the lips curl upwards, and relaxation of muscles leaving the teeth bare.

There is a procedure which is able to detect muscle activity which is so subtle that it is not observable by the FACS and other coding procedures: EMG, but this is considered a physiological measure so we will come back to this issue later on.

It seems that body movements or positions, without extra information from face or voice, do give some information about emotions. In a Japanese study (Sogon & Masutani, 1989), subjects viewed actors who were expressing an emotion from the back. They had to choose the emotion which they thought the actor was experiencing from a list. Recognition was 52% for Americans and 57% for Japanese subjects. Some emotions were better identified than others, such as sadness and fear.

Observation of overt behaviour or actions offers a lot of information for the emotion researcher. Actions of avoidance, approach or attack, facial expressions, crying, assuming a body position, all of these can tell a lot about the particular emotion the person is experiencing. They are easily observable. One important issue is that of interpretation. When using overt behaviour as an indicator of emotion, it is always necessary to make an interpretation of the internal processes. For example: when a car driver sounds the horn, one might assume that the driver is angry but he or she might also just be trying to warn someone.

6.2.2. *Physiological measurements*

We will restrict ourselves to the physiological measures that are most frequently used. For more measures we refer to *Chapter 3* from Frijda's book 'The Emotions' from 1986.

Electrocardiogram
Several things can be measured by ECG. The two most common variables are number of beats per time interval (heart rate) and the time between each heart beat (IBI, inter beat interval).

There are numerous early studies in which emotionally loaded stimuli were presented to subjects and the heart rate was recorded. A higher heart rate was assumed to be related to higher arousal levels, which was thought to reflect emotional experience. So, when the heart rate increased, emotional experience was present, and when the heart rate stayed the same or decreased, no emotional experience was present. In later studies, changes in heart rate were thought to be related to specific psychological states. Research of Ekman and colleagues (Ekman, Levenson and Friesen, 1983) linked specific patterns of autonomic response to the experience of specific emotions. They showed that the experience of disgust, happiness, and surprise was accompanied by a low heart rate activity; and the experience of anger, fear, and sadness was accompanied by a high heart rate. However, unique heart rate patterns for anger and fear are unlikely, since these emotions both require increased blood supply to the muscles (for fighting in the case of anger and fleeing in the case of fear).

In a meta-analysis, Cacioppo et al. (2000) compared several studies dealing with heart rate increases. The meta analysis showed that the heart rate response is:

- larger in anger than in happiness;
- larger in fear than in happiness;
- larger in fear than in sadness.

Electrodermal activity
The electrodermal activity shows how well the skin conducts electricity, and thus is a measure for imperceptible sweating. It is usually measured on the palm of the hand or on the sole of the foot. There is a difference between tonic and phasic changes in conduction levels. Tonic changes are gradual and relatively long-lasting changes. Phasic changes are elicited by stimuli or by activities of the subject. Phasic changes are usually referred to as electrodermal response (EDR) or galvanic skin response (GSR).

Skin conductance is affected by respiration, temperature, humidity, age, sex, time of day, season, arousal, and emotions. The measure is therefore not very selective (De Waard, 1996). However, Ekman and colleagues (1983) found support for the hypothesis that fear and disgust produce larger skin conductance increases than happiness.

EEG (Brain activity)
EEG or electroencephalogram measures electrical activity in the brain. Typically the following classification is made:

Delta waves (until 4 Hz) (sleep);
Theta waves (4-8 Hz) (decreased alertness);
Alpha waves (8-13 Hz) (relaxed wakefulness);
Beta waves (more than 13 Hz) (active wakefulness).

Under the influence of emotional or sensory stimuli, the energy in the EEG decreases. This is called alpha blocking. However, it doesn't say anything about the particular emotion a person is experiencing. Some evidence suggests that the left anterior region of the brain is involved in approach related emotions (e.g. anger), and the right anterior region is involved in avoidance related emotions (e.g. fear).

EMG (muscle activity)
Facial electromyography (EMG) measures the electrical activity of facial muscles. It is sensitive for muscle activity even when observable facial expressions are not present. There are two facial muscles which are important in measuring emotions: the corrugator supercilii (above the brow, used in frowning) and the zygomaticus major (around the edges of the mouth, which raises the lips to a smile). The EMG activity of the corrugator supercilii increases when experiencing negative emotions. The EMG activity of the zygomaticus major increases when experiencing positive emotions.

