

Measuring emotions in traffic

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Paper presented at the ESF Congress 'Towards Safer Road Traffic in Southern Europe', May 31st-June 2nd 2001, Ankara, Turkey

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Summary

This paper contains the text of a presentation held at the European Science Foundation Congress 'Towards Safer Road Traffic in Southern Europe' (May 31st – June 2nd, 2001, Ankara , Turkey). In this paper, methods to measure emotions are reviewed and possible applications for traffic research are discussed.

Several studies show that emotions have effects on all kinds of cognitive processing. Therefore it is likely that a number of driving tasks is affected by emotions as well. As yet, not much is known about the way in which driving behaviour is affected by emotions and what the consequences for traffic safety are. When doing research on this topic, one should first be able to recognise and measure an emotion. Therefore this paper presents three categories of methods to measure emotions.

The first category is observing overt behaviour. Overt behaviour aims to measure actions or action tendencies, for example by listening to vocal patterns, looking at facial expressions, or watching bodily gestures. An investigation into horn honking behaviour is an example of the use of this method in traffic.

The second category is formed by physiological measures, for example heart rate and skin conductance. In traffic, this measure can be used, for example by measuring heart rate while driving.

The third category is self-reported behaviour, for example interviews, diaries or questionnaires. This measure can be used while driving, for example by asking subjects how they feel at a particular moment. It can also be used after driving, for example by asking subjects to fill in a questionnaire about the emotions felt while driving.

Of each category of measures, examples are given of past use of these measures in traffic research. Also, implications for further research are discussed.

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1. Introduction, relevance for traffic safety

"I was driving in my car with a friend, and we got into an argument with another road user about his way of dangerous overtaking. We put the cars on the road side and started a physical fight (pushing, black eye, kicking against the car etc). Afterwards I thought that it could have been handled differently. Sometimes I feel ashamed for what happened there."

"When we were driving on the highway, we were frequently overtaken by another car who was flashing the headlights. The car kept cutting in in front of us, causing us to drive partly in the shoulder. Finally they took off at high speed. We were very happy to arrive home safely."

"Even though we were on a left turning lane waiting for the traffic lights, and we had the blinker on, another car overtook us. I got extremely angry, also because the car driver started to swear excessively."

"Some time ago I was overtaken by another car and I overtook him in my turn. A competition started. I got scared and let it go. Apart from that nothing happened, but it was a very unpleasant experience."

These are just some examples to show that emotions may play a similar role in traffic as in everyday life. All emotions that occur in normal life may at some point occur in traffic as well. An emotion can be described as a specific mental state that rearranges or drives cognition, perception and action. Specifically, the following three characteristics are generally thought to be essential for 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, actions.

Since emotions affect perception and action, they are relevant for traffic participation. It is likely that a number of driving behaviours are negatively affected by emotions. The links between anger, aggression and reported accidents have already been established in several studies (see for example Lajunen, Parker & Strading, 1998; Lajunen & Parker, 2001). But also other emotions are likely to affect traffic safety. In laboratory studies it has been shown that anxiety narrows attentional focus (See Öhman, 2000 for a review). Therefore, it is likely that someone who is anxious may be less capable of handling a complex situation in which attention has to be divided over several objects or events. Furthermore, Armitage, Conner & Norman (1999) found that positive moods promote risky decision making and more heuristic strategies, whereas negative moods instigate a more problem-focussed approach. All these effects may be relevant for traffic safety. Some evidence for the relevance of emotions for traffic safety has already been established: a study showed that people who have just experienced a distressing life event, like a divorce, are more liable to get involved in a traffic accident. Also, Levelt (2000) showed that truck drivers who report to be often annoyed or hurried, are liable to more violations and traffic fines than drivers who do not report these moods.

Our knowledge about ways in which emotions affect driving performance, is insufficient. In order to establish the effects of emotions, researchers should know when an emotion is present, and which emotion they are dealing with. This paper is about methodological issues concerning emotions and traffic. Specifically, I will talk about ways in which to measure emotions in a traffic situation.

