Determinants of Emotional Experiences in Traffic Situations and Their Impact on Driving Behaviour

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Zusammenfassung

Emotionen spielen eine wichtige Rolle bei der Erklärung von nicht angepassten Fahrverhaltensweisen und den daraus resultierenden Unfällen. Vor allem die Emotionen Ärger und Angst, ihre Entstehung und ihr Einfluss auf den Straßenverkehr stehen nach wie vor im Fokus des Forschungsinteresses. Diese Dissertation möchte durch drei aufeinander aufbauende Veröffentlichungen das Forschungsfeld beleuchten und erweitern. Hierbei wurde zum einen die Bandbreite möglicher Emotionen im Straßenverkehr untersucht. Des Weiteren war der Einfluss verschiedener Emotionen auf das Fahrverhalten von Interesse. Darüberhinaus sollte der Einfluss von situativen und persönlichen Einflussfaktoren auf Emotionen und die Auswirkungen auf das Fahrverhalten untersucht werden.

Der erste Artikel nahm sich der Fragestellung der Bandbreite von Emotionen an. In zwei aufeinanderfolgenden Online-Studien (Studie 1: n = 100; Studie 2: n = 187) wurde anhand des Geneva Emotion Wheels (und einer eigenen Weiterentwicklung) verschiedene Emotionen erhoben. Zielreize waren verschiedene textbasierte Verkehrssituationen, die durch spezifische Faktoren (Zielkongruenz, Zielrelevanz und Verantwortlichkeit) strukturiert wurden. Es zeigte sich, dass diese Merkmale der Verkehrssituationen Emotionen wie Ärger, Angst und Freude aber auch Stolz, Schuld und Scham auslösen konnten.

Im zweiten Artikel wurden die Situationsfaktoren bei der Entwicklung von Verkehrsszenarien im Simulator verwendet und getestet. Hier stand neben den ausgelösten Emotionen vor allem das Fahrverhalten im Mittelpunkt des Interesses. In der Simulationsstudie (n = 79) konnte gezeigt werden, dass Ärger und Angst das Fahrverhalten der Probanden ähnlich negativ beeinflussen und zu höheren Geschwindigkeiten, längeren Phasen der Geschwindigkeitsübertretungen und einer verschlechterten Spurhaltung führen.

Der dritte Artikel nahm sich der Frage an, inwiefern Ärger und personenzentrierte Charakteristika das Fahrverhalten negativ oder positiv beeinflussen können. Hierbei wurden zwei Studien (Studie 1: n = 74; Studie 2: n = 80) im Simulator ausgewertet. Es zeigte sich, dass spezifische Eigenschaften der Person (Männlich, wenig Fahrerfahrung, hohe Fahrmotivation und hoher Trait-Ärger) das Fahrverhalten direkt und indirekt über ausgelösten Ärger negativ beeinflussen kann.

Zusammenfassend lässt sich ableiten, dass die Bandbreite an Emotionen im Straßenverkehrs wesentlich größer ist als Ärger und Angst. Des Weiteren zeigen die anderen beiden angestrebten Veröffentlichungen, dass sich eine minimale, aber wirksame Emotionsintensität im Simulator erzeugen lässt und Ärger bzw. Angst ähnliche Fahrverhaltensprofile erzeugen kann. Persönliche Charakteristika spielen ebenfalls eine wichtige Rolle bei der Emotionserzeugung und besitzen einen distinkten Einfluss auf das Fahrverhalten. Die hier vorgestellten Artikel zeigen die Notwendigkeit für ein umfassenderes Modell von Emotionen und ihren Einfluss auf das Fahrverhalten auf.
Diese Dissertation ist in englischer Sprache verfasst.

Abstract

Emotions play a prominent role in explaining maladaptive driving and resulting motor vehicle accidents (MVAs). Above all, traffic psychologists have focussed their attention on anger and anxiety, including the origins and influence of these emotions on driving behaviours. This dissertation contributes to the field with three manuscripts that build upon each other. Those manuscripts have three separate objectives. The first identifies the broad range of emotions in traffic that should be analysed. Second, the impact of specific emotions on driving behaviour is focussed. Finally, the research investigates how situational and personal factors can influence emotional experiences and influence driving behaviour.

The first article tackles the bandwidth of emotions in traffic. In two consecutive online studies (study one: = 100; study two: n = 187), different emotional experiences were assessed using the Geneva Emotion Wheel (and an advanced version). The stimulus material consisted of written traffic situations structured around specific factors (in these studies, predominantly goal congruence, goal relevance and blame). It could be shown that the properties of the situation can elicit emotions such as anger, anxiety and happiness, but also pride, guilt and shame.

The second article saw a transfer of those situational factor structures from online-presented text to simulated driving. At this time, the focus of interest was the driving behaviour influenced by the elicited emotions. The simulator study (n = 79) revealed that anger, contempt and anxiety led to similar declines in driving performance profiles. Performance declines included driving at higher speeds, more frequent speeding and worse lateral control.

The third article examined to what extent anger and personal characteristics could negatively influence driving behaviour. Two studies were conducted (study one: n = 74; study two; n = 80). The results indicated that specific characteristics of the person (male, little driving experience, high driving motivation, high trait-driving anger) could influence driving behaviour in negative ways, both directly and indirectly, via triggered anger emotions.

It can be concluded from these results that the range of emotions in traffic encompasses much more than just anger and anxiety. Furthermore, the second and third articles show that within simulated environments, minimal but effective emotional intensities can be triggered, and those emotions (especially anger and anxiety) create similar performance patterns. Personal characteristics should be considered when explaining the elicitations of emotion and subsequent driving behaviour. The papers of this dissertation echo the call for new comprehensive models to explain the relationships among emotions and traffic behaviours.

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1. Introduction

1.1 Prologue

Drivers' emotions play an important role in understanding their behaviours in various traffic situations (Deffenbacher, Oetting & Lynch, 1994; Taylor & Paki, 2008). The relationship of aggressive and risky driving to the incidence of motor vehicle accidents (MVAs) calls for a reasoned explanatory model that can account for the impact of a driver's emotions (Dula & Ballard, 2003; Richer & Bergeron, 2012). A better understanding of the role of drivers' emotions can deliver answers about the origin, process and outcome of specific maladaptive driving behaviour and therefore enhance our ability to predict MVAs more precisely. The increase in such studies over the last two decades reflects the emerging awareness of the important role of emotions in dangerous driving, driver fitness and traffic accidents. Indeed, the literature on this topic has grown from 14 articles in the years from 1960 to 1990 to over 200 from 1991 to 2012[1].

The characteristics of the driver and the driving situation that are typically available in various accident databases (e.g., Destatis in Germany or the NHTSA and the AAA Foundation for Traffic Safety in the United States) do not usually provide the necessary insight to precisely explain the course of MVAs. Road conditions (dry, wet), traffic constellations (intersections, highways) and the observable delinquent behaviour of other drivers (speeding, taking the right of way) are most commonly reported as situational variables to the traffic administrations worldwide (e.g. Destatis, 2012; AAA, 2009). Characteristics of the drivers involved in MVAs include gender, age and the use of drugs or alcohol. By taking those variables into account, rudimentary models can be created. These models tell the reader, for example, how many young men were involved in an accident due to a disregard for the right of way at an intersection. However, this relatively low level of detail leaves further questions about the very nature of those incidents. For instance, we would like to learn how personal characteristics such as 'male', 'young' and environmental features such as 'intersection' are linked to cognitive processes, experienced emotion and, ultimately, behaviour to explain MVAs more thoroughly. This information is needed to fully understand the circumstances surrounding each accident and to develop possible interventions for increasing traffic safety. Perhaps the most important mission of traffic psychology is to answer these questions by connecting the personal characteristics and environmental features and their influence on cognitive processes, such as emotions, to create coherent explanatory models. This information could provide a valuable explanation for traffic

[1] [1] Database query (December 2012) on ISI Web of Science and IP Thompson Reuters with the keywords: *emotion* and *traffic*.

[2] Database query (December 2012) using ISI Web of Science and IP Thompson Reuters restraining the results to peer reviewed publications in traffic contexts and English language with the keywords: driving *anger* /

outcomes (with a focus on MVAs) and possibilities for (future) intervention (Deffenbacher, Huff, Lynch, Oetting & Salvatore, 2000; Galovski & Blanchard, 2002).

One can derive two implications from this short problem description. First, a driver's emotional state is one important building block to understanding driving behaviour. Driving under the influence of (negative) emotion could induce maladaptive behaviours such as erratic driving (Deffenbacher et al., 2000; Mesken, Hagenzieker, Rothengatter & DeWaard, 2007; Philippe, Vallerand, Richer, Vallières & Bergeron, 2009), delayed reactions (Cai & Lin, 2011; Matthews et al., 1998) and – in the case of driving angry – hostile behaviour such as honking and incorporating aggressive gestures (Björklund, 2008; Lajunen & Parker, 2001; Neighbors, Vietor & Knee, 2002), which can negatively influence driving performance and increase the risk for MVAs (Chliaoutakis et al., 2002; Deffenbacher, Lynch, Deffenbacher & Oetting, 2001; Schwebel, Severson & Rizzo, 2006). The second implication is a needed clarification of the causal relationships among situation, person, emotion and outcome in one coherent model. The following sections describe the specific elements of such a model in more detail.

The characteristics of the traffic situation and its salient elements function as external stimuli and can be described as an information stream, i. e., the bottom-up path of the model (Deffenbacher, Petrilli, Lynch, Oetting & Swaim, 2003; Deffenbacher, Oetting, Lynch & Yingling, 2001; Hennessy & Wiesenthal, 1999). From the top-down perspective, specific characteristics of the driver are of interest. These characteristics include the number of kilometres driven, years of having had a driving license and any history of MVAs. Together, these variables reflect one's cumulative exposure to the traffic environment and provide a first approximation to experienced crucial events. Additionally, these variables are an indicator for the mental model (Endsley, 1995) of the driver, and this could dynamically interact with several intra-personal constructs, namely personality variables (e.g., extraversion, neuroticism, agreeableness, openness, conscientiousness, and sensation seeking), emotional dispositions (trait anger or anxiety) and traffic-related motivations (e.g., risky or careful driving styles) (Britt & Garrity 2006; Dahlen & White, 2006; Deffenbacher, Deffenbacher, Lynch & Richards, 2003; Lajunen & Parker, 2001). The set of interacting personal variables together with the external stimuli can then trigger emotions and influence important cognitive processes, such as visual attention (Underwood, Chapman, Brocklehurst, Underwood & Crundall, 2003) and risk perception (Mesken et al., 2007). At the end of the (often causal) chain, these processes could effectively influence driving performance (Reason, Manstead, Stradling & Campbell, 1990).

Therefore, emotions can be considered as one centrepiece of a model for driving behaviour, connecting the dots between traffic environment, personal characteristics, elicited differences in cognitive processes and subsequent driving performance. It could be stated that research on the science of emotion and traffic revolve around these most important aspects.

The example of anger in a traffic environment should clarify the features of the proposed model. Feelings of anger can occur depending on the characteristics of the traffic situation itself

(Deffenbacher et al., 2001; Björklund, 2008; Lajunen & Parker, 2001). Hostile gestures, impeded progress or the reckless driving of others are salient characteristics that can trigger an anger response in a traffic situation (Deffenbacher et al., 1994). The characteristics of the driver, including age (Björklund, 2008), driving experience (Lajunen & Parker, 2001) or driving motivation (Philippe et al., 2009), could moderate the intensity of the anger experience. The end result could be increased aggressive and risky driving, the most thoroughly examined link in the proposed model (Nesbit, Conger & Conger, 2007). One reason for this strong focus might be the straightforward assumption that angry people drive aggressive and recklessly, causing more dangerous situations (Dahlen, Martin, Ragan & Kuhlmann, 2005; Schwebel et al., 2006). Indeed, the link between anger and increased driving speeds and reduced time-to-collisions (TTC) has been repeatedly reported (Deffenbacher, Lynch, Oetting & Swaim, 2002; Matthews et al., 1998; Mesken et al., 2007). The decline in driving performance is sometimes attributed to a maladaptive attention shift away from important visual features of the environment (Cai & Lin, 2011) and the change in risk perception (Mesken et al., 2007). Cai and Lin (2011) demonstrated a decline of visual attention to a lead car when the participant's arousal level was high and the experienced emotional valence was negative. As Mesken and colleagues (2007) demonstrated in a real driving situation, higher anger levels led to a reduction in perceived risk and – as a consequence – traffic situations were interpreted as being less dangerous under the influence of this emotion. In both studies (Cai & Lin, 2011; Mesken et al., 2007), the participants drove faster and caused more traffic violations.

The diagram below summarizes the building blocks for understanding emotions and traffic. In particular, these emotions are a) often triggered by (external) stimuli of the traffic environment, b) are influenced by the characteristics of the person, c) affect cognitive processes and d) shape driving behaviour.

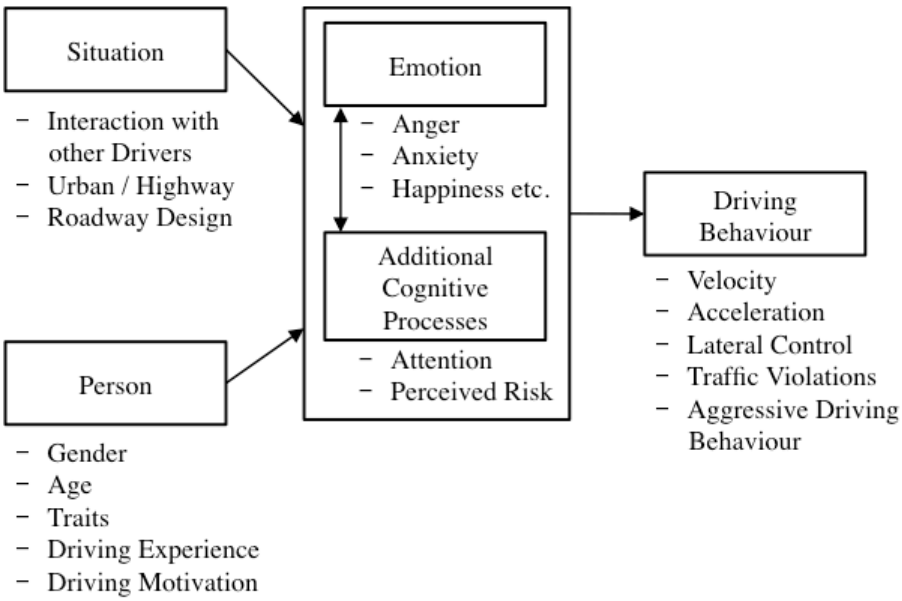

Figure 1: First approach of modelling behaviour in traffic

In the following sections, we provide a generic view of emotions, their generation, inter-individual differences and the influence of emotions on behaviour (Chapters 1.2, 1.3, 1.4, and 1.5) to clarify the theoretical connections between the causes of emotion and subsequent influence on driving behaviour. Additionally, the important implications for traffic psychology are identified and discussed, and the need for my research is outlined (Chapter 1.6). Starting from there, the research that was submitted to three journals (Transportation Research Part F, Accident Analysis and Prevention, and Journal of Safety Research) is presented (Chapters 2-4). The first article focuses on the range of possible emotions and the characteristics of the traffic environment that can cause this variety of feelings (Chapter 2). The second article explores the relationship between four distinct emotions (anger, contempt, anxiety and fright) and their impact on the longitudinal and lateral parameters of driving behaviour (Chapter 3). The third article investigates the influence that personal characteristics and anger have on risky driving within an integrated model (Chapter 4). An overall discussion and conclusion to this dissertation and possibilities for further fruitful research are presented (Chapter 5).

1.2 Definition of Emotion

Following William James's seminal article "What is an Emotion", the number of perceptions and definitions in this field grew steadily to a point where it became difficult to define emotions as one single construct (Reisenzein, 2007; Niedenthal, Barsalou, Winkielman, Krauth-Gruber, & Ric, 2005; Scherer, 2005). In 1981, Kleinginna and Kleinginna had already gathered 92 definitions for emotions and were able to organize them into an entire framework of properties. According to the authors, 'Emotion is a complex set of interactions among subjective and objective factors, mediated by neural/hormonal systems, which can (a) give rise to affective experiences such as feelings of arousal, pleasure and displeasure; (b) generate cognitive processes such as perceptual relevant effects, appraisals and labelling processes; (c) activate widespread physiological adjustment to the arousing conditions; and (d) lead to behaviour that is often, but not always, expressive, goal-directed and adaptive' (Kleinginna & Kleinginna, 1981; p. 355). These constitutional factors of emotion could be viewed as one foundation of an emotional response system, and only minor modifications occurred over time. Scherer (2005) proposed a component process model that involves five emotional components: bodily symptoms, appraisal, action tendencies, facial and vocal expression and emotional experience. This classification is nevertheless quite similar to the definition provided by of Kleinginna & Kleinginna (Scherer, 2001; 2005).

However, these complex response systems usually have difficulty providing adequate explanatory power because the correlations among mental and bodily components of emotions are typically low (Lazarus, 1991). This poor correlation led to the much-discussed emotion-paradox, which addressed the difficulty of assessing and categorizing emotions using a set of valid criteria (Reisenzein, 2007; see Barret, 2006, for an extensive review). Furthermore, the number of relevant

emotions varies vastly in the literature. The basic emotions might be limited to five due to their frequency and cross-cultural occurrence (Ekman, 1972, 1992; Izard, 1992), but depending on how one defines 'basic', this number could be increased easily (Scherer, 2005). Upon analysis of common language and folk concepts, the semantic space includes more than forty distinct emotional words, yet this distinction is blurred due to the grouping of evident similar verbal emotional expressions (Scherer, 1984, 2005; Barrett, 2006). Therefore, depending on the theory being discussed, many different concepts could carry the label 'emotion'. Such complexity has led to the proposition of other models, each of which rely on labelled transitory states and emotions as learned categorisations of an experienced feeling (Barret, 2006). First, there is a core affect, which is like an ever-changing affective state categorised during emotion conceptualisation (Russel, 2003; Russel & Barret, 1999). This conceptualisation involves sensory, motor and somatovisceral features as well as a language label stemming from cultural learning and which is heavily dependent on the given situation (Barsalou, 2003; Niedenthal et al., 2005). Therefore, the reported emotions are not necessarily directly related to specific patterns of affective experiences, physiological adjustments or behaviours (Barret, 2006).

Very often in traffic psychology, no attempt is made to establish such a theoretical foundation for explaining the elicitation and processing characteristics of emotions. This reflects the lack of an in-depth explanation of the theoretical concept and specific components of emotion and its effect on driving motor vehicles. Furthermore, the terms are often applied inconsistently, as 'emotion' and 'behaviour' are used in an interchangeable way. Traffic psychologists frequently refer only to the related outcomes, namely aggressive driving, which underlines the marginal importance of the theoretical concept of emotion in this domain (Nesbit et al., 2007).

Therefore, the available methods for assessing and labelling emotion must be validated in traffic contexts to create a shared understanding of emotions in traffic. At the same time, this challenge could put the findings of conventional models of emotion elicitation to the test. The next two sections will cover the topic of emotion generation and its relation to bottom-up (namely the situation in which an emotion is elicited) and top-down (focussing personal characteristics) elements.

1.3 Generation of Emotion

The theory of emotion generation having the largest impact might be the cognitive appraisal theory of emotion (Lazarus, 1991; Smith & Lazarus, 1993; Scherer, 2001). In appraisal theory, it is assumed that a certain situation (internal or external) triggers an appraisal of that situation within an individual who then experiences a specific emotion (Ortony, Clore & Collins, 1988; Smith & Lazarus, 1993). Aspects of the situation that might be relevant for the goals of the individual are appraised in a two-step process and are held responsible for the elicitation of an emotion as well as that emotion's quality and strength (Lazarus, 1991).

During the so-called primary appraisal stage, the individual assesses the relevance along with the motive-blocking (low goal congruence) or motive-promoting (high goal congruence) potential of the situation. This stage determines if an emotion will occur and whether it has a positive or negative valence. Within the second stage, the assessment is expanded to the coping potential and possible consequences of the given situation. Influencing determinants are controllability, probability and expected outcomes. The combination of the different appraisal components in the two stages is responsible for the elicitation of specific emotions, their quality and intensity (Scherer, Schorr & Johnstone, 2001; Lazarus, 1991; Smith & Lazarus, 1993; Kuppens, Van Mechelen, De Boeck & Ceulemans, 2007). This information processing could operate in different modes, namely automatic and non-automatic modes of appraisal and emotion generation (Reisenzein, 2001; 2007). In the non-automatic mode, deliberative thought and inference strategies are applied throughout the emotion generation and interpretation process. In contrast, automatic appraisal is – to a certain extent – unconscious, triggered rapidly and directly by an (external) event and impacting the subsequent appraisal components in a ballistic way (Bargh & Ferguson, 2000). The fact that many emotions are elicited in a rapid fashion could be explained by these automatic appraisals (Reisenzein, 2007). Another idea is that emotions do not need to be experientially mediated at all because of their hard-wired nature within the neural motor and vascular systems (Adelmann & Zajonc, 1989; Zajonc, Murphy, & Inglehart, 1989). Yet, until today, little is known about the role of those systems in mediating the consequences of emotions (e.g., additional cognitive processes and behaviour) (Schwarz & Clore, 2006).

The appraisal theory approach appears appropriate for explaining the traffic situation, which is the object of emotion elicitation. This approach enables the traffic psychologist to determine specific characteristics of common traffic environments and to predict the subsequent emotions (see Mesken et al., 2007). However, this approach is still neglected in the traffic psychology domain, in favour of a more holistic description of the situation to explain the relationship between the elicited emotion and driving behaviour (Shinar, 1998; Deffenbacher et al., 1994). Ignoring this approach in traffic psychology implies, to a certain degree, a black-box character and neglects the definition of emotions and their processing components. As a consequence, focus is often restricted to easily identifiable predictors (demographics, generic traffic situations). For example, Shinar (1998) inferred emotional intensities from waiting times at an intersection (congested by rush hour traffic) and subsequent red-light violations. In questionnaire studies, traffic situations are often presented as items with the length of one line, which are difficult to compare to each other (Deffenbacher et al., 1994; Lajunen & Parker, 2001). The questionnaire items are treated as a singular object without specifying any underlying characteristics of the situation; consequently, this leaves too much room for interpretation to the participant, greatly enhancing the chance of random error due to missing information. However, sufficient information and comparability between situations are each crucial for obtaining a valid description of an elicited emotion (Kuppens et al., 2007).

Therefore, a precise understanding of the important properties of the situation, aligned to the framework of a sound theory, is vital for the forthcoming of the domains of emotion and traffic. In addition, to the situation that describes the bottom-up path, the top-down view with personal inter-individual differences must also be considered to complete the basic building blocks for the elicited emotional experiences in traffic. The next section presents important personal characteristics responsible for variations of emotional experiences within comparable or even constant environmental settings.

1.4 Inter-individual Differences in Experiencing Emotions

Some people experience emotions more frequently and more intensely than others. The reasons for this experience vary and depend heavily on the emotion in question (Wranik & Scherer, 2010). Causes of variability generally include genetics (Giegling, Hartmannn, Möller & Rujescu, 2006) and personality, (Kuppens, 2005; Brebner 1998) as well as developmental and educational factors (Crowell, Evans, & O'Donnell, 1987; Caspi, Roberts & Shiner, 2005). Within the domains of anger and anxiety, physical (Santos, Caeiro, Ferro, Albuqierque, & Figueira, 2006) and mental illness, as described in Axis I (post-traumatic stress syndrome (PTSD), major depression and intermittent explosive disorder) and Axis II disorders (borderline, paranoid and narcissistic disorders) (Chemtob, Novaco, Hamada, Gross, & Smith, 1997; Fraguas et al., 2005; Orth & Wieland, 2006; Wilkowski & Robertson, 2008), are classifications that can be used to identify groups or types of individuals who might be prone to experiencing higher levels of anger and anxiety.