As was said earlier, emotional experience is sometimes accompanied by physiological change. Situations are possible in which people experience an emotion but no physiological activity can be measured, like in sadness. So physiological measures alone are not enough to establish whether an emotion has occurred (but this is the case for the other measures as well). One should always make an extra interpretation based on context, self-report, or observations. Also, when physiological activity is observed, this does not necessarily mean emotional activity. Physical or mental effort also produces changes in physiology. So, body change is neither a necessary nor a sufficient condition. And even when it is very likely that the observed physiological activity is related to emotional state, it is hard to establish which emotion the person is experiencing, just based on the specific physiological symptom. Finally, for using physiological measures, a lot of equipment is needed.

6.2.3.   *Self-report*

There are several ways of collecting self-reports:
-   Interviews: one has time to ask further and to get more context information.
-   Diaries: one gets information about how emotions and moods develop over time.
-   Questionnaires: one can ask a lot of questions in a limited time span.
-   Scoring scales: one can, for example, ask people to press a scoring button to score emotional state every minute or at several predefined moments.

There are standard questionnaires available to measure distinct emotions, such as degree of anxiety, anger, depression, and general sense of well-being. Other questionnaires measure various mood states.

Self-reports are an important source of information, since they can provide information that is not visible from other sources. No one can give a more accurate account of personal experiences than the person himself. Self-report may also give an explanation of one of the other variables observed (like changes in physiology or behaviour). Using self-reports is a convenient research method (one does not need complicated equipment). And until now, the other two types of measures have not been capable of discriminating sufficiently between different emotional states. For these reasons, self-report is a commonly used method in emotion research.

Of course, when using self-reports, one has to be careful how to interpret the results. Although this is true also for physiological measures and overt behaviour measures, some specific issues for self-reports deserve attention. Errors in memory might occur, especially when subjects are being asked about emotions from a long time ago. Also, in some cases, the issues of self deception and social desirability might be relevant, especially when asking about negative emotions. People are often encouraged to express positive emotions and discouraged to express negative emotions. Finally, there might be individual differences in lexical meaning: What one person means by the word 'happy' might be different from what another person means by the same word.

Also, during the measurement, problems may occur. Emotions and moods are easily affected by the environment. Just asking a question might induce some kind of affective state. For example, one procedure for inducing a sad mood in subjects, consists of a list of statements. For each statement, the subjects is asked whether he agrees or disagrees. But all statements are worded negatively, for example:

"I often feel that my life is worthless."
"Sometimes things happen that I have no control of."

This procedure is quite effective in inducing a negative mood state, even if the person disagrees with all the statements. So, this example shows that one should be very careful how to phrase the statements, since they might well influence the current mood state just by asking. In some standardized questionnaires, this problem is solved by reversing half of the statements, for example in Spielberger's Trait Anxiety Inventory (Spielberger et al., 1970).

7.   Research plans

In the previous chapters we have seen that emotions have an effect on cognitive processing, and might thus influence driving behaviour. Still, the relation between different emotions and task performance in traffic is not clear. This was thought to be sufficient reason to start up a long term project on emotions and task performance in traffic. The project was started in January 2001 and will be finished in December 2004. The results of the project will be published as a dissertation. In this chapter, we will describe the plans for research on this topic.

Generally, four main questions can be distinguished in the project:

1. Which are the determinants of emotions in traffic?
2. To what extent do emotions bias cognition?
3. To what extent do emotions affect the selection of action?
4. To what extent do emotions affect driving performance?

The four questions are visualised in *Figure 1*. Based on the literature reviewed in the previous chapters, it is hypothesized that emotions in traffic are affected by task goal interruption or promotion, task demands, and the extent of personal interaction (the box 'person/situation'). Then, emotion is thought to bias cognition and affect selection of action (questions 2 and 3). These are supposed to affect task performance (question 4). The box 'goal shift' refers to those instances when emotions are so strong that task performance collapses completely. The goals are no longer related to the driving task (driving safely and arriving at the destination). This is seen for example in instances of extreme aggression, when people get so mad that they stop the car and get out to attack another person.