Emotions can be measured by means of observable variables. In Chapter 2 the three classes of observable variables are discussed. The empirical findings of studies which have tried to measure emotions are presented in Chapter 3. The outcome of the discussion about the theory and practice of measuring emotions leads to implications for further research that are presented in Chapter 4.

2. Measuring emotions

When talking about measuring emotions in traffic, one could take three different perspectives: measuring the circumstances in which emotions occur (e.g. congestion might cause anger/frustration), measuring the emotions themselves and measuring the effects of emotions on task performance. I will discuss the topic from the second perspective: that of the emotions themselves, because I think that is the most central part of the topic. One cannot study the emotion process or emotion effects without measuring the emotion itself.

According to Lazarus (1991), there are two types of variables which are relevant for emotions: observable and non-observable variables. Together they constitute his theory of emotion, which I will not discuss any further at this point. I restrict myself to the observable variables Lazarus mentioned, because these are the variables by which emotions in traffic can be measured. Within the observable variables, there are three classes: overt behaviour or actions, physiological reactions and self reports. The three classes are presented in *Table 1*.

Variable class	Aims to measure	Examples	Advantage	Disadvantage	Example in on-road or simulator traffic research	Example in off-road traffic research
Overt behaviour	Actions, action tendency	Voice, face, body	Easily observable	Context/interpretation always needed, might affect emotion	Horn honking (anger), slow driving (anxiety)	
Physiology	Arousal / bodily changes	ECG EDR EEG EMG	Objective (can't be manipulated by subject)	Sensitive for effort (physical and mental), physically obtrusive	Heart rate during rush hour driving, EMG measures	EMG measures when watching slides
Self-report	Mental state, cognition, reasoning, strategy etc.	Questionnaires, diaries, interviews, scoring scales	Reveals information not otherwise visible, may explain other variables	Subjective, might affect emotion	Reporting moods through a mobile phone during driving	Questionnaires before or after the drive, interviews

Table 1. *Three classes of observable variables and their measurement characteristics.*

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.

Voice

Emotions expressed by *voice* can be inferred by judges with an accuracy which is much better than chance, as was shown by Banse & Scherer (1996). However, the differences in vocal patterns are often related to arousal and not to the specific quality of the emotion. But Johnstone &

Scherer (2000) say that even though, as yet, 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 expressed by voice so well, means that there should be specific acoustic patterns. Johnstone & Scherer give two reasons why these patterns have not clearly been found yet. 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 & Scherer showed that, taking a wide range of acoustic variables and clearly defining emotional states, can clearly increase the discriminating power of acoustic patterns.

Facial expressions

Facial expressions of emotions are sometimes considered as resulting from social motives rather than from 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. However, facial expressions do seem to correspond with other indicators of emotions, like the information of self-evaluation 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 & Jenkins, 1996). The coding is done after photographing or videotaping facial expressions. 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 to curl upwards, and relaxation of muscles leaving the teeth bare.

EMG 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 is considered a physiological measure, however, and will therefore be discussed in *Section 2.2*.

Body movements

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 from behind actors who were expressing an emotion. 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.

Advantages/disadvantages

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.

2.2. Physiological measures

The physiological measures discussed here, are the ones most frequently used (for more measures, see Frijda, 1986).

Electrocardiogram

Several things can be measured by electrocardiogram (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 their heart rate was recorded. A higher heart rate was assumed to be related to higher arousal levels which were 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, Levenson & 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 heart rate response are:

- 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, Levenson & Friesen (1983) found support for the hypothesis that fear and disgust produce larger skin conductance increases than happiness.

EEG (Brain activity)

An 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 and the right anterior region is involved in avoidance related emotions.

EMG (muscle activity)

Facial electromyography 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.

Advantages/disadvantages

As I 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, on the basis of a specific physiological symptom alone, which emotion the person is experiencing. Finally, for using physiological measures, a lot of equipment is needed.