In traffic psychology, Deffenbacher and colleagues (1994, 2001) developed the idea of driving anger, a propensity to react angrily in traffic akin to generic trait-anger constructs. A set of hypotheses was then created and served as a framework for conceptualising anger in traffic situations. High trait anger drivers, relative to low trait anger drivers, should:

1. have their anger triggered in a wider range of situations (elicitation hypothesis);
2. experience more frequent and intense anger in driving situations (frequency and intensity hypothesis);
3. exhibit aggressive behaviours or, at least, feel motivated to do so (aggression hypothesis);
4. show more impulsive and risky driving behaviour (risky behaviour hypothesis);
5. exhibit impaired perception and information processes, which are necessary for safe driving;

This framework has been confirmed in several studies (Deffenbacher et al., 2000; 2001). Trait driving anger, therefore, can be considered an important building block necessary for developing a better understanding of the relationships among various traffic situations, elicited anger and driving behaviour. Indeed, this association is well understood and has already been enriched by many researchers who have studied more personal characteristics (Björklund, 2008; Dahlen & White, 2006; Lawton, Parker, Manstead & Stradling, 1997; Parker, Lajunen & Summala, 2002). In addition to

possessing a higher anger trait, gender, age, driving experience and driving motivation could also affect the frequency and intensity of anger experiences in traffic situations. For example, men report greater levels of anger than women when impeded by other drivers (Deffenbacher et al., 1994), whereas women become angrier in the presence of direct hostility, illegal actions or traffic obstructions (Parker et al., 2002). Older drivers tend to show less aggressive driving behaviour because of weaker anger experiences than young drivers (Lajunen & Parker, 2001; Lajunen, Parker & Stradling, 1998). As a predictor of anger, driving experience shows an inconsistent pattern and is highly dependent on gender (Lajunen & Parker, 2001). It could influence levels of driving anger in various situations, such as when face with direct hostility or reckless driving; however, according to Björklund (2008), this was valid only for females. In male populations, no such effect has been observed.

To date, there has been no complete predictive model of anger (or any other emotion) and driving behaviour that combines a wider range of personal characteristics with an in-depth description of traffic situations simultaneously.

To complete the proposed model (Figure 1), the possible outcomes of an elicited emotion in traffic must be addressed. Therefore, the next section describes different functions of emotions, the cognitive processes or actions they can influence and what insights are already present in the traffic psychology domain.

1.5 Emotion and Behaviour

Emotions can trigger behaviours that are often expressive, goal-directed and adaptive (Kleinginna & Kleinginna, 1981). Several strategies exist to regulate emotional experiences with specific actions (Gross, 1998). These strategies include a) situational selection, b) situational modification, c) cognitive change, d) attention deployment and e) response modulation. The first four strategies are attention-focussed, in that they occur before appraisals and give rise to strong emotional responses, whereas the last strategy, being more response-focussed, occurs after the emotional response is generated (Gross & Munoz, 1995). Situational selection is the most forward-looking regulation, in which the individual chooses situations that generate a more favourable emotional impact. In situational modification, the person takes action to change situational characteristics to influence one's emotional experience. Cognitive change as a method of emotional self-regulation refers to an internal reappraisal of the situation. An internal method of situation selection is attention deployment; furthermore, there can be redirection, concentration or withdrawal of attention in a given situation, all of which can modify the experience of emotion-inducing features, and therefore, the emotion itself. Response modulation refers to managing one's emotional expressive behaviour, including the physiological, experiential or physiological aspects of the emotional response (McRae & Gross, 2009).

On the behavioural level, traffic psychologists usually concentrate on aggressive or risky driving patterns as a consequence of elicited emotions (Nesbit et al., 2007), a method comparable to the response modulation form of emotion regulation. The experience of anger, for example, could cause higher driving speeds (Lajunen & Parker, 2001; Björklund, 2008), stronger accelerations (Stephens & Groeger, 2009) and more speeding violations (Mesken et al., 2007). Anxiety might be associated with more driving errors, which could possibly lead to dangerous traffic situations (Dula & Ballard, 2003; Dula, Adams, Miesner & Leonard, 2010; Fairclough, Tattersal & Houston, 2006). Nevertheless, these behaviours are not exclusively a consequence of an elicited emotion, and many researchers claim that they can occur simply due to characteristics of the situation or the person, with no specific emotional experience involved (DeJoy, 1992; Ulleberg, 2001; Yagil, 1998). There is yet little evidence of how these personal and situational characteristics are related to important emotional experiences on the road and how they influence behaviour (Björklund, 2008).

1.6 Research Questions of the Dissertation

Derived from this introduction, several fruitful fields of research are available in traffic psychology. The proposed model and its components are not yet fully developed, and more experimental data are needed to examine its full potential. The research lines in this dissertation are therefore threefold and can be formulated along the following questions:

I. Which emotions are present in traffic and how are they elicited?

In traffic psychology, the focus is often anger. Other emotions, such as anxiety or happiness, are very seldom on the research agenda. Database research[2] reveals that in the domain of traffic and emotion, 90% of all articles (229 between 1985 and 2012) addressed anger (or one of its correlates, such as aggression, irritation and stress), with only 10% examining anxiety (such as PTSD or fear). Furthermore, no focus has been given to more complex emotional states, such as pride or guilt (Tangney, 1991; Tangney & Dearing, 2002; Frijda, 1986), and how they can be elicited in non-clinical populations. Thus, no domain-specific knowledge exists about the elicitation modalities, cognitive processes or outcomes of these emotions in traffic contexts.

A first step, then, should be the assessment of the potential of emotions other than anger and anxiety and which conditions are necessary to trigger them in traffic situations.

The goal of the article 'The Emotional Spectrum in Traffic Situations: Results of Two Online-Studies' (Roidl, Frehse, Oehl & Höger, 2012) was to test whether there are emotions in traffic situations other than anger and anxiety and, if yes, under what circumstances is this extended range of possible emotions reported. The appraisal theory of emotion was applied to elicit specific emotional

[2] Database query (December 2012) using ISI Web of Science and IP Thompson Reuters restraining the results to peer reviewed publications in traffic contexts and English language with the keywords: driving *anger* / *aggressive driving* / *driver irritation* / *driver stress* / *driving anxiety* / *driving fear*.

experiences such as happiness, relief, pride, guilt and shame. Two studies were conducted to test the range of emotion and the underlying elicitation mechanisms with different sets of traffic scenarios and methods. The results are presented and discussed in chapter 2.

II. What is the specific impact of different emotions in traffic situations?

It is common in traffic-related simulator testing to present different scenarios as specific tasks to the participants and then assess their levels of experienced anger or frustration (Matthews et al., 1998; Philippe et al., 2009; Stephens & Groeger, 2009). The driving situations at hand are often constructed to include common features of everyday traffic. These situations can include overtaking a car in front of the participant or just driving on plain, open roads (Matthews et al., 1998). The levels of reported anger are then put into relation with aggressive or risky driving. In line with the preceding online-studies, it is important to apply appraisal theory to develop different traffic situations that can elicit various emotions. There could be a greater range of emotions responsible for changes in driving behaviour, and indeed, results from studies such as Fairclough and colleagues (2006), which focussed on anxiety and driving errors, give sound reason to believe so.

In light of targeting a broader emotional range, a specific framework based on appraisal theory has to be developed to precisely describe emotions and their causes. Furthermore, different emotions can lead to different driving outcomes, requiring a wide range of driving parameters.

The article entitled 'Emotional States of Drivers and the Impact on Driving Behaviour – A Simulator Study' (Roidl, Frehse & Höger, under review) focused on these requirements and transferred the appraisal theory of emotion elicitation from the online studies to the simulator. Four scenarios were created according to the appraisal framework to induce different emotions and assess changes in longitudinal and lateral driving parameters. The results are presented in chapter 3.

III. Focus on anger: what is the specific impact of inter-individual variables on emotional experiences and behaviour in traffic situations?

To date, there is a lack of coherent models in traffic psychology that can integrate personal characteristics, emotion eliciting situations, experienced emotions and driving behaviours (see Figure 1). Specific parts of these models are present in most of the studies within this domain, but the integration of these classes of variables has not been further developed since the work of Matthews and colleagues in 1998. They combined gender, age and motivational tendencies (e.g., aggression and dislike of driving) with driving patterns in several studies incorporating regression analysis. Their results indicated that people at younger ages, males and drivers who were prone to driving aggressively were continuously showing increased speeds, more driving errors and more frequent risk-taking. However, they conducted no direct assessment of the anger emotions that might affect the influence of those personal characteristics on driving behaviour (Philippe et al., 2009).

A coherent model of driving behaviour must take into account the traffic situation, personal variables and induced emotions equally. There is a need for a model that can describe the distinct influences of these variables to explain subsequent driving behaviour more precisely.

The article entitled 'Introducing a Multivariate Model for Predicting Driving Performance: The Role of Driving Anger and Personal Characteristics' (Roidl, Siebert, Oehl & Höger, under review) investigated the possibilities of establishing such a complete model. In two simulator studies, participants had to complete a track with several critical and emotion-inducing events. Personal characteristics (gender, driving experience, driving motivation and trait anger) as independent variables and experienced anger as a mediator formed the building blocks of the framework of influencing variables. Longitudinal and lateral parameters were recorded and analysed as dependent variables using path analysis. Due to the model's complexity, analytical focus was directed to the most impactful emotion in traffic: anger. The results are presented in section 4.

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2. The Emotional Spectrum in Traffic Situations: Results of Two Online Studies

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Abstract

Statistics indicate that in 2011 almost 400,000 traffic accidents occurred on German roads inflicting round about 4,000 casualties. A contributing factor for accidents is inappropriate driving behaviour (e.g., risky or aggressive driving or delayed reactions) due to the drivers' strong emotional state. Several situational factors such as goal congruence, goal relevance and blame have been examined and are considered responsible for the nature and intensity of the emotions experienced. However, the impact – and especially the interaction – of these situational factors on emotions experienced in traffic situations are not yet sufficiently clear. Therefore two consecutive studies have concentrated on this question. The participants had to rate emotions they would experience in traffic scenarios, which were presented as short texts in an online-questionnaire. A distinct combination of the situational factors served as a framework for each of the scenarios. In order to assess an extensive variety of emotions, two different versions of the Geneva Emotion Wheel were used. In both studies different combinations of goal congruence, goal relevance and blame influenced participants´ emotions. Anger, anxiety and positive feelings such as hope, relief and satisfaction were related to the situational factors. The second study showed that the development of pride, guilt and shame could also be traced back and associated with the appraisal of those situational characteristics.

Keywords – Anger, Anxiety, Appraisal theory, Trait driving anger, Trait anxiety

2.1 Introduction

In 2011, almost 400,000 people were involved in traffic accidents in Germany. For about 4,000 of these people the accidents were fatal (Destatis, 2012). There is an ongoing debate about preliminary events leading up to those individual accidents and over the years more and more focus has been put on emotions that influence inappropriate driving (Dula & Ballard, 2003; Dula & Geller, 2003; Mesken, Hagenzieker, Rothengatter & De Waard, 2007; Nesbit, Conger & Conger, 2007). Emotions such as anger tend to influence our driving skills and can increase the probability of driving inappropriately (Matthews et al., 1998; Mesken et al., 2007; Stephens & Groeger, 2009). When risky (e.g. weaving in and out of slower traffic or speeding) or aggressive driving patterns (e.g. blocking a tailgating car or chasing another driver) occur in dense city traffic or in sharp curves on a country road, the situation can be fatal for all involved. Various studies have concerned themselves with elicited emotions such as anger and their impact on individuals' driving behaviour and the likelihood of having an accident (Deffenbacher, Petrilli, Lynch, Oetting & Swaim, 2003; Shinar & Compton, 2004; Stephens & Groeger, 2009; Underwood, Chapman, Wright & Crundall, 1999). Overall there is a strong focus on emotions related to anger and how they affect driving behaviour. Few cases have taken emotions such as anxiety or happiness into account when they analysed inappropriate driving behaviour (Dula, Adams, Miesner & Leonard, 2010; Mesken et al., 2007; Taylor, Deane & Podd, 2000). Considering the fact that in a study by Mesken and colleagues (2007), those emotions are almost as common as anger in everyday traffic, much more attention could be paid to them.

Another area which has not received much attention is the traffic situation itself. Only a few studies examine traffic situations and their defining attributes as emotional triggers (Hennessy & Wiesenthal, 1999; Mesken et al., 2007; Shinar, 1998). Clearly, it is extremely important to understand these situations and their relevant attributes in order to describe the cause of an experienced emotion more precisely (Frijda, 1994).

The appraisal theory of emotions is a suitable method for describing the defining attributes of traffic situations (Mesken et al., 2007). The subjective assessment of a given situation – the appraisal – determines whether an emotion has been elicited or not and, if an emotion has been triggered, its quality and intensity (Lazarus, 1991; Scherer, Schorr, & Johnstone, 2001). In the so-called primary appraisal stage the individual evaluates the personal relevance of the situation for his/her own goals and whether the situation is consistent with the goal (goal promoting / high goal congruence) or not (goal blocking / low goal congruence). For example if there is traffic congestion (the situation) on my side of the street (influences my arrival goal in a relevant way) but not in the other direction (irrelevant to my arrival goals) it's more likely that this will block my goals (goal incongruence). Therefore, this stage determines *whether* an emotion occurs and whether it is of positive (when goals are promoted) or negative valence (when goals are blocked). The components of the second stage are blame (or credit), the coping potential of the individual and possible consequences of the situation. Blame (or

credit) is related to the question of whether another person (other-blame), the individual him/herself (self-blame) or generic circumstances (circumstance-blame) is responsible for the event. The coping potential indicates the extent to which an individual believes he/she can master the situation in a satisfying way. The possible consequences describe whether the individual anticipates a change in the situation for the better or worse. Those components determine *what type* of emotion will occur. The combination of various appraisal components is responsible for the elicitation of specific emotions as well as their quality and intensity (Kuppens, Van Mechelen, De Boeck & Ceulemans, 2007; Lazarus, 1991; Scherer et al., 2001; Smith & Lazarus, 1993). These processes do not necessarily happen in a deliberate, conscious manner and can also occur in a rapid and implicit way (Scherer, 1999). Lazarus (1991) distinguished 15 different emotions and every single one of them has a distinct set of appraisal components. Anger, for example, might arise if the individual encounters a situation where a relevant goal is blocked by another person and his/her actions are perceived as unfair and not controllable (Kuppens, Van Mechelen, Smits & De Boeck, 2003). Anxiety could be a product of a perceived uncontrollable threat from outside; happiness (or a similar emotion such as joy and amusement) is experienced in safe and familiar contexts where only low effort is needed (Fredrickson, 1998; Frijda, 1986). In summary, appraisal processes and components can be used to explain the occurrence and intensity of specific emotions (Scherer, 1997).

Personal attributes and traits also play an important role in emerging emotion in traffic. However the focus is often put on the emotion of anger and sometimes on anxiety, but other emotional qualities are very rarely taken into account. According to state-trait-theory, a high disposition towards anger or anxiety causes more frequent and intense emotional reactions in a wider range of situations (Deffenbacher, Oetting & Lynch, 1994; Deffenbacher et al., 2003; Fairclough, Tattersall & Houston, 2006). In the domain of driving anger, Deffenbacher and colleagues (2003) conducted a questionnaire and driving-log study and they found a positive relationship between high driving anger scores on the DAS and more frequent and intense anger in various driving situations. Further characteristics that also have an effect on emotional episodes on the road are gender, driving experience and driving motivation. Men report more feelings of anger than women in response to impeded progress, inconsiderate driving and impatient driving (Deffenbacher et al., 1994, Parker et al., 2002). Women also report higher levels of anxiety compared to men (Mesken et al., 2007; Taylor & Paki, 2008). Experienced drivers often report less anger and anxiety than novice drivers: they have been in many different kinds of traffic situations during their driving careers and therefore feel more in control and self-assured, which may raise their emotional threshold (Björklund, 2008; Deffenbacher et al., 1994; Mesken et al., 2007; Lajunen & Parker, 2001). This mechanism also seems true for happiness, and experienced drivers show lower levels of this emotion (Mesken et al., 2007). An emotion related to a driving goal such as to reach a destination safely may be intensified by additional attributes of driving motivation such as “having fun” or “self-expression” (Philippe, Vallerand, Richer, Vallières & Bergeron, 2009). Traffic participants with an obsessive passion for driving, for example, have

internalized driving into their identity. When they experience goal-blocking situations on the road such as impeded safety due to the erratic driving of others, anger is often elicited (Philippe et al., 2009).

The present studies had two objectives: the first one was to explore whether there is a greater variety of emotions besides anger and anxiety that can occur in traffic situations. Secondly, identifying the emotional object is the key to understanding the cause and impact of emotions in a traffic context. In order to shed some light on the underlying mechanism of emotion elicitation, a framework based on the appraisal theory should be applied. Some emotional reactions such as anger, anxiety and sometimes happiness are related to specific personal characteristics, which is why they should be incorporated as control variables in the statistical framework. In this article we focus on the impact of situational factors on reported emotions, which lead to specific hypotheses for both studies.

2.2 Study 1

2.2.1 Theoretical Framework and Hypotheses

The first study examined the appraisal factors *goal congruence* (Kuppens et al., 2007; Mesken et al., 2007), *goal relevance* (Cnossen, 2001; Smith & Lazarus, 1993) and *blame* (Kuppens et al., 2007; Mesken et al., 2007; Scherer et al., 2001). An additional relevant factor, *task demand*, might influence emotional states in traffic situations and can increase or suppress specific emotional experiences (Hennessy & Wiesenthal, 1999). *Goal congruence* describes how a situation develops depending on how consistent it is with the driver's personal goal (Kuppens et al., 2007, Smith & Lazarus, 1993). An example for a goal incongruent situation, and therefore a blocked goal, could be when a driver has to stop due to a construction site which impedes further progress. Excellent road conditions could be perceived as highly goal congruent because safe driving is possible (Mesken et al., 2007). *Goal relevance* refers to achieving the two most important goals in traffic situations: arrival at your destination on time and arriving safely (Cnossen, 2001; Fairclough et al., 2006). The *blame* component in traffic can be described as a perceived agency of change in a given situation. In a traffic context, this change can be caused directly by other traffic participants (other-blame) or by circumstances caused by force majeure, e.g. bad weather (circumstance-blame) (Mesken et al., 2007). *Task demand* can be operationalized with high traffic density and time pressure and serves as a meta-attribute of everyday traffic situations (Hennessy & Wiesenthal, 1999).

Certain appraisal-factors can – by themselves or combined with others – elicit specific emotional experiences (Kuppens et al., 2003; Lazarus, 1991; Smith & Lazarus, 1993, Scherer, 1999; Scherer et al., 2001). Anger and anxiety can occur when important arrival or safety-related goals are blocked. This activates the person's sympathetic nervous system and can – in severe cases - initiate either direct action to eliminate the reason the goal was blocked or a delayed action after assessing the

situation (Scherer et al., 2001). The likelihood of feeling anger, for example, should be greater if a specific agent can be identified and his/her action is the reason for the blocked goal (Berkowitz, 1993; Frijda, 1986; Kuppens et al., 2007). Feeling anxiety usually indicates that the blocked goal is causing an existential threat to the individual (Lazarus, 1991). Positive emotions, though, are also part of the driving experience. Achieving a goal unexpectedly or in a convenient way may induce emotions such as satisfaction and relief (Lawton, Parker, Manstead & Stradling, 1997). While not directly related to appraisal theory, task demand could be another factor influencing the occurrence of emotion in traffic situations (Hennessy & Wiesenthal, 1999; Shinar & Compton, 2004). High task demand increases the pressure on the individual and this can cause stress-related reactions and diminish resources, which are necessary to cope with the situation. Building on this literature-based background information, four hypotheses could be stated for the first study (Table 1).

Table 1: Hypotheses and affected appraisal dimensions in study 1

#	Description	Goal Congruence	Goal Relevance	Blame	Task Demand
H1	In goal blocking situations anger occurs more intensively when the goals are blocked by another driver/person than in situations where the circumstances are responsible for the negative outcome.	Blocked	Any	Other Driver	Any
H2	In goal blocking situations anxiety occurs more intensively when safety-related goals are blocked than in situations where arrival goals are blocked.	Blocked	Safety	Any	Any
H3	In goal promoting situations positive emotions are more intensive than in goal blocking situations.	Promoted	Any	Any	Any
H4	Negative emotions occur more intensively and positive emotions less intensively when task demand is high than in situations where task demand is low.	Any	Any	Any	High / Low Task Demand

2.2.2 Method

2.2.2.1 Participants

Almost two thirds of the sample (N = 100) were male (64%), 42% were students at the university, 52% employed and 6% unemployed at the moment. The mean age of the tested population was M = 30.49 years (SD = 9.92) and the participants drove M = 10,490 km per year (SD = 8,840). Cumulative driving experience since attaining a driving licence was M = 138,410 km (SD = 15,800). Two out of three participants (63%) drove their car several times a week or even daily, 20% used it weekly or at least once a month and 17% less than once a month. This pattern is similar to the German average (Gallup, 2010).

2.2.2.2 Stimulus Material

The first draft of the traffic scenarios was theory-driven. In accordance with the appraisal framework, more than 30 different scenarios were designed and selected by three traffic psychologists from the Institute of Experimental Industrial Psychology. The most important criteria for designing and selecting the traffic scenarios were to be "realistic", to "match the appraisal category" and which "could happen on the street on a fairly regular basis". In a workshop session, 16 scenarios – covering all combinations of the four appraisal factors – were chosen (for examples see Table 2). These scenarios differed with regard to the appraisal factors mentioned above: goal congruency, goal relevance, blame and task demand. This led to four different clusters of scenarios (Figure 1). The scenario featuring the arrival goal and circumstance-blame had a construction site, which slowed down the participants' progress. The next scenario affected the safety goal and involved circumstance-blame and described a junction ahead of the participant with malfunctioning traffic lights. The scenario with an arrival goal and other-blame featured a car in front of the participant which wasn't reacting to a green traffic light. The situation involving the safety goal and other-blame used a car in front of the participant braking suddenly and therefore forcing him/her to brake as well. In the goal promoting conditions, the arrival goal was only blocked for a short time and in situations affecting the safety-goal the driver was never in any serious danger. In goal blocking conditions the driver was made to wait much longer and nearly experienced an accident during the braking-car and traffic junction situation. The condition of task demand was manipulated by varying time pressure and traffic density on the road (Figure 1).

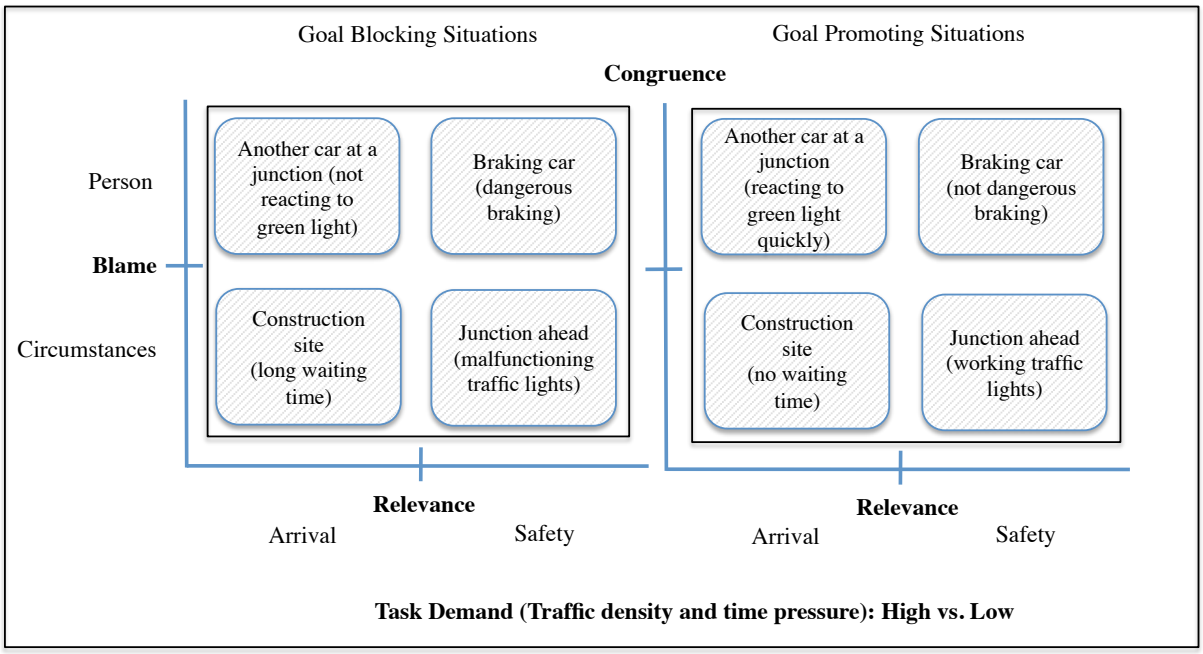


Figure 1: Experimental design of the first online study

2.2.2.3 Questionnaires and Emotion Assessment

The assessed personal characteristics were age and gender as well as how many kilometres were driven per year and in total. The various aspects of driving motivation were assessed by asking the participants how much they liked driving (from 1 = not at all to 5 = very much) and how important driving is to them (from 1 = not at all to 5 = very much). In order to analyse dispositional driving anger the German version of the DAS (Driving Anger Scale, Deffenbacher et al., 1994; Steffgen, Recchia & Ludewig, 2008) was used. It consists of 33 items distributed on six subscales: "Police presence", "Traffic obstructions", "Discourtesy", "Illegal driving", "Hostile gestures" and "Slow driving". Participants had to rate on a five-point-scale how much they would be angered in a given situation (1 = not at all to 5 = very much). The reliabilities of the German subscales (αs= .75 to .88) are similar to those of the original (αs = .78 to .87). Trait anxiety was assessed with the 20-item scale (α = .94) of the German version of the STAI (State-Trait Anxiety Inventory, Spielberger, 1983; Laux, Glanzmann, Schaffner & Spielberger, 1981). In this questionnaire, anxiety-frequencies were rated on a four-point scale (1 = not at all to 4 = very often).