When the four research questions are answered sufficiently, a link can be made between emotions in traffic and traffic safety. Although it will be very difficult (if not impossible) to link emotions to accidents, the results of the experiments will most likely lead to new insights regarding emotions and safe or unsafe behaviour. In the dissertation, special attention will be paid to this particular topic.
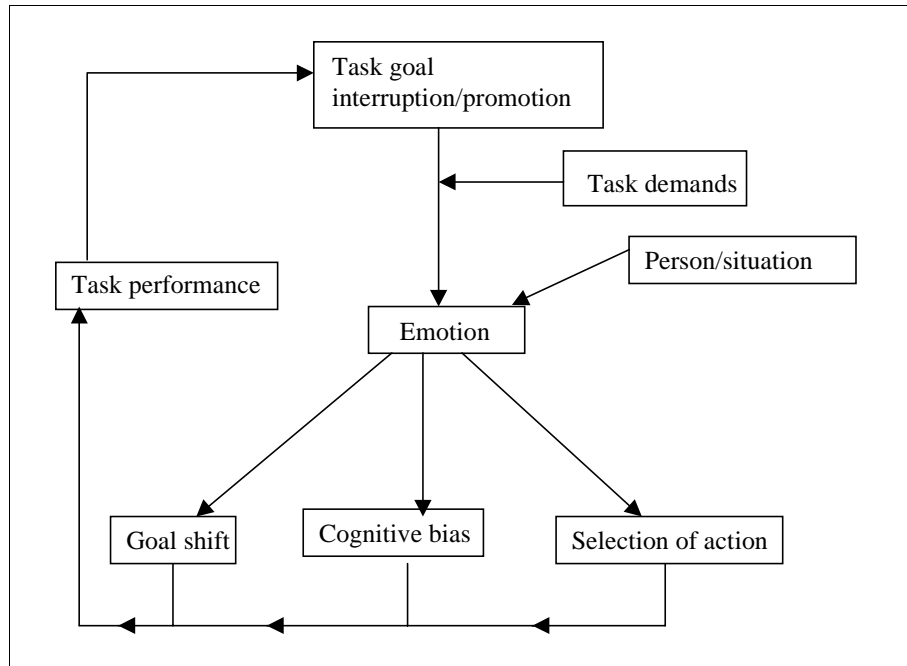
Figure 1. *Model of the four research questions, showing that emotions in traffic are affected by several 'boxes'.*

We will now describe the experiments planned to answer the four research questions. The first experiments are described in more detail than the later experiments, because we would like to keep the possibilities on the exact direction of the studies somewhat open still. Also the detailed planning of later experiments depends partly on the results of previous experiments.

7.1. **What are the determinants of emotions in traffic?**

Although several studies focussed on determinants of anger in traffic, research on other emotions in traffic is limited. This is true, as we have seen, for the effects of emotions, but also the determinants of emotions in traffic are unclear at this moment. In other areas than traffic, several aspects have been shown to be important.

First, from appraisal theory, we know that goal congruent events lead to positive emotions, and goal incongruent events lead to negative emotions. But the goals in emotion research mean something different than goals in traffic, which are much more related to the task at hand. Therefore it is necessary to know if the interruption of these task goals induces the same emotions as the interruption of more global life goals.

Second, studies in the area of stress have shown that high task demands may lead to stronger or differen t emotions than low task demands. In the area of traffic, one can imagine that a certain event does not raise much emotion when task demands are low, but will lead to much stronger emotions when task demands are high. Therefore, we want to answer the

question if emotions are stronger under levels of high task demands than under levels of low task demands.

Third, it is generally thought that most emotions are caused by other persons, or occur in social situations. Also in traffic research, it has been shown that anger occurs most often when other road users are involved. But the effect of other persons and the situation on experienced emotions in traffic have not been studied systematically. Therefore, the third question of this study is: do interpersonal events raise other or stronger emotions than situational events?

A questionnaire study was carried out to answer these questions. Respondents were presented with a number of traffic scenarios, that differed for each of the following three factors: value of the event (goal congruent vs. goal incongruent), task demand (high vs. low), and personal interaction (personal interaction vs. no personal interaction). Then a list of emotions was presented and respondents were asked to rate each emotion on a scale from 1 to 5.

At the time of writing of this report, the results of this study are being analysed. The results of the study will be published separately in an article.

7.2. **To what extent do emotions bias cognition?**

A large number of studies showed that emotion might cause biases in cognitive processing. Studies showed, for example, effects on memory, risk, attention, judgement, accuracy of performance, optimism etc. From a traffic psychology point of view, especially the optimism bias (the extent to which people believe positive things will happen to them and negative things will happen to others) is interesting, for two reasons. First, emotions are likely to affect the level of optimism bias, and second, the optimism bias has shown to be important for traffic safety.

Experiment 2

A video-based study will be carried out in the laboratory. Subjects will first be brought in a mild emotional state by an emotion induction procedure. No strong emotions will be induced, because of ethical reasons, and also because it has been shown that even mild emotional states have a profound effect on cognitive processing. The final choice of emotions that are relevant for traffic is partly dependent on the results of the first experiment.