2.3. Self reports

There are several ways of collecting self reports:

- interviews: the interviewer has time to ask further questions and to get more context information;
- diaries: the researcher gets information about how emotions and moods develop over time
- questionnaires: the researcher 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 at set intervals during driving

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.

Advantages/disadvantages

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 reports may also give an explanation for 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, as yet, the other two classes of measurement have not been capable of providing sufficiently discriminative measurement. For these reasons self reporting 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 also true for physiological measures and overt behaviour measures, some specific issues concerning 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 on 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.

3. Empirical findings in traffic research

3.1. Overt behaviour

There aren't many studies which use behaviour observation to measure emotions in traffic. Some studies are discussed here, which are all at least in some way related to anger or aggressive driving. Although aggression is not an emotion, those studies are discussed in which it is likely that the aggressive behaviour displayed is a result of anger. If this is the case, the aggressive behaviour can be seen as an emotion measure.

A Japanese study by Renge (1994) considered horn-honking as a way of communicating between drivers. Renge assumed that horn-honking can serve five different functions in traffic: expression of displeasure, giving an order, giving emphasis, giving notice and social etiquette. In an experiment, subjects viewed several slides which showed situations in which horn-honking would be relevant. Subjects had a sound button in front of them. When each slide was shown, the experimenter asked the subject to push the button as if he or she were in a car, experiencing the situation on the slide. The dependant variables were the duration of the sound and the frequency of using the horn in each situation. One of the results was that the duration of the sound was longer when the function of the sound was expression of displeasure, than when the function was something else. Also, within the category of expressing displeasure, differences were found between situations. For example, honking sounds were longer when bicycles crossed the road, ignoring a red traffic light, than when a car was double parked and thus prevented the driver to pass.

A problem with this study is that no actual emotions were observed. Subjects were asked to *imagine* a situation and then make the response.

A second study (Ellison et al., 1995) also dealt with horn honking behaviour, but in this study actual behaviour in traffic was observed. The experimenter's car stopped in front of a red traffic light. As the light turned green, the experimenter did not move for 12 seconds. During that time, duration and frequency of horn honking was recorded. It was shown that convertible cars with the top up showed longer and more frequent horn honking than cars with the top down. The explanation provided is that anonymity facilitates aggression.

Strictly speaking in this experiment no emotions were measured. However, one could assume that in several situations the subjects did get angry, because the car in front did not move when the lights turned green.

Obviously additional measures should be taken here to establish whether the subject was just sounding the horn to draw the attention of the car in front, or whether he was experiencing an emotional reaction.

Shinar (1998) carried out several studies about aggressive driving. He used the same method as the study mentioned before: horn-honking behaviour at a crossing when the light has turned green and the car in front is not moving. First, it must be noted that also in this study, anger is not measured, making it difficult to see horn-honking as a measure of emotion.

However, in one of the studies, horn-honking was related to other overt behaviours such as making gestures or cursing. When people used the horn briefly and only once, they showed other impatient behaviours in 16% of the cases. But people who used the horn continuously, showed these behaviours in 93% of the cases. So it does seem to be the case (as was also shown in the Japanese study) that when honk duration time is long, it is more likely that people experience anger.

Of course there are lots of other types of aggressive behaviour that may be a result of anger, like flashing lights, making gestures and close following.

3.2. **Physiology**

Most physiological measures that have been used in traffic research, have focussed on the measurement of stress, workload or fatigue. Brookhuis, De Vries & De Waard (1991), for example, had subjects using a mobile phone drive in a car in three traffic conditions: light traffic on a quiet motorway, heavy traffic on a four lane ring road, and city traffic. In the second condition, an additional task was given to the subjects (following another vehicle), to ensure heavy workload. Among other things, heart rate was measured while driving. Although the results of this study are mainly discussed in the light of workload and effort, it can be hypothesised that subjects in the second condition were in an emotionally charged state.

Jessurun (1997) used EMG to measure drivers' appraisal of two different road environments. She showed the subjects slides of the two road environments and measured activity of the corrugator supercilii. She also had subjects drive in a car equipped for the experiment, while measuring EMG. 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.