All emotions were described on the Geneva Emotion Wheel (GEW; see Scherer, 2005), which was translated back and forth from English to German. It assesses 16 different emotions divided into two dimensions; controllability (high / low) and valence (positive / negative) (see Barrett & Russel, 1999). The emotions are presented in circular fashion with positive emotions (e.g. pleasure, elation, satisfaction) on the right and negative (e.g. anger, contempt, anxiety) on the left side. Emotions which are described as highly controllable are in the upper region of the wheel (e.g. anger, pride), low-control-emotions can be found in the lower section (e.g. anxiety, surprise). Participants had to rate how they would feel in a specific traffic situation on a scale from one (very weak) to four (very

strong). In order to control the scenarios' plausibility the participants had to estimate on a five-point scale how likely they thought it would be to encounter such a scenario in real traffic (1 = very unlikely to 5 = very likely).

2.2.2.4 Procedure

The whole study was conducted online on the basis of the LimeSurvey software which is an open source platform for highly scalable online surveys (LimeSurvey, 2012). The participants were contacted using the university newsletter as well as social networks. After introducing and explaining the study, all sixteen scenarios where presented randomly. For each scenario the participants had to identify what emotion they would feel in such a situation and rate its intensity using the GEW. Due to the complexity of the situations and the anticipated emotional response the participants were allowed to choose their three most relevant emotions (out of sixteen) from the wheel and evaluate their intensity. After completing the situations their personal characteristics were assessed. The whole procedure took approximately 45 minutes.

Table 2: Scenario examples from study 1

#	Goal Con-gruency	Goal Relevance x Blame	Task Demand	Text
1	Short Waiting Time	(Circumstance x Arrival) Construction Site	Sufficient Time & Low Traffic Density	Today you have an important appointment downtown but there is still plenty of time to look for a parking possibility at the location. When you reach the next junction you turn onto a main road with three lanes and minimal traffic. You decide to take the right lane. All of a sudden, the traffic slows down and a warning sign predicts a narrowing of the street from three to two lanes due to a construction site. Here the road conditions are bad and you have to drive very slowly. Further ahead you can already see the end of the construction site and a clear road.
2	Near Accident	(Person x Safety) Braking Car	Insufficient Time & High Traffic Density	Today you have an important appointment downtown, but you are running late and are under time-pressure. At the next junction you turn right onto a main road with three lanes and very dense traffic. Without a warning a car brakes directly in front of you. You have to react quickly but you manage to stop in time.
9	TL Are Functional Again	(Circumstance x Safety) Malfunctioning Traffic Lights at a Junction	Sufficient Time & Low Traffic Density	Today you have an important appointment downtown, but there is still sufficient time to look for a parking possibility at the location. At the next junction you turn onto a main road with three lanes and minimal traffic. You decide to take the right lane. In the distance you see that the traffic lights at the next big junction are not working. Just as you reach the junction the traffic lights go on again. The green light indicates that you can proceed without delay.
10	Crossing Junction Not Possible	(Person x Arrival) Car In Front Does Not Proceed	Insufficient Time & High Traffic Density	Today you have an important appointment downtown, but you are running late and are under time-pressure. At the next junction you turn right onto the main road with three lanes and very dense traffic. At the next traffic light you have to wait behind another car. The traffic light turns green, but the car in front of you does not proceed. Just before the traffic light turns red it accelerates and manages to cross the junction but you have to wait for the light to change again.

2.2.3 Results

On a scale from one to five the participants liked driving very much (M = 4.07; SD = 0.99) and rated its importance with M = 3.37 (SD = 1.28). Cronbach's-Alpha of $\alpha = .60$ and a correlation of $r = .44$, ($p < .001$) revealed a sufficient identity between the two tested aspects of driving motivation. Therefore, the ratings of the two items (how much one enjoys driving and how important it is) were combined into one score and labelled as driving motivation.

2.2.3.1 Occurrence of Reported Emotions and Their Relationship to Personal Characteristics

From the sixteen emotions described by the GEW, seven were suitable for this study. To be selected, the emotion had to appear at least twice during the course of the experiment across all participants. Emotions such as disgust or envy were practically never triggered by the given stimulus and therefore excluded from further analysis (Table 3). The seven emotions that were used were anger, relief, anxiety, surprise, satisfaction, hope and contempt. Anger was the most prevalent emotion over all participants with M = 3.12 (SD = 0.55) in strength and M = 9.16 (SD = 3.12) in frequency in the sixteen situations. Contempt was the weakest (M = 2.14, SD = 1.11) and rarest emotion (M = 2.03, SD = 2.14) used in the more thorough analysis. The emotions anger (H1, H4), anxiety (H2, H4), relief, hope and satisfaction (H3, H4) as well as contempt (H4) were used to test the hypotheses. Surprise was an emotion that could not be associated with any hypothesis and was therefore not involved in this process.

The influence of gender, annual mileage and driving motivation as well as the DAS and STAI scores (if appropriate) on reported emotion was measured with multiple linear regressions (Table 4). Personal characteristics were the independent variables and the intensities of the specific emotions were the dependent variables. Linear regression made it possible to take any relationships between the influencing attributes of the person into account, and this could lead to more precise estimates of each independent variable (the results are presented as standardized coefficients (β) to facilitate comparisons). Women reported more intense anxiety and relief than men ($\beta = -.18$; $p < .048$ and $\beta = -.33$; $p < .001$). Driving experience was negatively related to anger, and participants with low mileage reported higher levels of this emotion ($\beta = -.25$; $p < .020$). Participants with high driving motivation stated more intense anger ($\beta = .22$; $p < .029$) and contempt ($\beta = .21$; $p < .037$) but also more satisfaction ($\beta = .29$; $p < .008$) as compared to low-motivated drivers. Participants scoring high on the DAS reported stronger anger ($\beta = .27$; $p < .001$) and contempt ($\beta = .31$; $p < .001$) over the course of the experiment. High trait anxiety participants, as measured with the STAI, reported more intense anxiety ($\beta = .40$; $p < .001$).

Table 3: Counts and means of reported emotions for all scenarios in study 1

#	Emotion	Count (SD)	Mean (SD)
1	Anger	9.16 (3.12)	3.12 (0.55)
2	Relief	6.84 (3.09)	3.09 (0.66)
3	Anxiety	3.96 (2.44)	2.44 (1.13)
4	Surprise	3.67 (2.5)	2.5 (0.96)
5	Satisfaction	3.57 (2.21)	2.21 (1.04)
6	Hope	2.44 (2.25)	2.25 (0.87)
7	Contempt	2.03 (2.14)	2.14 (1.11)
8	Pleasure	2.39 (1.3)	1.3 (0.94)
9	Guilt	0.63 (1.75)	1.75 (1.15)
10	Interest	0.68 (1.17)	1.17 (0.94)
11	Sadness	0.15 (1.17)	1.17 (0.51)
12	Elation	0.52 (0.65)	0.65 (1.03)
13	Pride	0.24 (0.46)	0.46 (0.68)
14	Shame	0.1 (0.36)	0.36 (0.5)
15	Disgust	0.02 (0.14)	0.14 (0.14)
16	Envy	0 (0)	0 (0)

Table 4: Relationship between personal characteristics and reported emotional intensities in study 1

#	Emotion	corr. R^2	Gender	Mileage	Driving Motivation	DAS	STAI
1	Anger	.15**	-.02	-.25*	.22*	.27**	-
2	Relief	.10*	-.33***	.04	.02	-	-
3	Anxiety	.37***	-.18*	-.23	-.11	-	.40***
4	Surprise	.03	.09	-.10	.18	-	-
6	Hope	0	-.04	.06	.02	-	-
6	Satisfaction	.09*	-.04	.03	.29*	-	-
7	Contempt	.17***	.13	-.02	.21*	.31**	-

*p < .05, **p < .01, ***p < .001
Values of the personal characteristics are standardized coefficients (β)
Regression model included gender, mileage driving motivation, DAS and STAI (if suitable)
Gender was coded with 1= female; 2 = male

2.2.3.2 Testing the Hypotheses: Appraisal Factors and Emotions

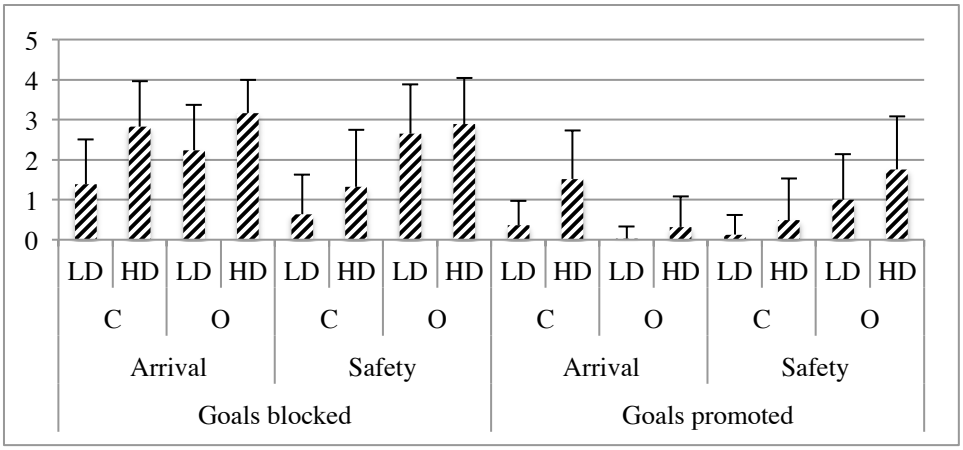
In order to assess the influence of a specific situation and its varying underlying factors, a repeated measures MANOVA was conducted. The 2x2x2x2 factorial structure (two levels for each factor: goal congruence, goal relevance, blame and task demand) described the independent variables, and the emotions of interest were the dependent variables. According to the state-trait theory of emotion, reported levels of anger, contempt and anxiety should be higher when participants have a general

disposition to experience these emotions. This assumption should only be valid in situations where emotion elicitation is likely (e.g. anger provoking situations). In order to provide adjusted and more precise results of the influence of each given situation and its characteristics on reported emotions, trait driving anger (DAS for anger and contempt) and trait-anxiety (STAI for anxiety) were used to control for known emotional dispositions. Furthermore, the scheme of control variables involved gender, driving experience (operationalized with annual mileage) and the combined driving motivation items. These variables were used as covariates in the analysis to control for their assumed influence on emotional experiences during the traffic situations. Bonferroni-Corrections were employed to account for the high number of tested effects in this study. This ensured that more conservative estimates for interpretation of the data were established (Table 5). If significant interaction effects in the omnibus F-Test were present, post-hoc tests were run to identify the origin of the effect more precisely. The reported comparisons between the cell means describe the critical difference points of the decomposed interactions at $p < .001$ level.

2.2.3.2.1 Testing H1

In goal blocking situations anger occurs more intensively when the goals are blocked by another driver/person than in situations where circumstances are responsible for the negative outcome.

Anger was the emotion with the highest mean in occurrence and strength during the experiment and it was strongly linked to all goal-blocking situations ($F (1, 99) = 385.02$; $p < .001$; $\eta_P^2 = .80$). The blame factor contributed to another main effect and anger was reported to be significantly stronger if the goals were blocked by another driver (showing no reaction at green light or braking suddenly) ($M = 2.74$, $SD = 0.98$) than in situations where the circumstances were to blame (long waiting time at the construction site or malfunctioning traffic lights) ($M = 1.54$, $SD = 1.16$; $F (1,99) = 88.50$; $p < .001$; $\eta_P^2 = .47$). Furthermore, goal-blocking situations were able to create a stronger discrepancy in anger evaluations associated with the allocation of blame ($F (1, 99) = 88.95$; $p < .001$; $\eta_P^2 = .47$): In those situations, participants reported stronger anger when others were involved compared to generic circumstances ($M = 2.74$; $SD = 1.09$ vs. $M = 1.52$, $SD = 1.02$). In goal promoting situations, overall anger-levels were much lower regardless of the blame level ($M = 0.78$; $SD = 0.88$ vs. $M = 0.63$, $SD = 0.84$). Another interaction effect was found between the type of goal and the level of blame involved ($F (1, 99) = 72.31$; $p < .001$; $\eta_P^2 = .42$). In the safety context, anger was much stronger if another driver was involved ($M = 2.08$; $SD = 1.22$ vs. $M = 0.65$, $SD = 0.89$); whereas when the arrival of the driver was affected, anger levels were similar for both blame levels ($M = 1.44$; $SD = 0.76$ vs. $M = 1.52$, $SD = 1.03$). Summarized, anger was stronger in goal-blocking situations when another driver was involved, and this is especially true in safety-contexts (Figure 2).

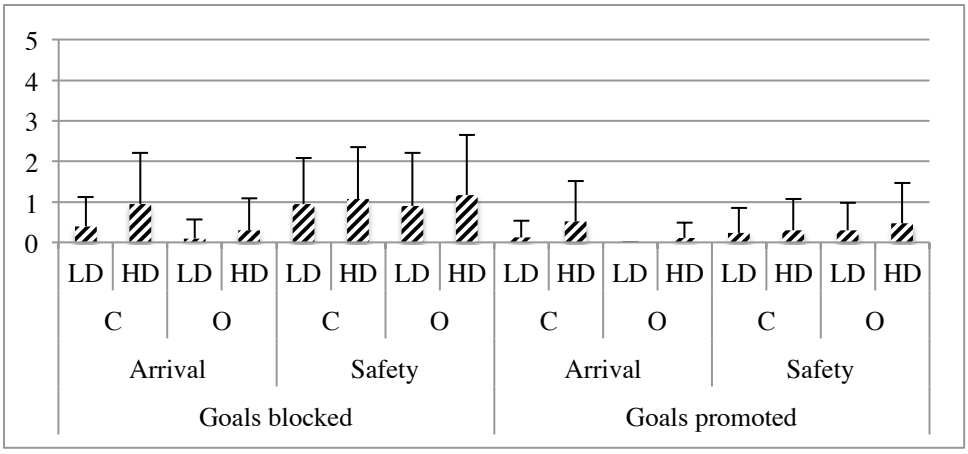


C = Circumstance-blame; O = Other-blame; LD = Low (task) demand; HD = High (task) demand; y-axis: intensity of anger
Figure 2: Situational properties and anger intensities in study 1

2.2.3.2.2 Testing H2

In goal blocking situations anxiety occurs more intensively when safety-related goals are blocked than in situations where the arrival goals are blocked.

In general, more intense anxiety was reported in goal blocking situations (average at M = 0.62, SD = 1.05) than in goal promoting situations (average at M = 0.24, SD = 0.60; F (1, 99) = 85.29; $p < .001$; $\eta_P^2 = .46$). Furthermore, the anxiety level was higher in situations where the safety goal of the participant was affected compared to arrival-related goals (M = 0.67, SD = 1.03 vs. M = 0.31, SD = 0.63), which supported another main effect (F (1, 99) = 34.22; $p < .001$; $\eta_P^2 = .26$). Taken together, the highest means were reported in situations where the safety-related goals of the driver were blocked (braking car and malfunctioning traffic lights), a fact that was also expressed by a simple interaction effect (F (1, 99) = 21.76; $p < .001$; $\eta_P^2 = .18$). The average mean for these events was at M = 1.02 (SD = 1.31) and this was significantly higher than the average M = 0.32 (SD = 0.67) in all other situations (Figure 3).



C = Circumstance-blame; O = Other-blame; LD = Low (task) demand; HD = High (task) demand; y-axis: Intensity of anxiety

Figure 3: Situational properties and anxiety intensities in study 1

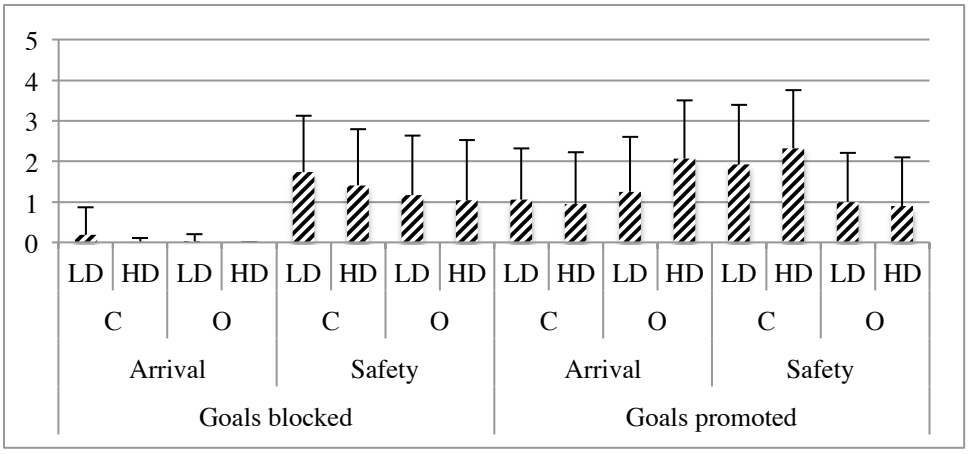
2.2.3.2.3 Testing H3

In goal promoting situations positive emotions are more intensive than in goal blocking situations.

This hypothesis was tested with three positive emotions: relief (Figure 4), hope (Figure 5) and satisfaction (Figure 6). Relief occurred when traffic situations resolved in a goal congruent manner (M = 1.43, SD = 1.42 vs. M = 0.67, SD = 0.83; F (1, 99) = 93.38; p < .001; η_P^2 = .51). A three-way interaction F (1, 99) = 36.94; p < .001; = .30) between goal congruency, relevance and blame was caused by the fact that even a goal incongruent situation could trigger relief on par with congruent ones (M = 1.16, SD = 1.44 vs. M = 0.97, SD = 1.12). But this requires a safety context and is slightly stronger when circumstances are to blame (malfunctioning traffic lights at a junction).

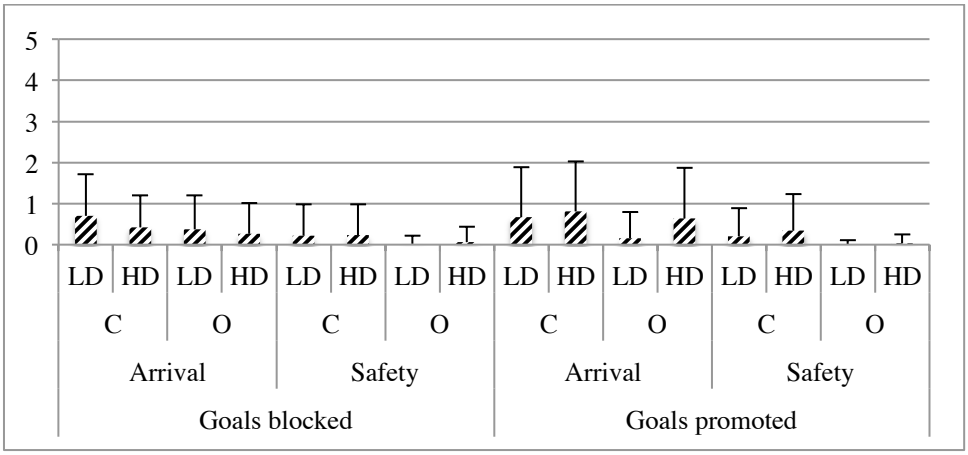
Hope occurred in arrival-related situations regardless of blame or goal congruency (F (1, 99) = 54.74; p < .001; η_P^2 = .36). The overall mean of M = 0.50 (SD = 0.96) was significantly higher compared to the grand mean of M = 0.14 (SD = 0.49) in safety related situations. Another main effect could be observed on the blame level: circumstance-blame elicited slightly stronger feelings of hope (M = 0.45, SD = 0.91) than other-blame situations (M = 0.19, SD = 0.54); F (1, 99) = 38.85; p < .001; η_P^2 = .30).

The third positive emotion in the experiment, satisfaction, was most strongly linked to goal promoting situations (F (1, 99) = 130.14; p < .001; η_P^2 = .57). A deeper analysis revealed a three-way interaction between goal congruence, blame and goal relevance. This effect (F (1, 99) = 70.03; p < .001; η_P^2 = .41) occurred on levels of promoted goals due to higher means of satisfaction in other-blame / arrival situations (a car in front of the participant at a junction) (M = 1.75, SD = 1.35) compared to safety contexts in general (M = 0.21, SD = 0.68).



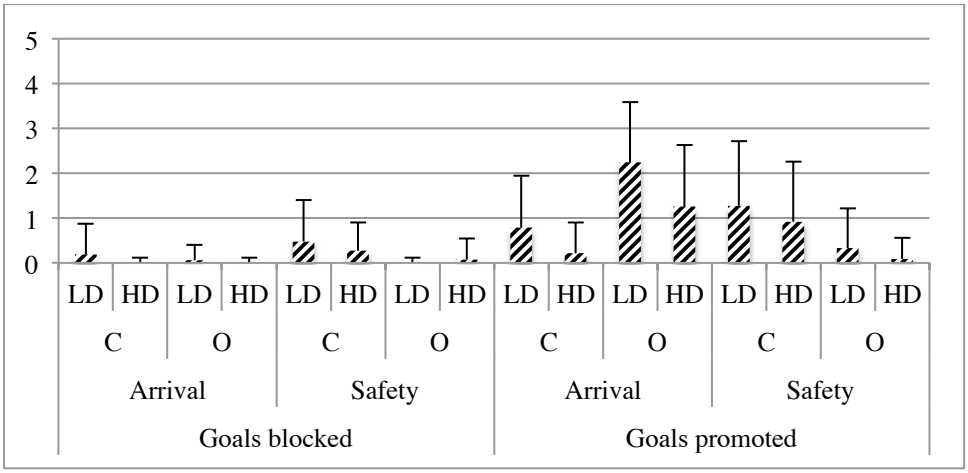
C = Circumstance-blame; O = Other-blame; LD = Low (task) demand; HD = High (task) demand; y-axis: intensity of relief

Figure 4: Situational properties and relief intensities in study 1



C = Circumstance-blame; O = Other-blame; LD = Low (task) demand; HD = High (task) demand; y-axis: intensity of hope

Figure 5: Situational properties and hope intensities in study 1



C = Circumstance-blame; O = Other-blame; LD = Low (task) demand; HD = High (task) demand; y-axis: intensity of satisfaction

Figure 6: Situational properties and satisfaction intensities in study 1

2.2.3.2.4 Testing H4

Negative emotions occur more intensively and positive emotions less intensively when task demand is high than in situations where task demand is low.

Task-demand as an emotion-eliciting factor had a significant effect on three out of the seven emotions over the course of the experiment. First it was able to increase the negative emotions, anger (especially in arrival-related situations) and anxiety ($F(1, 99) = 129.03$; $p < .001$; $\eta_P^2 = .57$ and $F(1, 99) = 23.34$; $p < .001$; $\eta_P^2 = .19$); their means rose from $M = 1.05$ ($SD = 0.88$) to $M = 1.79$ ($SD = 1.11$) for anger and $M = 0.37$ ($SD = 0.66$) to $M = 0.61$ ($SD = 0.99$) for anxiety. Thirdly, high task demand was able to suppress the positive emotion of satisfaction ($F(1, 99) = 39.58$; $p < .001$; $\eta_P^2 = .29$) during the experiment. The global means dropped from $M = 0.67$ ($SD = 0.85$) in the low task demand condition to $M = 0.36$ ($SD = 0.64$) during the scenarios with high task demand. The other emotions relief, hope and contempt were not affected by different levels of traffic density or time pressure.