After the emotion induction procedure, subjects will be presented with video fragments concerning traffic situations. The videos are recorded from the field of vision of the driver, so that it seems for the person watching the video as if he/she is behind the wheel him/herself. The use of video fragments is a good method, first because the validity has been shown (Horswill and McKenna, 1999), second because it creates a controlled enough environment to manipulate emotions, and third because the situations are more realistic than the pictures in a simulator are.

Fragments will differ on following distance to the lead car. A total number of 12 fragments will be shown in random order to the subjects. After viewing each fragment, the subject is asked several questions designed to measure optimism bias. Also, questions will be asked to measure illusion of control (the extent to which people believe they have control over the situation), since it is believed to be related to optimism bias (DeJoy, 1989).

After rating the fragments, the subject will be asked to fill in three short questionnaires, one is an emotion manipulation check, the second is Spielberger's Trait Anger Questionnaire (Spielberger et al., 1983), and the third is Spielberger's Trait Anxiety Questionnaire (Spielberger et al., 1970).

7.3. To what extent do emotions affect choice of action?

Apart from biases in cognitive processing, emotion may have an impact on the choice of action. Several studies showed a relationship between emotions and risky decision making. As risk perception, the selection of safe and unsafe courses of action are very important for traffic safety. Therefore this experiment will focus on the effect of emotions on the selection of more and less risky actions.

Experiment 3

Roughly the same method will be used as in experiment 2. Subjects in different kinds of emotional states will watch a series of video fragments where a car is driving on different road types and traffic conditions. The videos are recorded from the field of vision of the driver, so that it seems for the person watching the video as if he/she is behind the wheel him/herself. But instead of making estimates of risk or measuring optimism bias, in this experiment, subjects are asked to make choices. After each video fragment, the screen is put on 'still mode' and two or more options are presented to the subjects, including more and less risky options. Again, after watching the video's, the subjects will answer the emotion manipulation check questionnaire and Trait Anger and Trait Anxiety Questionnaires.

7.4. To what extent do emotions affect actual driving performance?

Possible effects of emotions on cognitive processing and selection of action are most likely to have an effect on actual driving performance as well. Therefore, in the fourth experiment, we will investigate if people in different emotional states perform differently in the driving task.

Experiment 4

Subjects will be brought in an emotional state before participating in a test ride in an instrumented car. During the test ride, subjects are either given specific instructions about how to drive (what speed or what distance to the lead car) or are instructed to drive as they normally would. Driving behaviour is measured, and the focus is on cognitive biases and on choices of action. Thus it can be seen if the results of studies 2 and 3, which were carried out inside the laboratory, extend to a real life driving situation. After the test drive, questions will be asked to measure the emotional state of the

subject. This is done to check if the manipulation has worked throughout the experiment. Induced emotional states usually don't continue during longer periods of time, therefore the test drive should not be very long.

7.5. **"Experiment 5"**

As said earlier, sometimes emotions can be so strong that they disrupt task performance completely. This has been seen in incidents concerning extreme anger and aggression, but also other emotions can have this effect, for example, someone with fear of driving can be so scared that it is impossible to continue driving and the car is stopped on the shoulder of the highway.

A number of earlier collected descriptions of aggressive incidents will be qualitatively studied. This will provide insights in the processes that lead to the disruption of task performance by extreme emotion, in this case anger.

Examples of disruption of task performance caused by anger:

"Me and a friend in my car. Argument with other road user about his way of (dangerously) overtaking. Making gestures and putting the cars on the roadside, a small physical fight. Pushing, black eye, kicking the car etc. "

"A car was driving against the mirror of my boyfriend's car. It was the fault of the other guy and he still continued driving further. Then my boyfriend got angry and chased him. It didn't take long. When we were standing still, my boyfriend had an argument with him and kicked against his car."

"In the early morning I was intending to drive away from the parking spot in my street, when a car stopped right there, so I couldn't drive away. When I asked him to move a few metres to give me some space, he refused. Then I got very angry, got out of the car, started yelling at him, and slammed his car door and window."

7.6. **Conclusions**

With the experiments we described above, we hope to gain knowledge about both the determinants of emotions in traffic, and the effects of emotions on task performance in traffic. This knowledge is needed, for several reasons. First, on a more general level, studies on the relation between emotions and task performance are limited. With this research we hope to contribute to the discussion on emotions and their beneficial or harmful effects.

Second, the knowledge is important for the area of traffic safety. If one knows which factors might lead to strong emotions, and if one knows how these emotions affect task performance, possibly in a negative way, then it might be possible also to say something about the relation between emotions and traffic safety. Also, measures can be developed to prevent these harmful effects.

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