Myrtek et al. (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 position of standstill. 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 than moving.

3.3. **Self reports**

Several self report studies have been carried out that deal with emotions in traffic. Most of these are about anger and aggression. I will discuss a few studies that are not about anger, but about other emotions.

As early as 1967, a study was carried out about the effects of mood on performance in a driving simulation task (Heimstra, Ellingstad & De Kock, 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, relaxed etc. After each adjective four symbols are placed, for example:

Anxious *vv* *v* ? *no*

When the person was sure he felt anxious, he had to draw a circle around the *vv* symbol. If he felt slightly anxious, he had to choose the *v* symbol. If he wasn't sure, he chose *?*, and if he did not feel anxious he chose *no*. Only four factors were considered: aggression, anxiety, concentration and fatigue. 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 more poorly than subjects scoring low on these factors.

In 1980 a similar study was carried out by Appel et al., but this study linked mood and performance in an actual driving situation: the performance of driving school students on a driving task on a slippery road. Also in this study, a mood adjective checklist was used. The adjectives form six dimensions, four of which were used in this study: pleasantness, activity, calmness and confidence. The study showed that pleasantness, calmness and confidence were negatively related to error scores on one of the sub-tasks: subjects who felt more pleasant, calmer and more confident made less errors.

Carbonell et al. (1997) studied anxiety responses in traffic situations and their relation to accident involvement. Using a measurement scale called ISAT (Inventory of Situations producing Anxiety in Traffic), they observed how three groups of professional drivers differed in their ISAT scores and studied which ISAT items were related to accident involvement. Taxi drivers were shown to experience anxiety in situations involving verbal aggression and in situations in which their physical well-being was threatened. Lorry drivers experienced anxiety in situations where there was a possibility of being detained by the police. In both groups the accident rate seems to be related to anxiety levels.

Groeger (1997) studied the relationships between drivers, their moods and their driving performance, both as they 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.

Levelt (2000) measured emotions in truck drivers. Drivers participated in interviews and answered questions regarding general traffic participation. Emotions that were reported to occur while driving were:

- enjoyment (freedom, driving, driving fast);
- pride (about being able to drive fast safely or about not getting upset);
- regret (about a deliberate violation);

- anger / annoyance (about not being able to pass a slow driver);
- guilt (about endangering to another road user).

Relations were found between emotions on the one hand and accidents and violations on the other. People who enjoy driving fast are more often involved in traffic accidents and violations. People who enjoy driving in itself and who enjoy the freedom are less involved in near-accidents. People who experience regret and guilt are less often involved in near-accidents and violations.

4. Implications for further research

The three categories of emotion measures could all be used (and have, in some cases, been used) in driving behaviour research. However, driving behaviour, as well as emotions, can be measured in different ways (simulator studies, actual driving, scenario judgement etc). Some emotion measures are more suitable for some ways of measuring driving behaviour than others. For example, when people are driving on the road they cannot fill out questionnaires, but they can for example push buttons to score a mental state. Also it is possible to record some physiological measures like heart rate while driving. So, when planning to do research on emotions in traffic, one should think carefully which measures are most suitable for the research questions.

The traffic research on emotions has as yet been limited. Most studies have measured moods and not emotions. If emotions have been studied, the focus is very often on negative emotions such as anger. The work of Levelt forms an exception to this. Apparently, more research on discrete emotions in traffic is needed, especially research on positive emotions.

Also, most studies that have been done in this area use self report data. This is understandable for reasons I stated before. However, it would be useful to carry out studies in which not only self report measures but also other measures are used. All three measure categories imply some kind of interpretation, but when for example someone says he is angry, and has clenched fists, while his heart rate goes up and he goes red in the face, one can be reasonably sure that the person is in fact angry.

In sum: A combination of methods is recommended. None of the three presented variable classes would separately provide enough evidence that an emotion is present. Using two or ideally three different measures of emotion would give a much clearer picture of what is going on.

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