Table 5: F-Values and effect sizes for the full-factorial model and the six extracted emotions in study 1

	Anger		Anxiety		Relief	
	F-Values (η)	p	F-Values (η)	p	F-Values (η)	p
Congruence	**385.02 (.80)**	**.000**	**85.29 (.46)**	**.000**	**93.38 (.51)**	**.000**
Relevance	2.61 (.03)	.066	**34.22 (.26)**	**.000**	**75.25 (.45)**	**.000**
Blame	**88.50 (.47)**	**.000**	10.46 (.1)	.001	4.09 (.04)	.001
Task Demand	**129.03 (.57)**	**.000**	**23.34 (.19)**	**.000**	**3.57 (.04)**	**.000**
Relevance * Blame	**72.31 (.42)**	**.000**	**16.26 (.14)**	**.000**	**31.77 (.25)**	**.000**
Relevance * Congruence	**49.77 (.33)**	**.000**	**21.76 (.18)**	**.000**	**46.63 (.34)**	**.000**
Blame * Congruence	**88.95 (.47)**	**.000**	3.58 (.03)	.099	0.13 (0)	.799
Task Demand * Relevance	**24.00 (.20)**	**.000**	6.34 (.06)	.022	1.95 (.02)	.222
Task Demand * Blame	10.09 (.09)	.002	3.73 (.04)	.064	4.81 (.05)	.064
Task Demand * Congruence	4.72 (.05)	.034	2.74 (.03)	.239	15.56 (.15)	.339
Relevance * Blame * Congruence	4.85 (.05)	.030	1.25 (.01)	.456	**36.54 (.30)**	.456
Task Demand * Relevance * Blame	8.47 (.08)	.002	10.28 (.09)	.007	6.89 (.07)	.007
Task Demand * Relevance * Congruence	10.35 (.09)	.001	0.24 (0)	.634	0.22 (0)	.634
Task Demand * Blame * Congruence	0.65 (.01)	.651	0.01 (0)	.996	0 (0)	.996

Continued on page 47

	Hope		Satisfaction		Contempt	
	F-Values (η)	p	F-Values (η)	p	F-Values (η)	p
Congruence	3.78 (.04)	.059	**130.14 (.57)**	**.000**	**32.42 (.25)**	**.000**
Relevance	**54.74 (.36)**	**.000**	6.23 (.06)	.025	0.42 (0)	.597
Blame	**38.85 (.30)**	**.000**	0.11 (0)	.979	**21.80 (.18)**	**.000**
Task Demand	3.04 (.03)	.090	**39.58 (.29)**	**.000**	**14.55 (.13)**	**.000**
Relevance * Blame	1.69 (.02)	.266	**74.31 (.43)**	**.000**	0.14 (0)	.631
Relevance * Congruence	1.96 (.02)	.207	**35.80 (.27)**	**.000**	9.14 (.08)	.004
Blame * Congruence	2.04 (.02)	.209	9.22 (.09)	.006	**25.52 (.2)**	**.000**
Task Demand * Relevance	0.03 (0)	.732	3.00 (.03)	.075	0.67 (.01)	.480
Task Demand * Blame	1.86 (.02)	.211	0.33 (0)	.568	2.03 (.02)	.209
Task Demand * Congruence	11.14 (.10)	.001	**31.92 (.24)**	**.000**	8.56 (.08)	.004
Relevance * Blame * Congruence	0.11 (0)	.772	**70.03 (.41)**	**.000**	8.93 (.08)	.001
Task Demand * Relevance * Blame	3.29 (.03)	.068	8.57 (.08)	.004	0.38 (0)	.503
Task Demand * Relevance * Congruence	11.30 (.11)	.001	4.55 (.04)	.040	2.36 (.02)	.092
Task Demand * Blame * Congruence	0 (0)	.988	0 (0)	.029	0.78 (.01)	.168

Reported F-Values (partial eta-squared effect sizes) controlled for gender, driving motivation, annual mileage, DAS (anger, contempt) and STAI (anxiety)
Number of observations: 15 (Effects) * 7 (Emotions) = 105
Bold F-Values are significant at the Bonferroni-corrected $p < .00047$ (.05/105)
Degrees of Freedom are df (1,99)

2.2.4 Discussion: Appraisal-Factors, Task Demand and Elicited Emotions in the First Study

The goal of this study was to show that the specific characteristics of traffic situations can explain reported emotions to a certain degree. The positively tested hypotheses demonstrate that this goal was accomplished. Anger was shown to be higher in goal blocking situations with another driver involved than under generic circumstances. This is concordant to what is found in literature on both traffic-related (Mesken et al., 2007; Neighbors, Vietor & Knee, 2002) and general studies and discussions on emotion (Berkowitz, 1993, Lazarus, 1991). However, the goal-promoting scenarios also elicited remarkable anger intensities. A construction site and a braking car in front of the participant still elicited reports of anger although those situations improved within seconds. This indicates a low contrast within the goal congruence factor and fuels the assumption that the goals in those situations were not really promoted but *less* blocked. It seems that as soon as the goals of the participant are blocked – even if only to a slight degree – feelings of anger are reported. Various levels of blocked goals trigger different anger intensities and the participants seem to differentiate between short and long waiting times when they report their anger. It would have been interesting to assess reports of anger in situations truly congruent with drivers' goals, in order to describe the relevant attributes of goal congruency more precisely (e.g. what exactly constitutes a goal congruent situation).

Anxiety is expected to be stronger in situations where safety-related goals are blocked. This was confirmed by the participants' reports of emotion. A car braking in front of the participant or a junction without working traffic lights were sufficient to elicit anxiety. This is concordant to appraisal theory, which states that threatening situations are able to elicit feelings of anxiety or fear (Berkowitz, 1993; Smith & Lazarus, 1993). Safety-related situations did provide a significantly contrasting level of anxiety in goal promoting vs. goal blocking events because anxiety only occurred in the latter ($M = 0.11$, $SD = 0.09$ vs. $M = 1.30$, $SD = 0.75$). Furthermore, the anxiety level was higher if the goal was blocked due to circumstance and not due to another driver, which is in line with other findings in the literature (Mesken et al., 2007). There was only one situation with these characteristics (junction without working traffic lights) and it is necessary to confirm the finding with more traffic situations. Another issue is the low overall mean of this emotion: the highest value is well below the theoretical maximum of four. One reason might be the presentation of the scenarios in a textual manner, which does not elicit the anxiety as vividly as other media such as film or audio would (Martin, 1990). Future studies could try to use videos as stimulus material in order to elicit emotional responses similar to those from real traffic. But on the other hand, the anxiety means from Mesken et al. (2007) measured in real traffic were around 1.3 (on a scale from 1 to 5) which is very close to our results. Even though those results were obtained in normal traffic, compared to the text-scenarios which described more extreme situations, strong anxiety does not seem to be an issue in many traffic contexts. A fruitful field for future research could be to analyse the impact of those small doses of anxiety on key-driving performance parameters and more general driving behaviour.

The fact that positive emotions were stronger in goal congruent situations was only true for one out of three positive feelings. The means for satisfaction were consistently higher in goal promoting contexts. The different driving goals influenced reported levels of hope and relief: higher levels of hope were reported in arrival situations and the achievement of safety-related goals promoted feelings of relief. This mirrors the nature of the relationships between specific situations and emotions: the intensity of hope describes how much someone wants a goal fulfilled (Peterson, 2000). The effect is even stronger in situations where no other driver is to blame (construction site or malfunctioning traffic lights). This might be related to the unfolding of events and with what certainty a specific outcome (e.g. to pass the construction site) is predicted (Roseman, 1991). Uncontrollable circumstances could lead to greater hope compared to a situation where the driver has to interact directly with other traffic participants and their (seemingly) predictable behaviour. But those situations were both construction sites; other possible contexts (e.g. traffic jams) were not tested in this study. A wider range of different situations might trigger different intensities of hope. Relief is a result of the successful management of a situation involving tension and uneasiness due to a direct threat (Corsini, 2001). Similar to reported anger, the contrast between the levels of goal congruence is relatively small and even goal blocking events (especially safety-related ones like the braking car or the malfunctioning traffic lights) were able to trigger considerable relief ($M = 1.56$, $SD = 0.87$). This might be due to the nature of the described events, which were in the worst-case near accidents in situations with a safety context. Mastering such a situation without experiencing any negative outcome (such as damage to the car) is the reason described for the relief. Those effects support the need for stronger goal promoting situations in future studies in order to elicit variance of relief-levels.

The subjects in the experiments rated the combination of goal-incongruent, safety goal and other blame as shown in the “braking car” situation, as eliciting the most emotion. Anger, contempt, and anxiety on the negative side and surprise and relief on the neutral / positive side indicated a strong emotional involvement in this situation. Out of all the situations, this was the most dangerous, because the driver completely loses and then regains control in a very short time frame. There are no reliable statistics for how often such a situation happens on German roads, but almost one quarter of all crashes show similar situational characteristics (e.g. a collision between two cars where one was behind the other; Destatis, 2012). Due to the prevalence and emotional intensity of this situation, it is recommended to test it in a driving simulator to assess the possible influences of the emotions which occur on the driving behaviour.

The task demand hypothesis could be confirmed: reported levels of anger and anxiety were higher in situations with high traffic density and more time pressure. This is concordant to the literature, where similar effects involving driver congestion, reported stress and aggressive behaviour were found during rush hour congestion (Hennessy & Wiesenthal, 1999). The results in this study extend the findings that satisfaction was significantly lower in high task-demand situations. Therefore, the whole emotional climate is negatively affected by those traffic conditions which are normal for

everyday rush hour (Shinar, 1998). This could have implications for driving behaviour: firstly, more risky and aggressive actions might be triggered due to more intense anger (Björklund, 2008; Deffenbacher et al., 2003; Parker et al., 2002). Secondly, courteous and cooperative behaviour on the road is shown to be less likely because of the lack of positive emotions (Frederikson, 1998; Isen, 1987; Oatley & Jenkins, 1996).

The online questionnaire in the first study successfully scripted various traffic situations and elicited a wide range of emotions. Due to the conclusions drawn from the first study, a second one was conducted. Here our goal was to validate the findings from the first study, increase the goal-congruence contrast and widen the scope of emotions with new situational factors.

2.3 Study 2

The second study concentrated anew on the diversification of the blame-factor. The first study laid emphasis on external accountability (other-blame vs. circumstance-blame) but the actions of the driver have to be taken into account (self-blame), too, because he can also affect a traffic situation. Slowing down in order to let another vehicle into the lane or hindering other cars by braking severely when looking for a place to park are two such interactions in traffic situations. Therefore, the situational factors were redesigned and a wider range of blame-attributes was included to take self-blame into account. Drivers' actions can be differentiated into two groups: participants' actions have an effect on the *outcome for other drivers* (the opposite of other-blame) and participants' actions have foremost an effect on *the outcome for themselves*. In the first case, the traffic situation and goals of another driver are directly influenced by the participants' behaviour. In the second case another driver is not directly involved; the participant only influences his own situation. This new blame perspective shifts the emotional object away from other drivers or the circumstances to the individual himself.

According to the appraisal framework of emotions (Lazarus, 1991, Smith & Lazarus, 1993), this change of the object can help to elicit a new set of emotions and make others unimportant. When an individual is able to influence the goals of others in a negative (or positive) way, emotions such as guilt and shame (or pride and satisfaction) might be stronger (Tangney, 1991; 2002). The goal relevance factor (Cnossen, 2001; Fairclough et al., 2006) as described in the first study, as well as the goal congruency principle (Smith & Lazarus, 1993) with promoted and blocked goals, were employed again and completed the factorial structure. The impacts of those factors on reported emotions were to be tested with new situations and a revised edition of the Geneva Emotion Wheel.

Five hypotheses focusing on the impact of certain factorial combinations on reported emotions were drawn. The first three (H1-H3) were intended to validate the outcomes of the preceding study, the latter two (H4 and H5) tested assumptions with a focus on the new blame attributes (Table 6).

Table 6: Hypotheses and affected appraisal dimensions in study 2

#	Description	Goal Congruence	Goal Relevance	Blame
H1	In goal blocking situations anger occurs more intensively when goals are blocked by another driver/person than in situations where the circumstances are responsible for the negative outcome.	Blocked	Any	Other Driver
H2	In goal blocking situations anxiety occurs more intensively when safety related goals are blocked by generic circumstances than in situations where another driver or self directed actions are responsible for the negative safety-related outcome.	Blocked	Safety	Circum-stance
H3	In goal promoting situations positive emotions are more intensive than in goal blocking situations.	Promoted	Any	Any
H4	In goal promoting situations pride occurs more intensively when the participant himself is responsible for the promotion of his goals or those of other drivers than in situations where he is not directly responsible for the positive outcome.	Promoted	Any	Participant influences own goals Participant influences goals of others
H5	In goal blocking situations guilt and shame occur more intensely when the participant himself is responsible for blocking other drivers' goals than in situations where he is not directly responsible for the negative outcome.	Blocked	Any	Participant influences goals of others

2.3.1 Method

2.3.1.1 Stimulus Material, Experimental Measures and Procedure

In contrast to the first study, the traffic situations described were no longer limited to a few basic scenarios. Study one used four different traffic situations each with two outcomes (one goal blocking,

one goal promoting) and two contexts of task demand (high / low time pressure and traffic density). In this second study, more than 50 new situations were developed, involving a great variety of settings and contexts. Due to the two additional variations in the blame-factor a 4x2x2 design seemed appropriate so that 16 traffic situations were selected and categorized by the same traffic psychologists from the first study (an extract of this selection is shown in table 7). The factor blame was now differentiated between circumstances to blame, other-blame and self-blame. The latter was split up into "Participants' actions have an effect on the outcome for other drivers" and "Participants' actions have an effect on the outcome for themselves" (4x). Goal relevance was again defined based on either arrival or safety related goals (2x). Goal congruence ranged from having goal promoting to goal blocking characteristics within the scenario (2x).

All emotions were demonstrated using a revised edition of the Geneva Emotion Wheel (GEW; Scherer, 2005). The number of emotions remained constant but some of them were exchanged for more relevant ones. The emotional facets disgust, elation and envy were removed completely because they could not be found in any traffic situations in the first study. Pleasure was merged with satisfaction because of the rather high similarity between both concepts. To fill the resulting gaps a survey of 33 undergraduate students was conducted in order to identify more possible emotions which could occur in traffic situations (Oehl, Roidl, Frehse, Suhr, Siebert et al., 2010). The participants had to recall traffic situations which they had experienced in the last six months and describe which emotions they had felt in each situation. This led to the addition of amusement, happiness, fright and feeling helpless to the emotional spectrum.

The intrapersonal attributes influencing reported emotions were again gender, annual mileage and driving motivation. The latter played the same role as in study one, to assess the importance of as well as pleasure from driving. Predispositions towards certain emotions were assessed again with the German version of the DAS (Driving Anger Scale, Deffenbacher et al., 1994; Steffgen, Recchia & Ludewig, 2008) and German version of the STAI (State Trait Anxiety Scale; Spielberger, 1983; Laux, Glanzmann, Schaffner & Spielberger, 1981). The experimental procedure of the first study – applying the LimeSurvey platform and acquiring participants via the university newsletter and social networks – was also used for the second study. A control question was used in order to prevent persons who had taken part in the first study from participating a second time.

Table 7: Scenario examples from study 2

#	Goal Congruence	Goal Relevance	Blame	Text
1	Supports my goal	Arrival	Another driver influences participants' goals	Another driver didn't take up the fight for a free parking space and let you use it.
2	Blocks my goal	Security	Another driver influences participants' goals	A driver on the rural road is speeding and starts tailing you, leaving hardly any space between your two cars for a considerable amount of time
5	Supports my goal	Security	Participant influences own goals	You're driving on a curvy rural road but staying below the speed limit.
6	Blocks my goal	Arrival	Participant influences own goals	You're in an unknown town. You didn't memorize your route well so you won't be arriving at your destination on time.
10	Blocks goal of others	Security	Participant influences goals of others	You're driving through the centre of town and you want to turn left. You don't notice the cyclist continuing straight in the opposite lane. When you turn he has to break hard in order to avoid a collision.
11	Supports goal of others	Arrival	Participant influences goals of others	On the highway you decide to slow down in order to let another car in front of you change lanes.
13	Supports my goal	Security	Circumstance	You're driving on a highway. You have great road conditions and it's sunny which supports a safe journey.
16	Blocks my goal	Arrival	Circumstance	You're driving on the highway and you're almost home when the traffic comes to a full stop. You have to wait.

2.3.2 Results

The participants liked driving with $M = 4.10$ ($SD = 1.09$) and rated its importance with $M = 3.26$ ($SD = 1.30$). Similar to study 1, the items for driving motivation (pleasure and importance) had a Cronbach's Alpha of $\alpha = .63$ and correlated with $r = .46$ ($p < .001$). Therefore, the mean value of the two items was used for further analysis.

2.3.2.1 Occurrence of Reported Emotions and Their Relationship to Personal Characteristics

In comparison to the first study, 14 out of 16 emotions could be used for further statistical analysis. Due to the conceptual heterogeneity of the sixteen situations providing real goal promoting scenarios and the revised emotion wheel, there was a greater variety of emotions. The main criterion by which an emotion was selected was that it had to appear at least twice during the course of the experiment. Sadness and interest were the only emotions excluded from the analysis (Table 8). To test the hypotheses and for further calculations, ten emotions were used: anger (H1), anxiety (H2), happiness (H3), satisfaction (H3), relief (H3), amusement (H3), hope (H3), pride (H4), guilt (H5), and shame (H5). Anger was the most prevalent emotion over the course of the study with a frequency of M = 7.60 (SD = 2.36) and M = 0.91 (SD = 0.35) in strength. Hope was the rarest (M = 2.04, SD = 2.19) and weakest emotion (M = 0.21, SD = 0.24) involved in the deeper analysis.

The impact of personal characteristics on reported emotions was analysed again with multiple linear regression. Gender, annual mileage and driving motivation as well as the DAS and STAI scores (if appropriate) were used as the independent variable, and the relevant emotion as the dependent variable (Table 9). Women reported increased anxiety (β = -.16; $p < .029$) whereas men stated increased pride (β = -.22; $p < .004$) over the course of the experiment. Drivers who were less experienced reported more intense anxiety and pride (β = -.20; $p < .010$ and β = -.15; $p < .031$, respectively). Persons scoring high on driving motivation described stronger positive emotions such as satisfaction, happiness and pride (β = .30, β = .26 and β = .22; all correlations at least $p < .01$) but also increased anger (β = .16; $p < .030$). The STAI inventory did not predict anxiety responses this time and effects were very small (β = .07; n.s.). Participants scoring high on trait-driving anger as measured with the DAS reported stronger anger (β = .40; $p < .001$).

Table 8: Counts and means of reported emotions for all scenarios in study 2

#	Emotion	Count (SD)	Mean (SD)
1	Anger	7.60 (2.36)	0.91 (0.35)
2	Satisfaction	5.37 (2.61)	0.60 (0.35)
3	Happiness	5.26 (2.46)	0.65 (0.37)
4	Anxiety	5.19 (2.46)	0.56 (0.32)
5	Surprise	4.50 (2.66)	0.48 (0.31)
6	Fright	4.16 (2.00)	0.48 (0.25)
7	Guilt	4.02 (1.58)	0.49 (0.24)
8	Relief	3.73 (2.25)	0.45 (0.29)
9	Shame	3.53 (2.11)	0.40 (0.28)
10	Pride	3.04 (2.51)	0.33 (0.31)
11	Feeling helpless	2.67 (2.08)	0.26 (0.24)
12	Contempt	2.39 (1.87)	0.27 (0.25)
13	Amusement	2.33 (2.02)	0.26 (0.25)
14	Hope	2.04 (2.19)	0.21 (0.24)
15	Sadness	1.14 (1.57)	0.10 (0.14)
16	Interest	1.03 (1.36)	0.10 (0.14)

Table 9: Relationship between personal characteristics and reported emotional intensities in study 2

#	Emotion	corr. R^2	Gender	Mileage	Driving Motivation	DAS	STAI
1	Anger	.22***	-.08	-.07	.16*	.40***	-
2	Satisfaction	.08**	.01	-.06	.30***	-	-
3	Happiness	.06**	.01	-.06	.26***	-	-
4	Anxiety	.11***	-.16*	-.20*	-.07	-	.07
7	Guilt	.01	-.03	-.07	-.03	-	-
8	Relief	.08**	-.05	-.26***	.01	-	-
9	Shame	.01	.04	-.11	.09	-	-
10	Pride	.09**	.22**	-.15*	.22**	-	-
13	Amusement	.01	.10	-.09	.04	-	-
14	Hope	.01	.11	-.07	.05	-	-

*p < .05, **p < .01, ***p < .001

Values of the personal characteristics are standardized coefficients (β)

Regression model included gender, mileage driving motivation, DAS and STAI (if suitable)

Gender was coded with 1= female; 2 = male

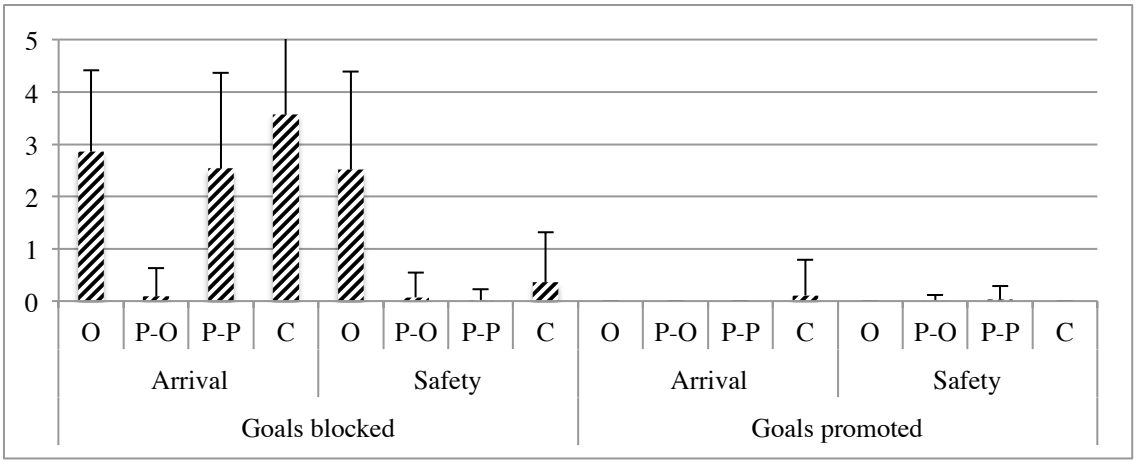
2.3.2.2 Testing the Hypotheses: Appraisal Factors and Emotions

As in the first study, a repeated-measures MANOVA was conducted in order to assess the impact of the appraisal factors, which were implemented in a 4x2x2 fashion. The variation of blame was four-fold and consisted of: "Others are influencing goals of the participant (other-blame)", the two dimensions of self-directed blame "Participant influences the goals of others" and "Participant influences own goals" as well as "Generic circumstances (circumstance-blame)". Goal congruence differentiated again between whether goals were promoted or blocked and goal relevance was dichotomized with safety and arrival goals. Similar to the first study, the control variables gender, driving experience (annual mileage), driving motivation and, if appropriate, the emotional disposition measured with the DAS (driving anger) and the STAI (trait anxiety) were used.

2.3.2.2.1 Testing H1

In goal blocking situations anger occurs more intensively when the goals are blocked by another driver/person than in situations where the circumstances are responsible for the negative outcome.

Anger was again a very strong emotion over the course of the experiment (Figure 7). Due to the strict differentiation between goal blocking and promoting situations in the second study, only a negative outcome was able to elicit appropriate anger levels ($F (1, 186) = 936.74$; $p < .001$; $\eta_P^2 = 84$). Furthermore, if the arrival of the participant was blocked (e.g. slow driver in front of the participant), anger intensities were often higher than in safety related events (e.g. a tailgating driver) ($F (1, 186) = 508.14$; $p < .001$; $\eta_P^2 = .74$). In addition to those two factors, the different levels of blame also led to different anger reports, which was mirrored by the significant results of the post-hoc tests ($p < .001$): high levels of anger could be observed when another person (other-blame) tried to hinder the participant from achieving his arrival ($M = 2.85$, $SD = 1.56$) or safety goal ($M = 2.52$, $SD = 1.83$) (Figure 7). But the values of anger peaked in the traffic jam event, when the circumstances were to blame for blocking the arrival ($M = 3.57$, $SD = 1.53$). Self-directed anger could be observed when the participant blocked his own arrival goal due to incorrect behaviour (e.g. losing the way) ($M = 2.53$, $SD = 1.89$) but if the participant blocked the arrival goal of other participants (e.g. due to double parking), anger dropped to $M = 0.09$ ($SD = 0.53$). These results are supported by a three-way interaction; they revealed that in situations when the arrival goal was blocked, all blame contexts – except when the participant influenced the goal of others – caused reasonably high means ($F (3, 558) = 159.83$; $p < .001$; $\eta_P^2 = .47$).



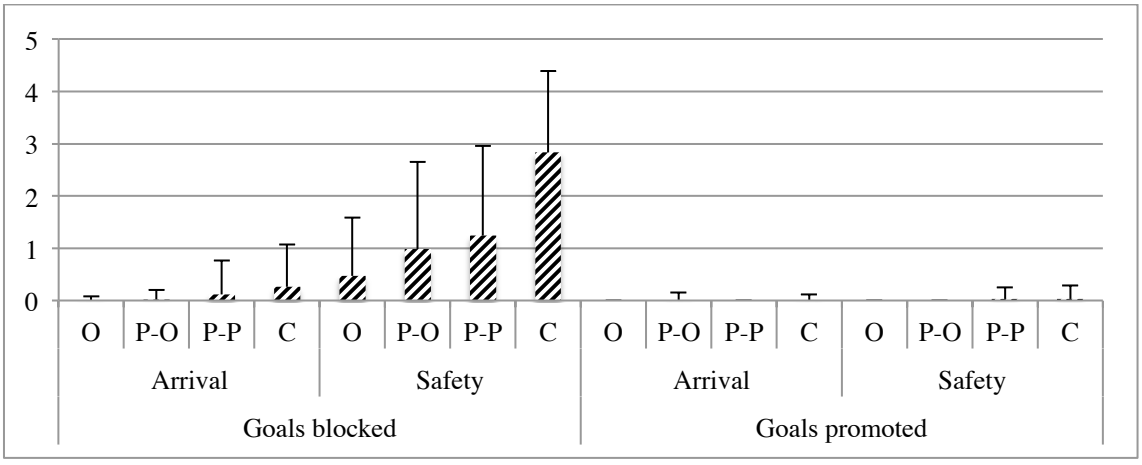
O = Other-blame; P-O = Participant influences goal achievement of others; P-P = Participant influences own goal achievement; C = Circumstance-blame; y-axis: intensity of anger

Figure 7: Situational properties and intensity of anger in study 2

2.3.2.2.2 Testing H2

In goal blocking situations anxiety occurs more intensively when safety related goals are blocked by generic circumstances than in situations where another driver or self directed actions are responsible for the negative safety-related outcome.

Similar to anger, anxiety was only triggered in goal blocking situations ($F(1, 186) = 306.61$; $p < .001$; $\eta_P^2 = .63$) and safety-related goals seemed to trigger more intense levels of that emotion ($F(1, 186) = 241.10$; $p < .001$; $\eta_P^2 = .57$). In those situations, the various blame settings elicited significantly different intensities of anxiety: average means ranged from $M = 0.46$ ($SD = 1.12$) when others were to blame (e.g. took right of way), and up to $M = 2.83$ ($SD = 1.56$) under generic circumstances (e.g. bad weather on a rural road at night) (Figure 8). These findings were supported by a three-way interaction ($F(3, 558) = 48.70$; $p < .001$; $\eta_P^2 = .21$) and post-hoc tests (all $p < .001$).



O = Other-blame; P-O = Participant influences goal achievement of others; P-P = Participant influences own goal achievement; C = Circumstance-blame; y-axis: intensity of anxiety

Figure 8: Situational properties and anxiety intensities in study 2

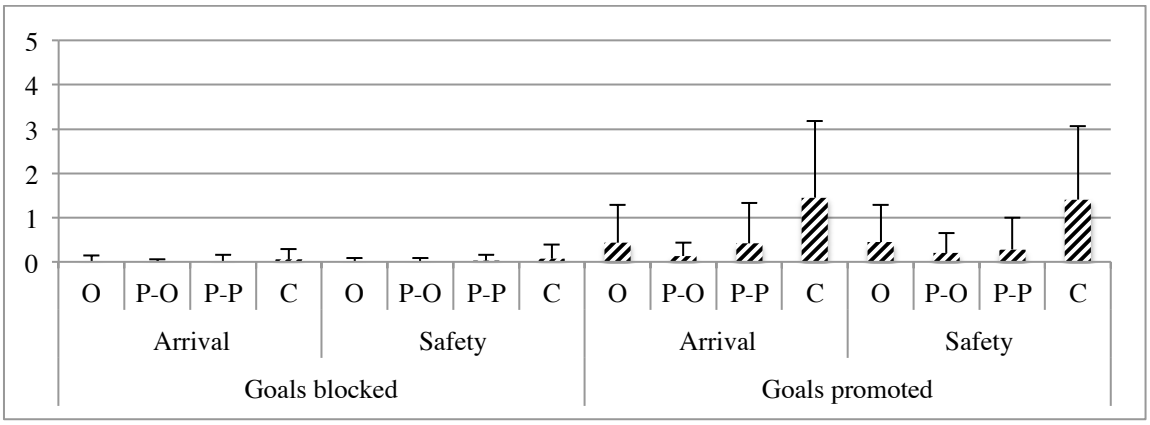
2.3.2.2.3 Testing H3

In goal promoting situations positive emotions are more intense than in goal blocking situations.

In the first study even the outcomes of goal promoting situations tended to be (slightly) negative due to the low contrast between promoted and blocked goals (every situation had at least one negative aspect). The newly designed goal congruent situations generated entirely positive outcomes, and so five emotions (happiness, satisfaction, amusement, relief and hope) could be analysed. In order to reduce the complexity of the analysis, the first three emotions were combined. The mean correlation between them over the course of the sixteen scenarios was $r = .41$ ($p < .001$) with a range of $r = .28$ to .57 and a Cronbach's-Alpha at $\alpha = .68$. Therefore grand means and standard deviations for emotional intensity were calculated, labelled as a "feel-good" construct of emotion and used for in-depth analysis (Figure 9 and table 10). Naturally, those positive emotions were only present in goal-promoting situations ($F(1, 186) = 404.87$; $p < .001$; $\eta_P^2 = .69$) Furthermore, the blame factor affected the occurrence of those emotions: The intensities of positive emotions were highest if the (positive) change in the situation was because of the generic circumstances (e.g. perfect road conditions on a highway or avoiding a traffic jam) ($M = 1.43$, $SD = 1.70$) and lowest if the participant actively influenced the goal achievement of other drivers (e.g. due to considerate driving) ($M = 0.40$, $SD = 0.67$). This constituted the only interaction effect for this emotional cluster ($F(3, 558) = 296.04$; $p < .001$; $\eta_P^2 = .62$) (Figure 9).

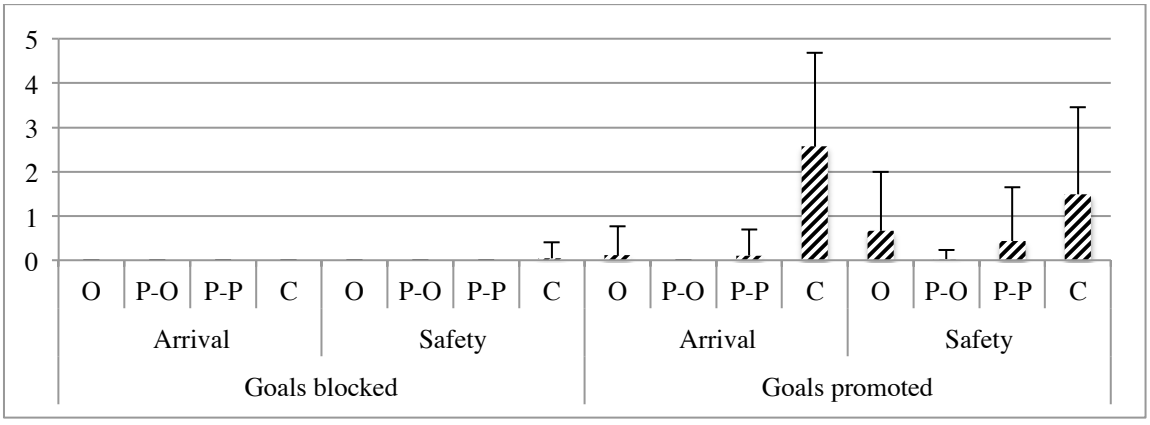
The same pattern of influence for situational variables could be observed for the emotion relief. The means were highest in goal promoting situations with no specific persons involved (circumstance-blame) ($F(3, 558) = 171.21$; $p < .001$; $\eta_P^2 = .48$) with $M = 2.57$ ($SD = 2.11$) and $M = 1.49$ ($SD = 1.98$), respectively (Figure 10). Furthermore, the higher mean in the arrival context (avoiding a traffic jam) compared to the safety context (perfect road conditions) constituted a three-way interaction ($F(3, 558) = 29.91$; $p < .001$; $\eta_P^2 = .14$).

The emotion of hope was only influenced by the blame factor ($F(3, 558) = 55.50$; $p < .001$; $\eta_P^2 = .23$), with higher reported means in circumstance-blame situations ($M = 0.38$; $SD = 1.05$) compared to all other variations of blame ($M = 0.03$; $SD = 0.22$) (Figure 11).



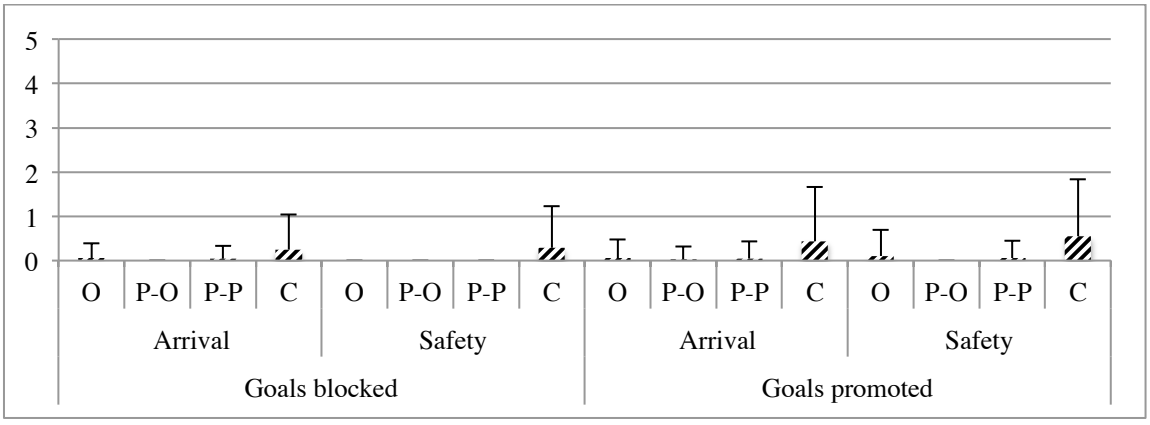
O = Other-blame; P-O = Participant influences goal achievement of others; P-P = Participant influences own goal achievement; C = Circumstance-blame; y-axis: intensity of "feeling good" emotions

Figure 9: Situational properties and overall positive emotions in study 2



O = Other-blame; P-O = Participant influences goal achievement of others; P-P = Participant influences own goal achievement; C = Circumstance-blame; y-axis: intensity of relief

Figure 10: Situational properties and relief intensities in study 2



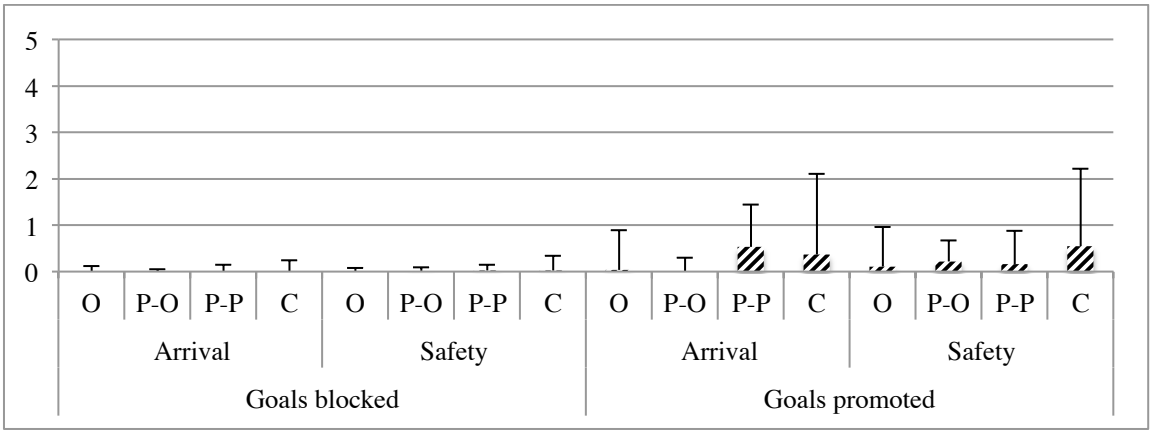
O = Other-blame; P-O = Participant influences goal achievement of others; P-P = Participant influences own goal achievement; C = Circumstance-blame; y-axis: intensity of hope

Figure 11: Situational properties and hope intensities in study 2

2.3.2.2.4 Testing H4

In goal promoting situations pride occurs more intensively when the participant himself is responsible for the promotion of his goals or those of other drivers than in situations where he is not directly responsible for the positive outcome.

Pride was connected to situations where the participants' goals were promoted (F (1, 186) = 64.74; $p < .001$; $\eta_P^2 = .26$) (Figure 12). General means were at M = 0.58 (SD = 1.02) and therefore higher compared to events with blocked goals (M = 0.04, SD = 0.18). The blame factor also had an influence on pride and the reported emotion peaked in situations where generic circumstances (M = 0.46, SD = 1.28) or the participant influenced his/her goal achievement in a positive way (M = 0.52, SD = 1.31), which is confirmed by a two-way interaction (F (3, 558) = 15.91; $p < .001$; $\eta_P^2 = .08$).



O = Other-blame; P-O = Participant influences goal achievement of others; P-P = Participant influences own goal achievement; C = Circumstance-blame; y-axis: intensity of pride

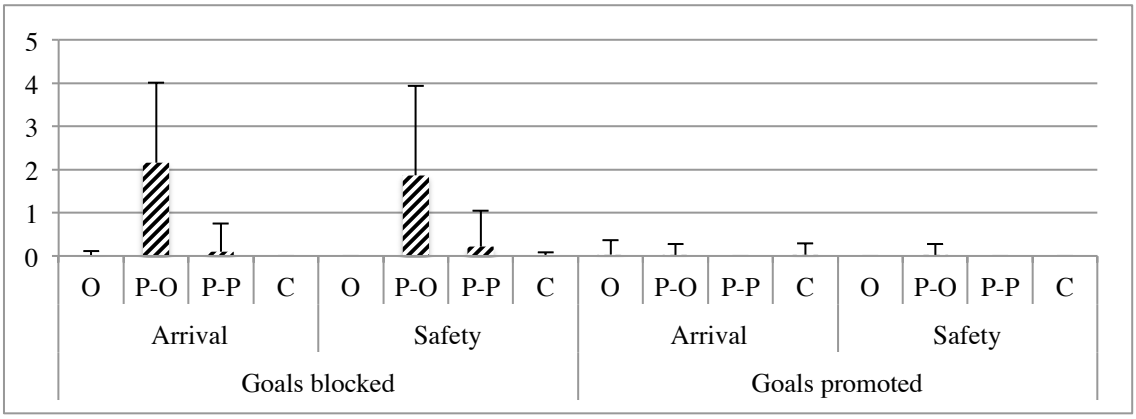
Figure 12: Situational properties and pride intensities in study 2

2.3.2.2.5 Testing H5

In goal blocking situations guilt and shame occur more intensely when the driver himself is responsible for blocking other traffic participants' goals than in situations where he is not directly responsible for the negative outcome.

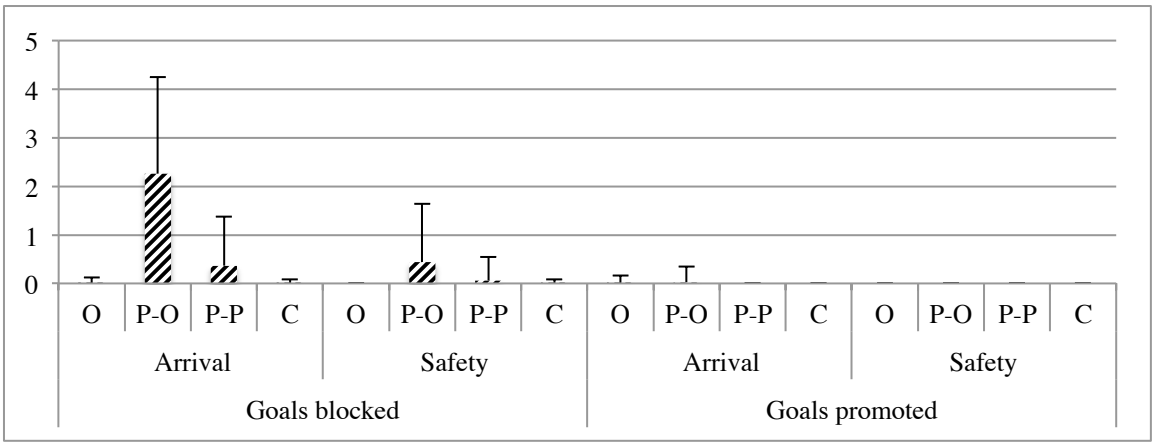
Guilt and shame were both generally related to blocked goals in traffic situations (F (1, 186) = 210.31; $p < .001$; $\eta_P^2 = .54$ and F (1,186) = 169.61; $p < .001$; $\eta_P^2 = .48$) (Figure 13 and 14). Furthermore, the blame factor strongly influenced reports of those emotions (F (3, 558) = 204.74; $p < .001$ $\eta_P^2 = .53$ and F (3, 558) = 127.13; $p < .001$; $\eta_P^2 = .41$) and post-hoc tests revealed significantly higher values of guilt and shame when the participant influenced the goal achievement of other drivers (M = 2.01, SD = 1.96 and M = 1.35, SD = 1.60) compared with all other forms of blame (M = 0.07, SD = 0.29 and M = 0.05, SD = 0.25, all $p < .001$). These findings were confirmed by an interaction effect between goal congruence and blame (guilt: F (3, 558) = 129.79; $p < .001$; $\eta_P^2 = .41$ and shame: F (3, 558) = 196.48; $p < .001$; $\eta_P^2 = .52$). Regarding the differences with relation to goal relevance, the reported intensities of guilt were similar in both arrival and safety-related situations (M = 2.18, SD = 1.85 and M = 1.87,

SD = 2.07 respectively). But shame occurred less intensely in situations where the safety rather than the arrival goal of others was negatively affected (M = 0.44, SD = 1.20 vs. M = 2.26, SD = 1.98). This constituted a significant three-way interaction (F (3, 558) = 72.05; p < .001; η_P^2 = .28).



O = Other-blame; P-O = Participant influences goal achievement of others; P-P = Participant influences own goal achievement; C = Circumstance-blame; y-axis: intensity of guilt

Figure 13: Situational properties and guilt intensities in study 2



O = Other-blame; P-O = Participant influences goal achievement of others; P-P = Participant influences own goal achievement; C = Circumstance-blame; y-axis: intensity of shame

Figure 14: Situational properties and shame intensities in study 2

Table 10: F-Values and effect sizes for the full-factorial model and the ten extracted emotions in study 2

	Anger		Anxiety		Amusement		Satisfaction	
	F-Values (η)	p	F-Values (η)	p	F-Values (η)	p	F-Values (η)	p
Blame	**27.42 (.60)**	**.000**	**83.89 (.32)**	**.000**	**88.33 (.33)**	**.000**	**197.45 (.52)**	**.000**
Congruence	**939.74 (.84)**	**.000**	**306.61 (.63)**	**.000**	**77.99 (.30)**	**.000**	**295.81 (.62)**	**.000**
Relevance	**508.14 (.74)**	**.000**	**241.1 (.57)**	**.000**	**55.52 (.23)**	**.000**	**34.96 (.16)**	**.000**
Blame * Relevance	**166.89 (.48)**	**.000**	**48.18 (.21)**	**.000**	**36.69 (.17)**	**.000**	**52.03 (.22)**	**.000**
Blame * Congruence	**267.07 (.60)**	**.000**	**78.58 (.30)**	**.000**	**82.60 (.31)**	**.000**	**184.69 (.50)**	**.000**
Relevance * Congruence	**495.51 (.73)**	**.000**	**257.18 (.59)**	**.000**	**38.77 (.18)**	**.000**	**30.44 (.14)**	**.000**
Blame * Relevance * Congruence	**159.83 (.47)**	**.000**	**48.7 (.21)**	**.000**	**33.57 (.16)**	**.000**	**47.58 (.21)**	**.000**

	Happiness		Relief		Hope		Feeling Good	
	F-Values (η)	p	F-Values (η)	p	F-Values (η)	p	F-Values (η)	p
Blame	**88.33 (.33)**	**.000**	**184.66 (.50)**	**.000**	**55.5 (.23)**	**.000**	**308.6 (.63)**	**.000**
Congruence	**77.99 (.30)**	**.000**	**215.53 (.54)**	**.000**	13.73 (.07)	.000	**404.87 (.69)**	**.000**
Relevance	**55.52 (.23)**	**.000**	1.32 (.01)	.259	0.50 (0)	.489	2.95 (.02)	.098
Blame * Relevance	**36.69 (.17)**	**.000**	**27.53 (.13)**	**.000**	1.22 (.01)	.372	7.08 (.04)	.004
Blame * Congruence	**82.6 (.31)**	**.000**	**171.21 (.48)**	**.000**	7.92 (.04)	.003	**296.04 (.62)**	**.000**
Relevance * Congruence	**38.77 (.18)**	**.000**	1.79 (.01)	.181	3.09 (.02)	.081	1.68 (.01)	.223
Blame * Relevance * Congruence	**33.57 (.16)**	**.000**	**29.91 (.14)**	**.000**	0.97 (.01)	.416	6.5 (.03)	.005

Continued on page 63

	Pride		Shame		Guilt	
	F-Values (η)	p	F-Values (η)	p	F-Values (η)	p
Blame	**18.75 (.09)**	**.000**	**127.13 (.41)**	**.000**	**204.74 (.53)**	**.000**
Congruence	**64.74 (.26)**	**.000**	**169.61 (.48)**	**.000**	**210.31 (.54)**	**.000**
Relevance	3.99 (.02)	.052	**122.17 (.40)**	**.000**	.89 (.01)	.351
Blame * Relevance	6.19 (.03)	.006	**83.58 (.31)**	**.000**	2.96 (.02)	.035
Blame * Congruence	**15.91 (.08)**	**.000**	**129.79 (.42)**	**.000**	**196.48 (.52)**	**.000**
Relevance * Congruence	0.77 (0)	.382	**115.83 (.39)**	**.000**	0.28 (0)	.681
Blame * Relevance * Congruence	7.12 (.04)	.003	**72.05 (.28)**	**.000**	3.08 (.02)	.033

Reported F-Values (partial eta-squared effect sizes) controlled for gender, driving motivation, annual mileage, DAS (anger, contempt) and STAI (anxiety)
Number of observations: 7 (Effects) * 12 (Emotions) = 84
Bold F-Values are significant at the Bonferroni-corrected $p < .00059$ (0.05/84)
Degrees of freedom are df (3,558) for any analysis involving the blame-factor and df (1,186) otherwise

2.3.3 Discussion: Appraisal-Factors and Elicited Emotions in the Second Study

The aim of the second study was to confirm and to extend the results of the first study. On the one hand the hypotheses were repeated, and on the other, new situational factors were designed to test new assumptions. The results of the second study were much more detailed due to the revised Geneva Emotion Wheel and the greater variety of new scenarios. The sixteen new traffic situations elicited fourteen distinct emotions (seven were used in the first study) and the newly developed goal promoting scenarios provided a stronger contrast in the positive and negative emotions elicited. Anger is the emotion which participants reported most often in the situations presented, followed by satisfaction and happiness.

The hypothesis that goal blocking situations with other-blame leads to more intense anger was proven again. Although the peak of reported anger was not directly person-related but occurred in a traffic jam, the results of the first study were confirmed by combining the means from both contexts of goal relevance (arriving and safety). Compared to the first study, there was a higher contrast between high and low goal congruency and anger was almost absent in situations where participants' goals were promoted ($M = 0.21$, $SD = 0.07$ vs. $M = 1.52$, $SD = 0.48$). Anger is generally stronger in situations where the participants' goals are blocked (if the outcome is self-directed the participant is usually angry with her/himself) and almost non-existent when the participant blocks the goals of others. This might be a result of a lack of empathy and understanding for the actions of other road users or due to a perceived right to block others' goals in the traffic situation. Such an asymmetry of anger perception could provoke even stronger anger reactions because the blocked driver might see arrogance and disinterest in the behaviour of the other which could facilitate the escalation of the situation.

Anxiety was – as it had been in the first study – linked to safety related goals and was strongest when circumstance-blame was present compared to situations in which other forms of blame were involved. This result differs slightly from the first study's findings, but was in accordance with the literature (Lazarus, 1991; Mesken et al., 2007). Anxiety also occurs in situations where the driver impairs the safety of others, which could either be seen as empathetic behaviour or derived from the fact that the overall situation was dangerous for all traffic participants including the participant who caused it. However the first of these assumptions can be discarded based on the findings from the relationship between blocked goals of others and reported anger in this study. Similar to the first study, intensities and frequencies of anxiety were again lower than those of anger. There are two possible reasons for this. First, anxiety is harder to imagine or report, and therefore to measure, when the situations are only presented in text form (Martin, 1990). Second, anxiety is a much more situation-specific emotion than anger and only occurs in some critical situations. The latter assumption is supported by our results and the research from Taylor & Paki (2008). In their findings, 90% did not describe anxiety or fear as part of their normal driving experience. On the other hand participants in the study from Mesken et al. (2007) reported anxiety more frequently than anger but only the latter was related to specific events. There might be different perceptions of anxiety, ranging from "feeling

discomfort" to "fear". Therefore different levels and kinds of anxiety are reported depending on the instructions in the experiment, driving environment and experimental setting.

The various positive emotions were generalised under the "feeling good" label. This procedure is supported by the literature, which states that certain positive emotions such as amusement, happiness and satisfaction tend to share the same appraisal contexts (safe and familiar) and action tendencies (broadening the thought–action repertoire) (Ellsworth & Smith, 1988; Frederikson, 1998). Positive emotions were strongest in goal promoting situations which did not involve another party. In these situations four specific positive emotions peaked (happiness, satisfaction, relief, amusement). If another person interacted with the participant, the intensity of all positive emotions dropped significantly, even if their action was actually goal promoting. In a driver-to-driver interaction lowered positive emotions could result from a perceived lack of appreciation from others. Combined with the findings of anger and task-demand from the first study (high task demand leads to higher levels of anger), it could be argued that there is a strong tendency towards expressing negative emotions and at the same time suppressing positive emotions such as appreciation and happiness. The consequence might be less polite and considerate behaviour on the street due to the lack of positive emotions during driver-to-driver interaction. This does not mean that there were no positive emotions all together over the course of the study. The high frequency and intensity of reported happiness proved that traffic participants could imagine positive emotions in some situations.

Furthermore, in relation to emotion-specific hypotheses H4 (pride) and H5 (guilt / shame), it was revealed that drivers connect their own actions which affect themselves and others with very strong emotions both positive as well as empathetic. Pride was strongest if the participant successfully promoted his own goals. Negative emotions such as guilt and shame were much stronger if the participant was responsible for blocking other people's goals. Both negative emotions can be a result of the individual's awareness that he/she had violated moral, social, or ethical principles (Tangney, 1991). There seems to be little support that the type of event (e.g. safety vs. arrival) differentiates between those two emotions and scholars tend to deem appraisals on internal attributes (unstable behaviour vs. stable self) as more appropriate (Tangney, Stuewig & Mashek, 2007). Therefore, the experience of stronger feelings of guilt could be connected with unstable internal attributes such as the lack of individual effort, which caused a negative event for the other driver (Tracy & Robins, 2006). Participants might have the feeling that he/she could have prevented the event if only they had been more focussed at that moment or reacted more quickly (Tangney & Dearing, 2002). This feeling grows stronger with the severity of consequences faced. In summary, these findings on shame and guilt strongly indicate that empathy-related emotions are still active – even in traffic situations where a high level of tension and competition is an everyday phenomenon (Shinar, 1998).

2.4 General Discussion and Conclusion

Confirmation of the Hypotheses

The first three hypotheses from study one were confirmed in the second study. This backed the assumption that anger, anxiety and some positive emotions could be generated from the variety of situations designed on the basis of the appraisal-factor framework. Goal (in)congruence, goal relevance and blame proved to be good predictors of those emotions in many situations. The combined results of both studies are an important step towards developing a framework for traffic situations and predicting certain emotional outcomes due to underlying situational factors and their appraisal. Even the use of two different versions of the Geneva Emotion Wheel and the application of two completely different scenario architectures resulted in similar situation-emotion patterns, which indicates the stability of the results. In the second study, the change of perspective – looking at self-directed changes in traffic situations – expanded the range of emotions extracted. Shame, guilt and pride were assessed in a traffic context for the very first time and the results from the appraised situations indicate that these emotions belong to the common spectrum of feelings of the traffic participant. The impact these specific emotions might have on behaviour within traffic situations is a promising field for future research.

Personal Characteristics and Reported Emotions

Emotional responses might be influenced by personal characteristics which therefore could play a role in explaining situational characteristics. The samples in both studies differed by gender: in the first study participants were predominantly male (64%), in the second study female (70%). The analysis of the seven extracted emotions from study one revealed that gender did affect anxiety and relief responses and females reported slightly higher intensities of both emotions. In the second study anxiety was again stronger among women and men reported more intense pride. Those results are in line with the literature, stating higher driving related fear and anxiety among women than men (Armstrong & Khawaja, 2002; Taylor & Paki, 2008) and stronger feelings of pride in male populations (Brebner, 2003). Anger responses were not influenced by gender and did not show any interaction effects with specific situational characteristics. Regarding this issue the findings in the literature are mixed. On the one hand, some studies did not find any gender differences (Deffenbacher et al., 2003; Lajunen, Parker & Stradling, 1998), others report differences in at least some contexts such as impeded progress and impatient and inconsiderate driving (Parker et al., 2002). Experienced drivers seem to report less anger (study 1) and anxiety (study 2) which seems to confirm the results from the literature which states that high exposure to traffic sets new baselines for the situational assessment because such drivers have mastered more critical situations (Björklund, 2008; Deffenbacher et al., 1994; Mesken et al., 2007; Lajunen & Parker, 2001).

Driving motivation was related to more intense happiness, pride (only study 2), satisfaction and anger (both studies). This indicates that people who value and enjoy driving are also able to

experience positive emotions more strongly. At the same time, they are more angered by blocked goals, which is exactly in line with the argumentation from Philippe and colleagues (2009) who stated a similar relationship between passionate driving motivation and anger responses in traffic.

According to state-trait-theory, trait anger and anxiety should lead to more intense and frequent anger and anxiety in potentially emotional situations. Only the first assumption was supported by the data of the study. Participants scoring high on the DAS or the STAI did report more intense (but not more frequent) anger (in both studies) and anxiety (only study 1) over the course of the experiment. This was true on a global level: in-depth analysis revealed no interaction effects between the underlying situational factors and emotional traits. Therefore, the factorial structure of the traffic situation does not moderate the relationship between trait and state emotions. It could be argued that some of the situations presented were conceptually quite similar to those used in the DAS. Therefore, the scenarios which were presented in both studies could be seen as a method to test the convergent validity of this trait measure. On the other hand correlations were small enough to state that the item pool measures a distinct emotional construct or, at least, extends the range of possible emotional traffic situations. This might be generally true for any measure with hypothetical traffic situations, where an abstract emotional state has to be imagined.

Limitations

The results from these two studies may be limited in that they are based on self-reported responses in reaction to hypothetical text-based critical traffic situations. Although such procedures have been proven to generate valid information in relation to appraisal and emotion (Schorr, 2001), each participant might have a different mental model of traffic in general and, therefore, different expectations and theories about what emotion will be elicited and why. One approach might be to ask the participants not only to describe their hypothetical emotion but also their reasons for why that emotion was elicited in the first place. This analysis of the appraisal process would not only shed some light on important cognitive processes which are influenced by emotions (e.g. risk perception, attention), but also validate the appraisal framework and its components. Two possible uses for the scenarios might be the validation of the emotional profiles in real-drive or simulated events, as a template for new state measures (e.g. as a framework for driving logs or traffic simulator scenarios) or to develop new trait driving emotion scales (e.g. trait driving happiness / shame / guilt).

Furthermore, the reported emotions (besides anger) were not very intense and this raises the question of whether these methods produce valid results for predicting emotional experiences in similar, real traffic situations. Mesken and colleagues (2007) asked their participants during several highway and urban area sections about their emotional state (anger, anxiety and happiness). The experiment was not designed to confront the participant with critical situations but still there were events where the progress of the participant was impeded and safety-related goals were blocked. The reported emotional intensities for the three emotions were at $M = 1.4$ ($SD = 0.5$). This is still higher than the overall means in our online studies (Study 1: $M = 0.75$, $SD = 0.79$; Study 2: $M = 0.74$,

SD = 0.70), but the profile of situational attributes (e.g. more intensely experienced anger due to another driver blocking the arrival goal of the participant) are very similar, which underlines the importance of and the potential for describing traffic situations with the selected factors goal congruence, goal relevance and blame.

Additionally, due to the relatively young and inexperienced sample in both studies, future research should focus on representative samples taking more age groups and experienced drivers into account. Their inclusion could lead to even more precise results and researchers would have to deal a lot less with the often confounding variables of gender, driving experience and age.

Finally, the high similarity between the emotion-situation pattern in both studies might be a result of our selection of emotions from the GEW. Emotions which were not predictive (e.g. disgust, envy) were eliminated and replaced by more suitable emotions (e.g. feeling helpless, happiness). This might have hampered the comparability of how participants selected emotions, and thus exaggerate estimates of similarity between both studies. On the other hand, having a larger set of highly traffic relevant emotions in study 2 automatically reduces the likelihood that any one of them will be chosen, especially when participants are only allowed to pick the three most suitable emotions from the wheel. In addition to this possible limitation, the GEW needs more validation especially in the traffic context. Therefore, future studies should employ the emotion wheel together with other measurements of emotion (e.g. physiological methods). However, in order to use this instrument in real traffic, a different form of presentation is necessary (e.g. read aloud context-specific emotions and receive verbal response).

Conclusion

The results of both studies described in this paper imply that an understanding of situational characteristics of traffic events such as goal congruence, goal relevance and blame leads to a more precise description of the nature of emotion elicitation. The results indicate that a greater variety of emotions besides anger and anxiety can be experienced in everyday traffic. The implications for driving behaviour are not as yet clear, and much more research is needed to fully understand the relationship between a traffic situation, personal characteristics, emotional experiences and actual driving behaviour. For a start, future models of emotions and driving behaviour should take the richness of emotions in traffic into account in order to improve their precision and validity.

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3. Emotional States of Drivers and Their Impact on Driving Behaviour – A Simulator Study

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Abstract

Maladjusted driving, such as high speeds and delayed reactions, is seen as one important cause of traffic accidents. Such behavioural patterns could be influenced by strong emotions in the driver. The causes of emotions in traffic are divided into two distinct classes: personal factors and properties of the specific driving situation. In traffic situations, various appraisal factors are responsible for the nature and intensity of experienced emotions. These include whether another driver was accountable, whether goals were blocked and whether progress and safety were affected. In a simulator study, seventy-nine participants took part in four traffic situations which each elicited a different emotion. Each situation had critical elements (e.g. slow car, obstacle on the street) based on combinations of the appraisal factors. Driving parameters such as velocity, acceleration, and speeding, together with the experienced emotions, were recorded. Results indicate that anger leads to stronger acceleration and higher speeds even for two kilometres beyond the emotion-eliciting event. Anxiety and contempt yielded similar but weaker effects, yet showed the same negative and dangerous driving pattern as anger. Fright correlated with stronger braking momentum and lower speeds directly after the critical event.

Keywords – anger, contempt, anxiety, fright, appraisal theory, driving performance

3.1 Introduction

In 2011, round about 400,000 people were involved in traffic accidents in Germany. Almost 4,000 died in those situations (Destatis, 2012). One important cause is the presence of strong emotions in the traffic participant and the resulting maladaptive driving behaviours (Nesbit, Conger & Conger, 2007; Dula & Ballard, 2003). Emotions create a motivational tendency (and therefore an increased probability) to perform a class of driving behaviours. This could be devastating for all traffic participants when, for example, risky or aggressive driving occurs in situations like dense city traffic or sharp curves on a country road. Several studies in the past examined the connection between the frequency of elicited emotions and their potential negative consequences such as high speeds (Deffenbacher, Deffenbacher, Lynch & Richards, 2003) aggressive behaviours towards other drivers (Shinar & Compton, 2004) and accidents (Underwood, Chapman, Wright & Crundall, 1999). Those studies focused on the personal characteristics of the driver including trait driving anger, the propensity to display anger in various traffic situations (Deffenbacher et al., 2003). They found evidence for the maladaptive power of emotions, but most of them failed to generalize causes for emotions based on the attributes of traffic situations. Normally, the focus lies on salient and observable behavioural classes, such as aggressive gestures, honking and driving too fast as elements of driving anger and aggressive driving. But that does not account for the context in which the situation is happening, nor does it describe the implications for possible appraisal. Both are vital to explain the cause of an experienced emotion precisely (Ekman & Davidson, 1994; Kuppens, Van Mechelen, Smits & De Boeck, 2003). Only one study conducted by Mesken, Hagenzieker, Rothengatter & De Waard, (2007) examined specific situational attributes and shed some light on their impact on emotions elicited (anger and anxiety) as well as the traffic related consequences (velocity and speeding behaviour).

According to the appraisal theory of emotions, the subjective assessment (appraisal) of a given situation determines whether an emotion is elicited or not, as well as the quality and the intensity of the emotion (Lazarus, 1991; Frijda, 1993; Scherer, Schorr, & Johnstone, 2001). This happens in a two-step process (Scherer et al., 2001). During the primary appraisal stage, the individual assesses the relevance and goal-blocking (low goal congruence) or goal-promoting (high goal congruence) potential of the situation and this determines if an emotion (positive or negative) will occur. In the second stage, the type of emotion is determined based on the evaluation of the coping potential and the anticipated consequences. Combinations of different secondary appraisal components are therefore the cognitive determinants and responsible for the evocation of specific emotions, their quality and intensity (Scherer et al., 2001; Smith & Lazarus, 1993).

The present study examines the factors goal congruency, goal relevance and other-accountability and their impact on experienced emotions (Scherer et al., 2001; Kuppens, Van Mechelen, De Boeck & Ceulemans, 2007). Goal congruency labels the development of a situation with high or low accordance with one's personal goals. An example of low goal congruency could be when progress on the road is impeded due to a slow car in front. High goal congruence could be

associated with very good road conditions, which promote safe driving. Goal relevance focuses on the two most important traffic-related goals: timely and safe arrival at the destination (Cnossen, 2001). Other-accountability relates to different agents causing changes in a given situation (Kuppens et al., 2003). On the one hand, these can be other drivers interacting directly with others in a traffic situation. Examples are specific negative driving patterns (speeding and tailgating) or gestures (honking and verbal aggression). On the other hand a generic situational context (heavy rain or fog) can force a driver to reassess the traffic event and change the driving behaviour.

This factorial structure has been discussed by many studies looking at driving anger but mostly in an intuitive, general way. The frustration – aggression hypothesis (Dollard, Doob, Miller, Mowrer, & Sears, 1939) was employed to cover all those traffic situations with various goal blocking characteristics (and very often direct personal agency, too) (Björklund, 2008; Lajunen & Parker, 2001; Lawton & Nutter, 2002; Lajunen, Parker & Summala, 2004). For example, the UK Driving Anger Scale (Lajunen, Parker & Stradling, 1998) identified several clusters of anger provoking situations, which shared similarities on the level of goal congruency and goal relevance: either the progress of the participant was impeded or reckless driving reduced the safety. But the focus lays on the anger emotion, caused by another driver's blame. Furthermore, only two items from the original DAS (Deffenbacher et al., 1994) deal with a potential anger-provoking event with no specific personal agency (traffic jam and construction site). This picture changes however when looking at driving anxiety (or driving related fear). Building on the assumption that a lack of control in a situation with no specific identifiable agent can induce anxiety (Berkowitz, 1993; Lazarus, 1991), new sets of traffic situations were studied. Dangerous road conditions and own maladjusted driving behaviour became important and completed the catalogue of emotion eliciting events. (Ehlers, Hoffmann, Herda & Roth, 1994; Taylor, Deane & Podd; 2000).

In addition to situational attributes, personal characteristics are responsible for the occurrence of emotions in traffic. Persons scoring high on trait (driving) anger tend to experience more emotions in that specific domain than others and, as a result, drive faster and generate more traffic violations (Deffenbacher, Oetting & Lynch, 1994; Mesken, Hagenzieker, & Rothengatter, 2005). High state anxiety is associated with more self-inflicted errors while driving (Fairclough, Tattersall & Houston, 2006). Furthermore age, gender, driving experience or how important driving is to the driver and how much they enjoy it (driving motivation) have an effect on emotional episodes on the road: younger drivers tend to experience more anger than older ones (Lajunen & Parker, 2001; Parker, Lajunen & Summala, 2002); men report more anger when they are impeded by other drivers (Deffenbacher et al., 1994); woman are more angered when they are confronted with direct hostility, illegal actions or traffic obstructions (Parker et al., 2002). Driving experience is generally negatively correlated with anger feelings and experienced drivers feel less irritated in various traffic situations. It is assumed that their anger-threshold is heightened due to a frequent exposure to critical situations (Lajunen & Parker, 2001). When traffic participants internalize driving in their identity, this obsessive passion starts to control their actions and leads to greater desire and more intense will to drive. These highly motivated

drivers are prone to negative emotions in goal-blocking situations (e. g. impeded progress on the road or erratic driving of others; see Roidl, Frehse, Oehl & Höger, 2013), which could, in turn, lead to maladaptive driving behaviours (e. g. aggressive driving) (Philippe, Vallerand, Richer, Vallières & Bergeron, 2009).

The implications of those emotions (anger and anxiety) in traffic are two-fold. Firstly, cognitive processes are influenced due to emotional experiences (Lazarus, 1991; Lerner & Keltner, 2002) and, as a result, effectively influence driving behaviours. The appraisal tendency approach implies that experienced emotions and its associated appraisal components trigger an aligned evaluation of subsequent events. Negative moods, such as feelings of anxiety, appear to lead to pessimistic risk perceptions, as opposed to positive mood, which makes people more confident in situation where they don't have any control over the events (Johnson & Tversky, 1983). However, anger could lead to more perceived control and therefore to more optimistic risk appraisals (Lerner & Keltner, 2001); This translates into the traffic context, that angry drivers are prone to underestimate risky situations and therefore change their behaviour in a maladaptive way (Mesken et al., 2007). They tend to show aggressive behaviours in traffic (e.g.; Lajunen & Parker, 2001; Björklund, 2008; Dahlen & White, 2006; Stephens & Groeger, 2009; Britt & Garrity, 2006) such as increased speed (Deffenbacher et al., 2003; Matthews Desmond, Joyner, Carcary & Gilliland, 1997), traffic violations (Mesken et al., 2007; Maxwell, Grant & Lipkin, 2005; Sümer, 2003), (hostile) gestures (Philippe et al., 2009) and honking (Shinar, 1998; Philippe et al., 2009). Ultimately, these forms of behaviour increase the risk of crashes and endanger other road participants (Deffenbacher et al., 2003; Chliaoutakis, Koukouli, Lajunen & Tzamalouka, 2002; Underwood et al., 1999).

According to the appraisal tendency approach high levels of anxiety should lead to reduced speed and more cautious driving behaviour. But the literature shows different results: anxious drivers tend to perform even more risky and dangerous behaviours (Fairclough et al., 2006; Dula et al., 2010). One interpretation might be, that anxiety works as restricting factor on overall working memory, which limits cognitive capacity that could otherwise be used for driving tasks (Shahar, 2009; Dula et al., 2010). This could trigger lapses, errors and violations while driving (Fairclough et al., 2006; Shahar, 2009; Taylor, Deane & Podd, 2007). The present study has pursued two different goals: first, the emotion-eliciting potential of various situational factors within traffic situations were tested. According to the appraisal theory framework, different combinations of situational factors should elicit different emotions. In this experiment, the focus was laid on anger, when the driver's arrival or safety goal was blocked due to another driver (Parkinson, 2001; Mesken et al., 2007; Roidl et al., 2013) and anxiety, when the driver's security in traffic is at stake (Ehlers et al., 1994; Taylor, Deane & Podd, 2000; Roidl et al., 2013). A second aim was to evaluate the impact of emotions of anger and anxiety on driving behaviour in the simulator. Velocity, acceleration, lateral acceleration and speeding were focused in this study due to their relevance in the literature of emotional driving (Stephens & Groeger, 2009; Cai & Lin, 2011; Deffenbacher et al., 2003). Furthermore, driving accidents (with no other traffic participants involved) due to maladaptive speeds contribute to 35% of all accidents and

45% of all traffic fatalities on rural roads and highways in Germany (Destatis, 2012). Additionally, driving parameters such as high velocities and strong acceleration can increase the negative impact of more complex behaviours such as tailgating or risky overtaking (which are also endangering other traffic participants) even more. However, to elicit emotions in a controlled experiment in the laboratory is a difficult task, which requires a thorough design and reliable measures (Mesken, Hagenzieker & Rothengatter, 2005). On the other hand, simulator based studies promise a high standardization of the emotion eliciting events and the precise recording of the relevant risky driving parameters. This provides an acceptable environment for pursuing the goals of the study.

3.2 Method

3.2.1 Participants

Seventy-nine drivers took part in this study, of which 48 were female and 31 male. The participants' ages ranged from 18 years to 43 years (M = 23.54; SD = 4.21), with an average of 5.67 years (SD = 4.02) driving experience. They drove on average 7,130 kilometres per year (SD = 8,840) and had a total mileage of 53,000 kilometres (SD = 70,280). Participants were mostly recruited on the university campus. They were compensated for their participation with a small present worth 15 Euro.

3.2.2 Apparatus

The study was conducted with the driving simulator StiSim W100 from System Technology Incorporated. A Volkswagen Golf cockpit with original steering wheel and instrument panel was used to control the car. During the simulation drive, the StiSim W100 registers all driving activities like accelerating, braking and lateral position.

3.2.3 Stimulus Material

The driving simulation consisted of a 17120m rural route including hills, trees, curves, traffic signs and oncoming traffic. Within these 17 kilometres, four critical events took place, which differed on the aforementioned appraisal factors: goal congruency, goal relevance and other-accountability (Figure 1). To enhance comparability between situations and subjects the situations were highly standardized and actions such as overtaking were impossible due to oncoming traffic. Furthermore, there was no traffic in front of the participant (besides the interacting cars in two situations) to facilitate unobstructed driving.

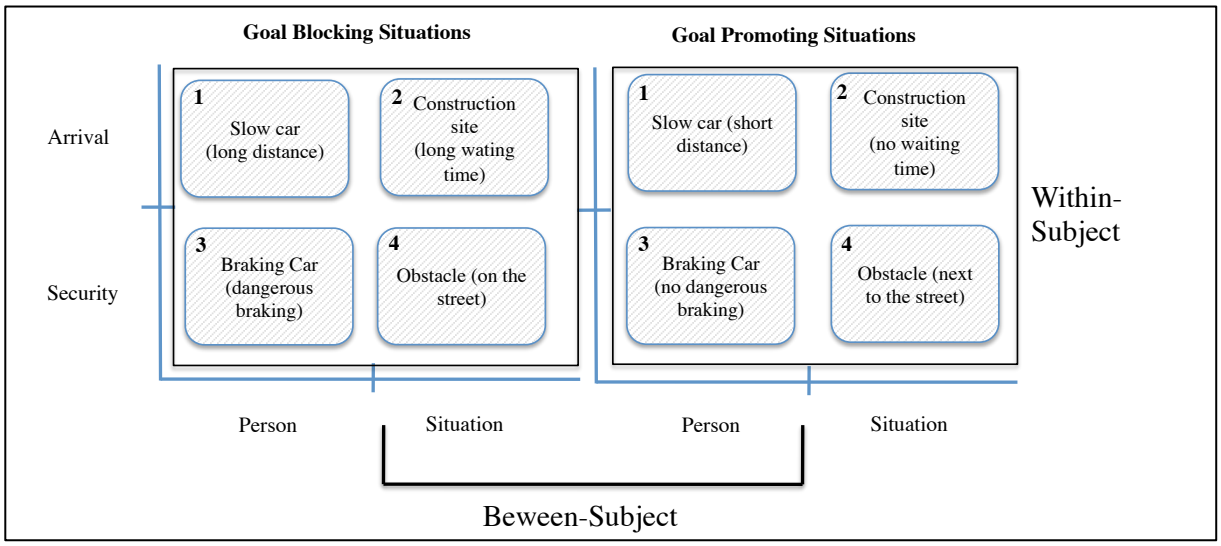


Figure 1: Mapping of the situations on appraisal theory factors

3.2.4 Design

The experimental design consisted of the three independent situational factors, which influenced how the participants appraised the situation. The experiment was a 2x2x2 mixed-design, consisting of eight different traffic scenarios: the 2x2 within-subject factors were goal relevance (*arrival* vs. *safety*) and other-accountability (*personal blame* vs. *situational blame*). The goal congruency factor varied between subjects, so that each participant had either four *goal congruent* scenarios or four *goal incongruent* scenarios during their experimental drive. The emotions experienced were compared to the driving behaviour.

3.2.5 Experimental Measures

The driver was questioned about his/her emotion *after* the drive in order not to interrupt the participant and to prevent potential behavioural cues, therefore, four pictures of the critical sections of the experimental drive were provided. Every situation was rated using an internally revised edition of the Geneva Emotion Wheel (Oehl, Roidl, Frehse, Suhr, Siebert et al., 2010; Scherer, 2005), covering 16 emotions suitable for the driving context. This edition was derived from the original wheel, which spatial structure was confirmed in English and French language (Bänziger, Tran & Scherer, 2005). Back-and-forth translation and the exchange of emotional qualities (disgust, elation, envy and pleasure were removed, amusement, happiness, fright and feeling helpless were added) made the tool more suitable for traffic settings (Roidl, Frehse, Oehl & Höger, 2013). The participants were allowed to rate up to three different emotions within each critical situation on a Likert-scale ranging from 1 (weak emotion) to 5 (very strong emotion). The emotions were later analysed and compared with the specific driving behaviours displayed during the four critical situations. To investigate the influence of individual factors, trait driving anger was measured with a German version of the Driving Anger Scale (DAS; Deffenbacher et al., 1994; Steffgen, Recchia & Ludewig, 2008). It includes 33 items which

measure six subscales: “hostile gestures”, “illegal driving”, “police presence”, “slow driving”, “discourtesy” and “traffic obstructions”. Trait anxiety was measured with a translated version of the STAI (State Trait Anxiety Inventory; Spielberger, Jacobs, Russel & Crane, 1983), which consists of 20 Items measuring stable anxiety tendencies (e.g. ‘I lack self-confidence’, ‘I am content’). Furthermore two items, specific to driving motivation (‘I really like to drive; ‘Driving is important to me’) (Gregersen & Bjrurulf, 1996), age, gender, mileage (kilometres per year and total), years of driving and experienced accidents (active and passive) were assessed as possible control variables for the relationship between emotion and driving behaviour.

Driving behaviour was recorded in two phases after each of the four critical situations. Firstly, for 500 metres after the event, the mean speed (km/h), acceleration (m/s^2) as well as the lateral acceleration were analysed. During the next 2000m in the neutral zone, the set of driving parameters was completed by the assessment of speeding behaviour in % of the track as a potential traffic violation.

3.2.6 Procedure

At the beginning, all participants completed a questionnaire providing personal characteristics and driving history. As an introduction to the graphical presentation of the virtual StiSim environment and to get used to the handling of the steering and speed controls, three training scenarios were prefixed to the actual driving task. Within this familiarization run, the subjects had to drive in a huge parking lot, as well as a rural highway and an urban street. After the training, the participants were asked about their subjective feeling concerning their driving behaviour and if they felt ready to start the test. They were randomly assigned to one of the four scenario arrangements (goal blocking or goal promoting) and started the experimental drive. In order to up the stakes and to create a motivational climate the instruction demanded from the participants to imagine that they were late on their way to work and had to hurry. Immediately after the drive the participants were asked about their emotions experienced. In the end, questionnaires on driving related anger (DAS) and trait anxiety (STAI) were filled out.

3.3 Results

3.3.1 Occurrence of Reported Drivers’ Emotions

During the 30 minutes of the experimental drive the participants reported, on average, 8.4 emotions (SD = 2.7). The focus of the analysis was laid on the anger and anxiety area of the Geneva Emotion Wheel and due to the semantic similarity and frequent occurrence during the experiment the emotions of contempt and fright were additionally analysed. The intensity of those four emotions was on a low level out of to the potential range of 1 to 5. Only anger levels (M =1.67) were above 1.5, other emotions were far less intense (Table 1). Although surprise and feeling helpless were comparatively intense and frequent (Surprise: M =1.07; Freq. = 1.45; Feeling helpless: M =.43; Freq. = .72), they

were excluded from the analysis due to lacking theoretical support regarding their influence on driving behaviour.

Table 1: Frequency, median and means of emotions

#	Emotion	Frequency	SD	Median	Mean	SD
1	Anger	2.24	1.09	1.75	1.67	1.05
2	Surprise	1.45	1.14	1.00	1.07	0.88
3	Fright	1.14	0.99	0.75	0.80	0.74
4	Anxiety	1.00	0.99	0.50	0.55	0.71
5	Feeling helpless	0.72	0.99	0.00	0.43	0.68
6	Contempt	0.57	0.85	0.00	0.38	0.65
7	Relief	0.38	0.75	0.00	0.29	0.62
8	Amusement	0.20	0.43	0.00	0.13	0.30
9	Hope	0.20	0.52	0.00	0.11	0.29
10	Interest	0.14	0.39	0.00	0.09	0.24
11	Satisfaction	0.12	0.46	0.00	0.08	0.31
12	Pride	0.09	0.33	0.00	0.07	0.28
13	Guilt	0.11	0.31	0.00	0.05	0.17
14	Happiness	0.03	0.16	0.00	0.03	0.20
15	Shame	0.01	0.11	0.00	0.00	0.03
16	Sadness	0.00	0.00	0.00	0.00	0.00

3.3.2 Determinants of the Drivers' Emotions: Relation to Appraisal Factors

Generalized linear models for repeated measures with categorical outcomes were conducted in SPSS20 as a manipulation check for the experiment, answering the question of whether the four scenarios could induce an anger, contempt, anxiety or fright emotion in the participants. Therefore the four extracted emotions were mapped to the combination of appraisal factors. The two forms of goal relevance (arrival and safety) and other-accountability (other-driver and situational) were inserted as within-subject-factors. Goal congruency (promoting and blocking) served as the between-subject-factor. To control for personal characteristics of emotion elicitation, gender, driving experience, driving motivation and trait anger and anxiety were used as covariates. Values for AIC and BIC were reported as indicators of model-fit (Burnham & Anderson, 2004).

Other accountability (χ^2 (1, 78) = 32.15; p< .001) yielded a substantial effect on the emotion anger and scenarios with other drivers involved triggered higher intensities (M = 2.13; SD = 1.63) compared to generic situations (M = 1.11; SD = 1.28). But there is also an interaction between goal relevance and accountability, which has an impact on the level of anger (χ^2 (1, 78) = 17.58; p< .001). This interaction mirrors the weak anger in the safety relevant scenario with situational accountability (Scenario 4, road obstacle): the mean anger here is at M = .40 (SD = 0.98) and thus about five times less than in the other situations.

The contempt emotion follows a similar pattern as anger, being higher in situations with another car involved (χ^2 (1, 78) = 10.90; p< .001). There is the same interaction between goal relevance and accountability due to weak contempt in Scenario 4 (M = .07; χ^2 (1, 78) = 46.20; p< .013) No main effect of goal relevance or goal congruence was observed, which indicates that those situations induce a similar level of contempt.

Where the safety of the driver is negatively affected without any other driver to blame, anxiety is experienced the most. The interaction effect between goal relevance and other-accountability reflects the observed means (χ^2 (1, 78) = 14.12; p < .001). The highest anxiety values (M = 1.08 (SD = 1.48) in the goal blocking, respectively M = 0.67 (SD = 0.98) in the goal promoting situation) are within the situational accountability / safety-goal scenario (Scenario 4, road obstacle). The same interaction effect was true for the fright emotion, which was at the highest level in scenario 4 (M = 2.43; SD = 1.83; χ^2 (1, 78) = 3.93; p< .047). The four situations are causing different emotions based on their constituent factors, but the mapping is not as clear as stated in the literature (Smith & Lazarus, 1993; Kuppens et al., 2007) due to a lack of impact of the goal-blocking factor (see Figure 2).

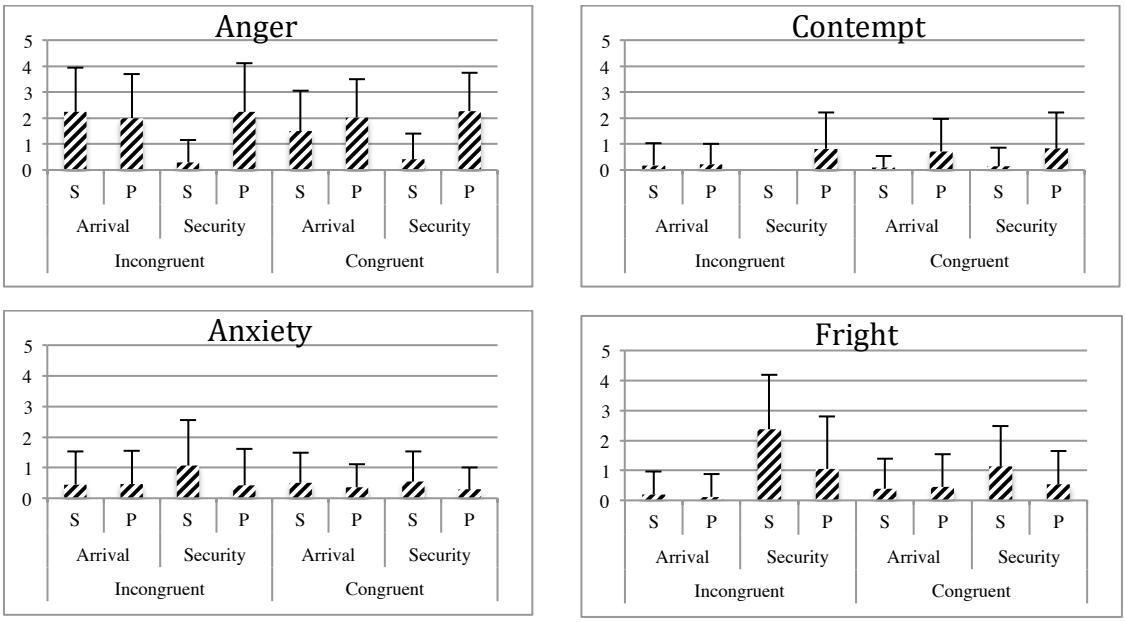


Figure 2: Relation between emotional intensity and situational characteristics (S = situational blame; P = Personal blame)

3.3.3 Determinants of the Drivers' Emotions: Personal Factors

The impact of demographic, driving and personality related scales and items on the four selected emotions was analysed with a generalized linear model. Participants stated their emotional status at four times and, therefore, the values were combined. Due to the zero-inflated distribution of contempt, anxiety and fright a compound Poisson distribution was observed and employed for further analysis. Anger showed a normal distribution which allowed the assumption of linear relationships. Gender,

driving experience, driving motivation and driving anger were added as independent variables. Driving anger and driving motivation were positively related to anger intensities (χ^2 (78; 1) = 7.30; p< .007; χ^2 (78; 1) = 13.66; p< .001). Contempt was significantly stronger in male than in female populations (χ^2 (78; 1) = 4.85; p< .028). The intensity of anxiety and fright was not related to any personal characteristic in this experiment (Table 2).

Table 2: Relationship between personal characteristics and reported emotional intensities

Anger		Wald χ^2	Sig.	CI (95%)	
AIC/df	3.042				
BIC/df	3.225				
Likelihood χ2	**18.568**		**.001**		
Constant		**103.39**	**.000**	**1.452**	**2.146**
Gender		0.55	.457	-0.519	0.234
Mileage		0.13	.719	-2.502E-05	1.727E-05
Driving Motivation		**13.66**	**.000**	**0.08**	**0.505**
DAS		**7.3**	**.007**	**0.183**	**0.598**

Contempt		Wald χ^2	Sig.	CI (95%)	
AIC/df	2.268				
BIC/df	2.451				
Likelihood χ2	6.914		.141		
Constant		**1.62**	**.000**	**-1.172**	**0.25**
Gender		**4.85**	**.028**	**-1.53**	**-0.089**
Mileage		0.15	.702	-6.608E-05	4.448E-05
Driving Motivation		1.24	.265	-0.195	0.709
DAS		1.28	.258	-0.189	0.703

Anxiety		Wald χ^2	Sig.	CI (95%)	
AIC/df	2.549				
BIC/df	2.803				
Likelihood χ2	5.056		.282		
Constant		**8.28**	**.004**	**-0.235**	**8.284**
Gender		1.57	.211	0.935	1.563
Mileage		1.31	.253	1.16E+00	1.307
Driving Motivation		0.91	.341	0.359	0.908
STAI		0.14	.706	0.337	0.142

Fright		Wald χ^2	Sig.	CI (95%)	
AIC/df	2.817				
BIC/df	3.014				
Likelihood χ2	1.305		.806		
Constant		8.28	.086	0.06	2.944
Gender		1.57	.430	0.645	0.622
Mileage		1.31	.404	3.30E-01	0.696
Driving Motivation		0.91	.311	0.121	1.025
STAI		0.14	-950	0.205	0.004

Gender was coded with female = 0, male = 1

Bold χ^2-Values are significant at $p < .05$

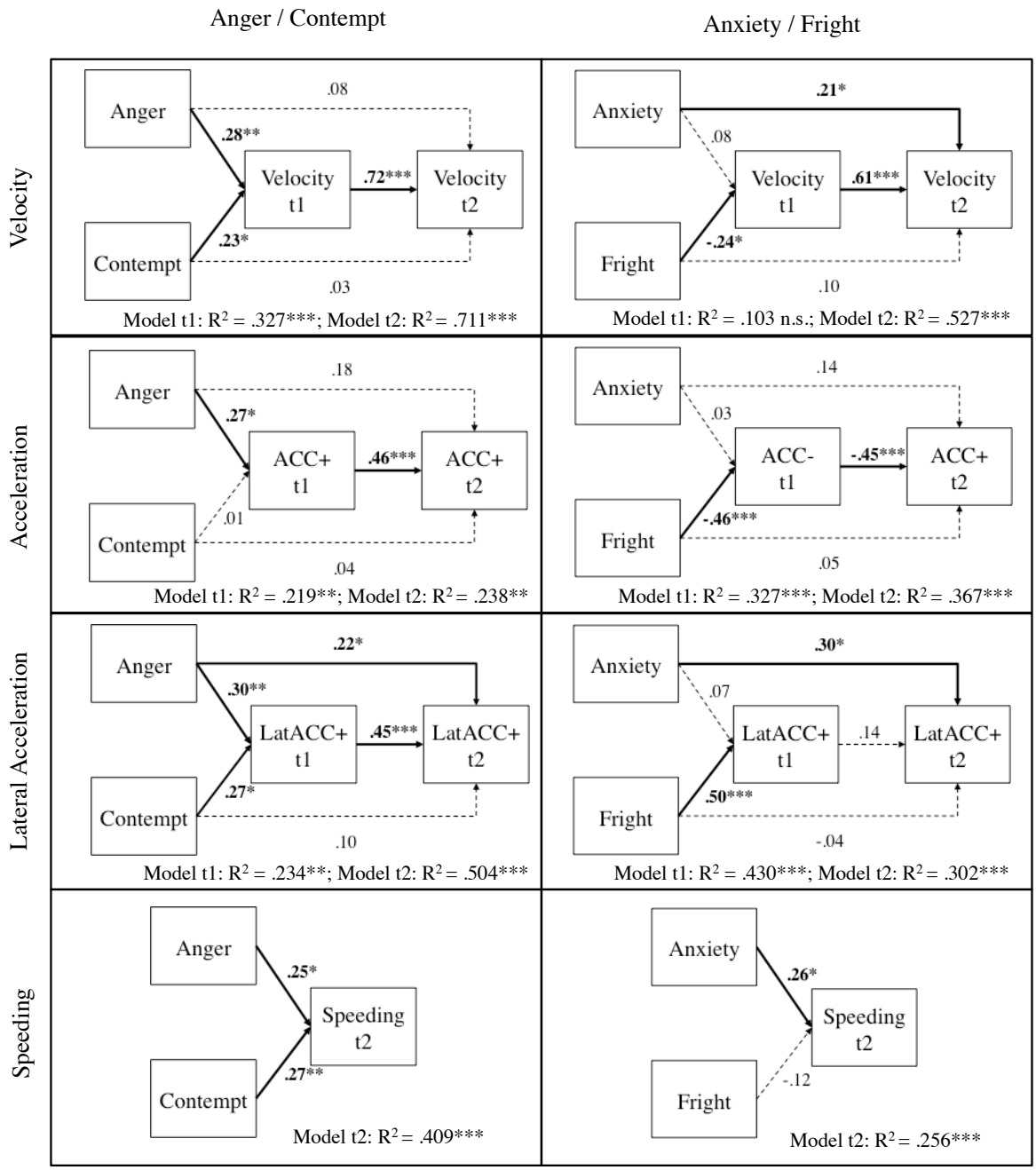
3.3.4 Emotions and Driving Behaviour

In the next step, the self-reported emotions were related to the driving parameters of the participant by employing a multiple linear regression. As independent variables, the experienced emotion of interest, the emotion from the same domain (anger with contempt / anxiety with fright; all dichotomized at the median), gender, driving experience, driving motivation and the associated trait-emotion-questionnaire (DAS for anger and contempt / STAI for anxiety and fright) were inserted. The dependent variables were the specific longitudinal and lateral driving parameters: scenario 1-3 focussed on acceleration (m/s^2) directly after the impeding event (slow car, construction site, braking car) and those values were summed up. Scenario 4 focussed on the strength of braking (m/s^2) after the confrontation with the obstacle. In all scenarios, the impact of the emotions on the velocity (km/h) and lateral acceleration (m/s^2) directly after the event and in the neutral zone were evaluated. Speeding behaviour was only analysed in the neutral zone because the critical event forced the participants to slow down in the first place. Two time frames were analysed: the first 500m after the critical event (t1) and a subsequent neutral zone, which consisted of several road sections with an overall length of 2000m (t2). To account for the high correlations between driving patterns directly after the event and in the neutral zone multiple regressions were employed: (1) with the complete set of predictors and the driving indicator at t1 as dependent variable and (2) with the same set of predictors (including t1) and t2 as dependent variable. As the results indicate, anger, contempt, anxiety and fright had an effect during the experiment (Figure 3, 4 and 5).

People who experienced more anger drove faster (standardized coefficient β = .28, t(73;6) = 2.71, p< .009) directly after the event (Figure 3 and 4). But heightened anger did not explain additional variances of speed in the neutral zone (β = .08, t(73;6) = 0.94, n.s.) and previous velocity was the strongest predictor here (β = .72, t(73;6) = 9.15, p< .001). The same pattern of influence was true for acceleration: higher anger scores lead to stronger acceleration directly after the event (β = .27, t(73;6) = 2.28, p< .023), but not necessarily during t2 (β = .18, t(73;6) = 1.12, n.s.). Lateral acceleration was

positively influenced by anger intensities at t1 (β = .30, t(73;6) = 2.11, p< .038) and t2 (β = .22, t(73;6) = 2.29, p< .025). Furthermore, participants who reported stronger anger violated the speed limit for a longer period of time (β = .31, t(73;6) = 2.78, p< .007). Contempt had similar effects compared to anger and people reporting high levels of contempt had higher speeds, stronger lateral acceleration and showed more speeding behaviour. Due to the relatively low levels of contempt compared to anger during the experiment, the effects were not as strong. They became significant for velocity directly after the event (β = .23, t(73;6) = 2.33; p< .023), lateral acceleration (β = .27, t(73;6) = 2.13; p< .023) as well as speeding behaviour at t2 (β = .27, t(73;6) = 2.48; p< .016). Anger and contempt didn´t show any significant correlation in this study (r = .17; ns).

Anxiety and fright were experienced more intensively in Scenario 4 (obstacle on street) and influenced driving parameters in a sequential way (Figure 3 and 5): high fright scores rapidly affected driving speed (β = -.24, t(73;6) = -2.05, p< .045), braking behaviour (β = -.46, t(73;6) = -4.55, p< .001) and lateral acceleration directly after the event (β = .50, t(73;6) = 4.78, p< .001) but not in the neutral zone (βs ranging from -.04 to .10, n.s.). Speeding, which was only assessed for the neutral zone was not affected by fright intensities either (β = -.12, t(73;6) = 1.12, n.s.). Anxiety intensities did not affect any of the driving parameters directly after the event (βs ranging from .01 to .04). But within the neutral zone, anxiety was effective and changed the driving behaviour – often to the worse. Highly anxious drivers showed higher overall velocities (β = .21, t(73;6) = 2.50, p< .014), lateral acceleration (β = .30, t(73;6) = 2.29, p< .025) and speeding (β = .26, t(73;6) = 2.43, p< .018). Anxiety and fright were not significantly correlated which each other (r = .20; ns).

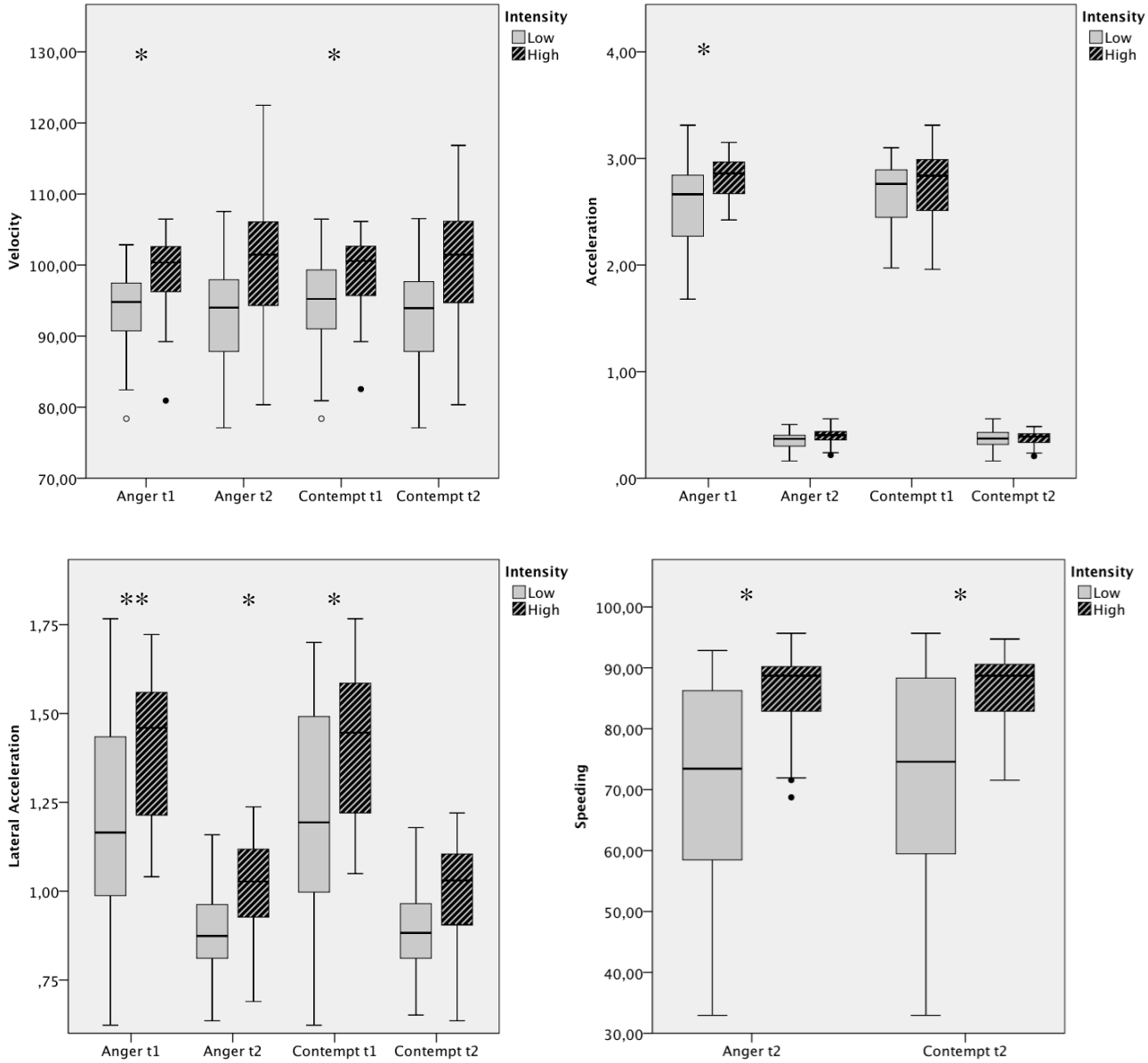


Standardized β-Values are obtained through multiple linear regressions, controlled for driving motivation, driving experience, gender, DAS (Anger and Contempt), STAI (Anxiety and Fright)

Anger and contempt were tested for scenario 1-3, anxiety and fright in scenario 4

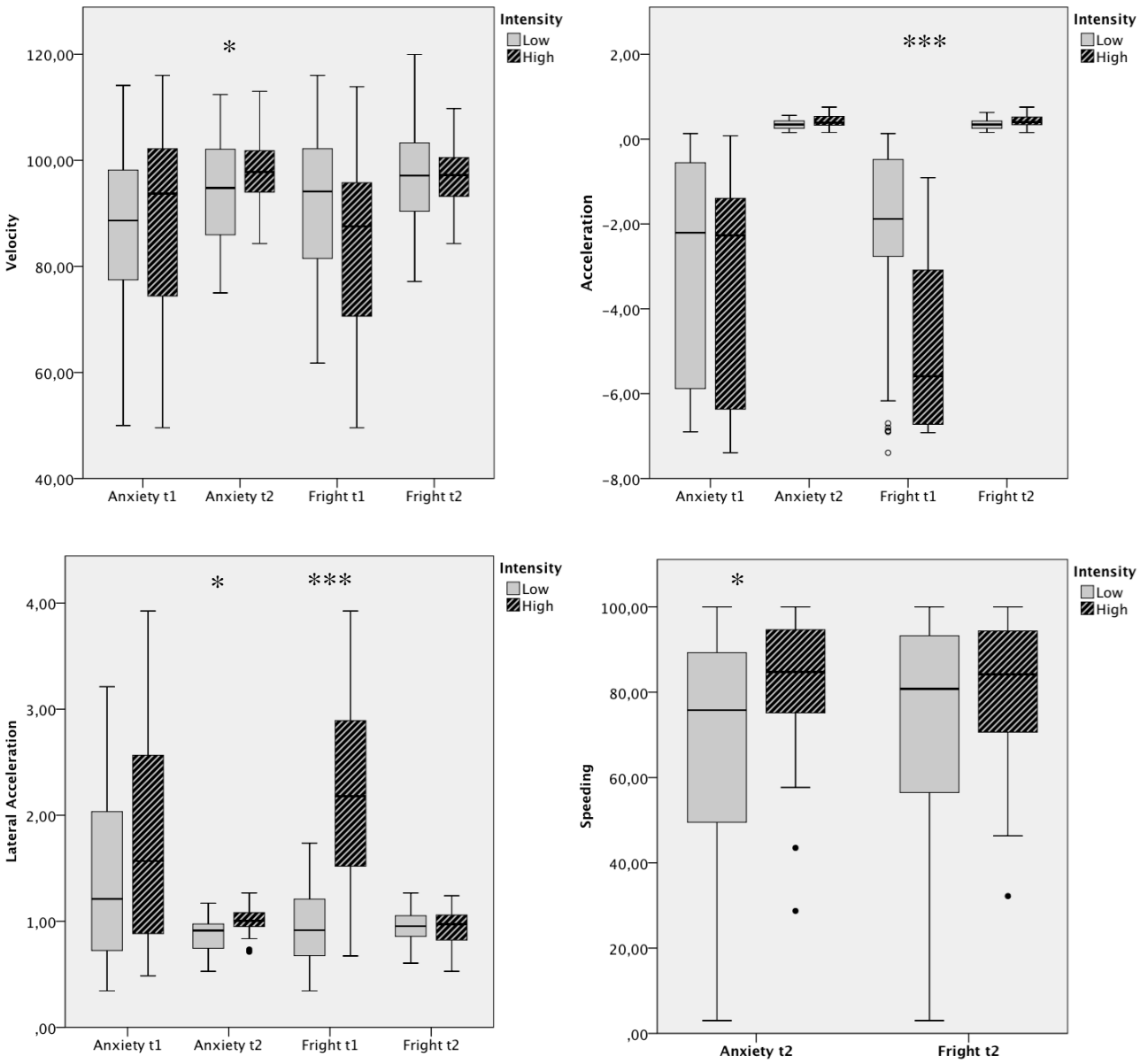
* p< .05; ** p< .01; *** p< .001

Figure 3: Influence of Anger / Contempt and Anxiety / Fright on driving parameters directly after the event (t1) and in the neutral zone (t2).



** p < .05; ** p < .01; *** p < .001*
Anger and contempt are tested for scenario 1-3

Figure 4: Means of driving parameters during t1 (after the event) and t2 (neutral zone) clustered by anger and contempt.



** p < .05; ** p <.01; *** p < .001*

Anxiety and fright are tested for scenario 4 only

Figure 5: Means of driving parameters during t1 (after the event) and t2 (neutral zone) clustered by anxiety and fright

3.4 General Discussion and Conclusion

The present study was designed to observe the effect of specific emotions on driving behaviour. Therefore, based on an appraisal framework of emotion, four scenarios were created and tested in order to observe whether behavioural changes occur due to elicited emotions. The analysis of the

emotional pattern revealed that anger, contempt anxiety and fright could be elicited during the test drive. However the mapping of the emotions on the factorial structure of the theoretical model did not perfectly meet the theoretical assumptions: contrary to the literature, anger in particular was similarly strong in both goal blocking *and* goal promoting situations but the latter should elicit stronger anger experiences (Smith & Lazarus, 1993). Several mechanisms might explain this finding. Firstly, the mere presence of another cars interacting with the participant, were sufficient to elicit anger. This is emphasized by the fact, that in three out of four scenarios, other traffic participants were at least partly responsible for the (negative) change in the situation. Secondly, the goal-obstacle factor did not have sufficient contrast: both classes of situations were very similar in order to standardize the narrative structure of the event, which resulted not in obviously promoted but *less* blocked goals for the driver. For instance, participants had to wait a short time at the construction site even in the goal congruent condition. The fact that the participant had to wait (regardless of length of time) was sufficient to elicit measureable anger levels. The experience of anger in arrival *and* safety related goals could be explained as due to near accidents caused by another driver eliciting an anger reaction (Underwood et al., 1999). One reason might be the connection between control and anger. As long as the participant had the feeling of control (which was possible due to the low degree of difficulty) anger rather than anxiety is prevalent and shapes subsequent behaviour (Berkowitz, 1993). Contempt was especially stronger when another person was involved during the traffic situation and there was no effect when no other driver was present. This is concordant with the findings of Roidl and colleagues (2013). Anxiety was elicited the most during safety-related situations with no other driver to blame. This is in line with the general literature (Lazarus, 1991; Kuppens et al., 2003) and the specific findings of Mesken et al. (2007), who found traffic-related anxiety particularly in situations, where no specific traffic participant was responsible for the change in the situation. The personal characteristics were mainly not linked to any emotional experience. This is at least partly contrary to the literature: a connection between anger, age and driving experience could be observed on a regular basis, but the findings for gender are mixed (Hauber, 1980; Herzberg, 2004; Britt & Garrity, 2006). Furthermore trait anxiety as measured with the STAI is expected to go along with higher levels of experienced anxiety, but this was not the case in this experiment. This might be due to the sample employed for our study: mainly students and less experienced drivers took part, which could be the cause for range restriction effects (Hunter, Schmidt & Le, 2006) and therefore underestimated relations between the sample characteristics and elicited emotions.

Anger, contempt, anxiety and fright were important emotions influencing driving behaviour in various ways during the traffic situations: immediate effects due to reported anger or fright include changes in acceleration and velocity directly after the emotion eliciting sequence. Furthermore, long lasting effects were significant: especially anxiety was related to higher velocity and more speeding. The driving performance of people scoring high on anger and anxiety was generally worse. These findings are partly supported by the relevant literature, showing similar relationships between anger and maladaptive (simulated) driving (see for an extensive review Nesbit et al., 2007). One reason

might be a change in risk perception, assessing less danger in a situation and, therefore, influencing behaviour (Mesken et al., 2007). Anxiety was expected to have a positive effect on those basic driving patterns due to fearful evaluations (Lerner & Keltner, 2001; Lerner, Gonzalez, Small, and Fischhoff, 2003) but the opposite could be observed. The consistency of the deviance from the expected pattern is concordant with the findings of Cai & Lin (2011) and Fairclough and colleagues (2006), who found that experiences of negative valence and high arousal like anxiety emotions cause more errors related to vehicle control as well as more traffic violations and slower braking reaction times. The explanation might be selective attention for the (imagined) emotional object, which is distracting and impairs the ability to concentrate on relevant tasks at hand like proper driving on a road (Johnston & Dark, 1986). Fright was correlated with stronger braking and reduced speed directly after the event, which indicates the adaptive component of emotions, and the ability to shape adequate behaviour during critical driving situations. On the downside, lateral driving parameters were affected in a negative way, with stronger lateral acceleration. However, due to the experimental design (and the subsequent emotional assessment) it was not possible to determine whether fright emotions were triggered by the obstacle on the road, the driving behaviour (braking, evasive action) or a combination of both.

Interestingly, while anger could explain variations in driving patterns directly after the event anxiety showed its influence only in the neutral zone. This finding does not mean that anger lost its impact after 500m completely but rather that the driving behaviour was maintained throughout the neutral zone. It remains unclear whether the driver was still angry because the emotional assessment after the experiment was always related to the critical situation itself. Verduyn and colleagues (2009) reported a median duration of 22 minutes for one anger episode in everyday life. To enter the neutral zone took a fraction of this time which makes it possible that the anger emotion – even if it occurred in a simulated environment – was still active. Focussing on the influence of anxiety there is a clear gap between elicitation in the critical event and the variations of velocity, speeding and lateral acceleration even 2000m after the event. One explanation might be that fright and anxiety were activated in a sequential way and the participants needed some time to recover from the event and the feeling of fright. The deliberative thinking about the event and anxiety-related cognitions (e.g. imagination of a crash) were triggered later on. Those thoughts (which were remembered after the experiment) might have triggered the anxiety emotion (Barrett, 2006) shifting the attention focus away from the road (Fairclough et al., 2006; Levis & Lindner, 1997) and therefore changing driving patterns to the worse. But not every frightened driver reports anxiety and vice versa (correlations were low throughout the experiment) which makes it difficult to describe both as interconnected feelings.

The limitations of this study were threefold. First, only four scenarios in a within-subject design were experienced by the participants. Real traffic is more complex with a much greater variety of situations. The appraisal framework should represent a comparable and transferable structure to explain the occurrence of certain emotions in specific traffic situations. This goal was partly accomplished but the framework has much more potential to analyse other situations. Therefore further investigation with other appraisal factors is needed. The second limitation was that this

experiment gives no explanation for *why* emotion changes driving behaviour. In their study, Mesken et al. (2007) reported findings that anger / anxiety change individual risk assessment, which could in turn explain differences in vehicle speed or lateral position. On the other hand, Stephens and Groeger (2009) did not find any differences between anger and threat evaluations. Therefore, the link between emotion and risk assessment might be highly dependent on the given situation. In the present study, the assumptions were derived directly from the driving patterns and not from verbal reports. This was in order to minimize the interaction with the participant and, therefore, prevent a shift towards a certain (behavioural) direction by consciously making them aware of the emotion-risk relationship. Third, the reported emotions were very weak and the emotional assessment was only given once for each scenario as an overall-statement. Only two out of five measured emotions were stronger than 1 (on a 1-5 scale). Furthermore, participants were exposed to simulated events (with no human opponent) and no reward or punishment was related to goal attainment. Therefore, a lack of motivation and perceived risk might have been the consequence. Although, simulator studies from Stephens and Groeger (2009) or Deffenbacher and colleagues (2003) reported consistent relationships between state anger and increased speeds in different driving scenarios Schwebel, Severson, Ball & Rizzo (2006) did not find any relationships between anger reports and driving speed in a driving simulator study. Furthermore, in the domain of driving anger and aggressive driving, method variance might be existent between self report measures and driving simulators which is indicated by smaller effects of the latter one (Nesbit et al., 2007). This lack of effect seems to be the problem in many laboratory situations and suggests that by eliciting stronger emotions in a simulated traffic situation, we could observe greater changes in driving behaviour, approximating real life. This would allow us to explain the relationship between emotion and behaviour more precisely. Furthermore, a higher temporal resolution of emotional assessment would it make possible to explain the relationship between reported feelings of anger and anxiety and driving behaviour in different sections on the road. These topics are closely related to the problems of determining absolute validity in simulator research. To what extent are the emotional reports and behaviours similar to those experienced in real traffic situations? The first problem could be resolved with more research where additional psychophysiological measures of emotion such as heart rate or electrodermal activity are employed to get a more complete picture of activation and emotional valence of the participant in different traffic settings. The second problem could be tackled with the transfer of the simulator scenarios into real traffic, which could demonstrate the similarity between those settings. This procedure raises new questions about the composition of controlled critical situations in real traffic and how to implement them in a feasible research design. This might not be necessary to this extent: researchers such as Blana (1994) and Bella (2008) compared driving behaviour in simulated and real traffic situations and found strong relationships between both. Furthermore, Mesken and colleagues (2007) showed in a real drive setting that experienced anger in goal blocking situations leads to higher speeds. These findings are concordant with the results in this paper. Therefore, a strong indication exists that simulated behaviours are transferable to real traffic conditions. Nevertheless, much more research is needed to

describe the nature of emotion elicitation and influenced driving behaviour. Additional research should also assess the necessary general conditions of simulator experiments (e. g. low vs. high fidelity simulators), to enhance comparability with real drive environments and improve external validity.

In conclusion, this study definitely shows that anger, anxiety and fright had significant influence on several aspects of driving behaviour in various simulated traffic situations. In the case of anxiety this influence continued even two and a half kilometres after a critical emotion-inducing event.

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4. Introducing a Multivariate Model for Predicting Driving Performance: The Role of Driving Anger and Personal Characteristics

This article was submitted to the Journal of Safety Research in October, 2012.

Abstract

Maladaptive driving is seen as one important source of self-inflicted accidents. It is defined by high speeds, speeding violations and poor lateral control of the car. The literature suggests, that certain groups of drivers such as novice drivers, males, highly motivated drivers and those with a high frequency of experienced anger in traffic situations tend to show more maladaptive driving patterns than others. Remarkably, until today there is no coherent framework describing the relationship and distinct influences of those factors. We therefore conducted two studies with the aim of creating a multivariate model which combines those factors, describes their relationship and predicts driving performance more precisely. Each study had a different technique to elicit emotion and a different track design in order to explore the driving behaviour of the participants in potentially anger-provoking situations. Study one induced emotions with short film-clips. Study two confronted the participants with potentially anger-inducing traffic situations during the simulated drive. In both studies, participants who experienced high levels of anger showed higher speeds and a stronger longitudinal and lateral acceleration. Furthermore multiple linear regressions and path-models revealed that highly motivated male drivers displayed the same behaviour independent of their emotional state. The results indicate that anger and specific risk characteristics lead to a maladaptive change in important driving parameters and drivers in this group are prone to experience more anger while driving, which further worsens their driving performance.

Keywords – emotions, driving anger, driving motivation, driving performance, risky driving

4.1 Introduction

Driving at high speeds is one example of risky and aggressive driving (Dula & Geller, 2003), a phenomenon, which has become prevalent on streets worldwide in recent years (Deffenbacher, Deffenbacher, Lynch & Richards, 2003; Paleti, Eluru & Bhat, 2010; Stradling & Parker, 1997). The American Automobile Association estimates that more than half of all fatal crashes between 2003 and 2007 were due to risky and aggressive driving behaviour (AAA Foundation for Traffic Safety, 2009). They identified maladaptive speed, responsible for 31% of incidents, as the most prevalent cause of fatal crashes. In Germany, almost 400,000 people were involved in traffic accidents in 2010 and 4,000 lost their lives (Destatis, 2012) and maladaptive speeds were held accountable for over 26% of vehicle crashes. For example, driving too fast can lead to a reduced safety distance from other traffic participants, decreasing reaction times or leading to a loss of control over the car. Those traffic reports usually do not allow any conclusions about the motivational or emotional state of the driver. Shinar (1998) defines two different states of unsafe driving behaviour; in the “cold”-state drivers demonstrate maladaptive driving such as driving at high speeds or violating the speed limit in an instrumental way to overcome obstacles and accomplish their goals without intending to harm others. On the other hand, drivers in a “hot”-state are prone to behave aggressively towards other traffic participants (Shinar, 1998). Both states can involve tailgating, running red lights and cutting other drivers off, but only the latter incorporates the clear intention to do harm (Dula & Geller, 2003, Lajunen, Parker & Stradling, 1998; Ellision-Potter, Bell & Deffenbacher, 2001). This diverse understanding of behaviours and motivational and emotional states leads to communication problems between researchers and slows down progress in the traffic psychology domain (Dula & Geller, 2003; Reason, Manstead, Stradling, Baxter, Campell, 1990). Dula & Geller (2003) suggested the term dangerous driving be defined as a construct with three dimensions: risk-taking, intentional acts of aggression toward others and negative emotions experienced while driving. The relations between these dimensions and their impact on driving safety are manifold. Risk taking can incorporate high speeds, strong acceleration and poor lateral control, and might be intensified by negative emotions such as anger and / or frustration. In traffic, the influence of anger and risk taking on higher speeds and stronger acceleration has been shown in a series of studies (Deffenbacher et al., 2003; Matthews et al., 1998; Mesken, Hagenzieker, Rothengatter & DeWaard, 2007; Stephens & Groeger, 2009). Aggressive acts of driving are also related to the emotions of frustration and /or anger and, usually, to intentional acts against other road participants, with gestures, honking and giving chase added to the repertoire. For the purpose of this paper, the focus is laid on the risky driving patterns of velocity, speeding and longitudinal as well as lateral acceleration (see Stephens & Groeger, 2009), which are labelled as maladaptive driving parameters.

Research suggests that driving related anger is an important negative emotion which can fuel risky driving such as at high speeds and/or speeding (Björklund, 2008; Deffenbacher et al., 2003; Lajunen & Parker, 2001; Nesbit, Conger & Conger, 2007). But other variables, such as driving experience, gender (Björklund, 2008; Dula & Ballard, 2003; Ferguson, 2003; Laapotti & Keskinen,

2004; Mesken, Lajunen & Summala, 2002) and driving motivation (Philippe, Vallerand, Richer, Vallières & Bergeron, 2009) can also lead to similar driving patterns. To our knowledge there is no empirically tested model which combines those variables and reveals the interaction and distinct impact of personal characteristics, driving related anger and key indicators of safe driving performance. To create and validate such a model, two simulator studies were conducted. The core elements of our model are a) the impact of anger on key risky driving parameters (velocity, speeding, longitudinal and lateral acceleration), b) the influence of personal characteristics on anger experiences in traffic situations and c) the impact of personal characteristics on maladaptive driving parameters independent of anger. The following sections review the literature and show the key findings of the specific core components. The lack of any research which examines the interaction of these elements underlines the necessity for a coherent model

Anger and Risky Driving

Unlike emotional and hostile aggression in driving situations, which is fed by strong emotional states and focuses on harming other traffic participants (Shinar, 1998), risky driving patterns often lack accompanying emotion or intention to harm. Nonetheless, studies indicate a consistent relationship between anger and specific risky driving behaviour in traffic (e.g., Dahlen & White, 2006; Deffenbacher et al., 2003). Most importantly it can influence an increase in speed (Deffenbacher, Lynch, Oetting & Yingling, 2001; Matthews et al., 1998; Underwood, Chapman, Wright & Crundall, 1999), traffic violations (Maxwell, Grant & Lipkin, 2005; Sümer, 2003) and more generic risky behaviour such as driving recklessly or acting carelessly when other people are in the car (Deffenbacher et al., 2001). These behaviours can increase the risk of crashes and endanger other road participants (Chliaoutakis et al., 2002; Deffenbacher et al., 2003; Underwood et al., 1999). Generally speaking, there is a moderate relationship between anger and risky driving, which is most often described with broad behaviours (e.g. reckless or drunk driving) and less often in terms of the specific driving patterns. Therefore, real driving and simulator studies are necessary to assess driving parameters such as speed adequately (Matthews et al., 1998; Mesken et al., 2007). Stephens & Groeger (2009) added means and standard deviations of longitudinal and lateral acceleration, lateral position, steering wheel, throttle and brake input to the predicted parameters. They revealed a consistent relationship between high anger levels and increased values for most of those variables.

Personal Characteristics and Anger

To describe the factors influencing anger in traffic environments more precisely, the personal characteristics of the driver have to be taken into account (Mesken, Lajunen & Summala, 2002). Driving experience measured in total or yearly mileage shows inconsistent patterns as a predictor of anger and is strongly dependent on gender (Lajunen & Parker, 2001). In a study by Björklund (2008) driving experience had an influence on driving anger levels in situations with reckless driving or direct hostility of others, but only for female participants. In male populations there was no effect altogether of mileage on the anger experienced (Björklund, 2008). The gender of the participants can influence

anger-reactivity in various situations (Blows, Ameratunga, Ivers, Lo & Norton, 2005): men report more anger when they are impeded by other drivers (Deffenbacher, Oetting & Lynch, 1994), women are more angered when they are confronted with direct hostility, illegal actions of others or traffic obstructions (Parker, Lajunen & Summala, 2002). Combining these findings, there seems to be a strong situational component in the relationship between anger, driving experience and gender.

A more constant link exists between trait related anger and the actual anger experienced in traffic situations, 'state anger' (Deffenbacher, Huff, Lynch, Oetting & Salvatore, 2000; Deffenbacher et al., 2001). People show different tendencies to become angry in traffic, for example in frustrating or provoking situations (Deffenbacher et al., 2003). Subsequently, a high trait anger leads to experiencing more and intensified anger in those situations compared to drivers scoring low on trait anger (Spielberger, 1988). This disposition to become angry in traffic is a construct labelled trait-driving anger which is often measured with the driving anger scale (DAS, Deffenbacher et al., 1994).

Another important determinant of anger while driving is driving motivation. When driving starts to play a role in personal identity of traffic participants and this becomes an obsessive passion which controls their actions, it can lead to more and intensified driving behaviour (Philippe et al., 2009). These highly motivated drivers tend to experience negative emotions such as anger in goal-blocking situations (e. g., impeded progress on the road or erratic driving of others) more often and more intense (Philippe et al., 2009).

Personal Characteristics and Risky Driving Parameters

Besides the relationship between personal characteristics and driving anger, some evidence indicates a direct influence of personal characteristics on risky driving patterns without driving anger (Fisher et al., 2002; Krahé & Fenske, 2002; Reason et al., 1990). Males drive faster than women in traffic, which could increase the frequency and severity of accidents. One important reason for that behaviour are different risk homeostasis levels, which increase risk taking behaviour in men and could in turn lead to higher speeds and more traffic violations in general (Laapotti & Keskinen, 2004). Furthermore male drivers overestimate their driving skills, which could lead to higher speeds and to a greater involvement in a greater share of motor vehicle accidents (DeJoy, 1992; Ulleberg, 2001; Yagil, 1998).

The findings for the impact of driving experience on (maladaptive) driving performance are more complex (Lonero, 2008). There is a consensus that constant exposure to traffic (operationalized with miles per year) shapes the mental model of the driver and improves the ability to detect hazards (McKnight & McKnight, 2000) and assess risks (Ferguson, 2003). This leads to more adaptive driving behaviour. Therefore, experienced drivers do not encounter as many critical situations per kilometre as novice drivers and react more appropriately if such situations arise. This reduces the probability of crashing (Laapotti, Keskinen, Hatakka & Katila, 2001). On the other hand a better understanding of the traffic environment can lead to higher speeds and more traffic violations (Björklund, 2008; Laapotti & Keskinen, 2004), which is a risk factor for other traffic participants.

There is no research to date which explicitly addresses the relationship between driving performance and motivation to drive, with the exception of aggressive behaviour while driving (e.g., swearing and hostile gestures) due to intensified anger in persons with an obsessive passion to drive (Philippe et al., 2009). There is some evidence, though, that young males differ in their motives and attitudes compared to older drivers and females. For the latter driving cars is more instrumental (e.g., to reach a destination or to transport goods), whereas for young males driving is a means to express and assert themselves, and they therefore display higher speeds to gain admiration from their peers (Laapotti & Keskinen, 2004).

Taken together, the findings of past research indicate that there is a strong relationship between anger and driving parameters such as velocity and acceleration. This anger is influenced by personal characteristics such as gender, driving experience and driving motivation. But there are shortcomings in the in the literature about the relationship between those personal characteristics, experienced anger and driving behaviour. The aim of this research was therefore to disentangle the influences of personal characteristics and experienced anger on driving performance within a simulated driving environment. Therefore, a model was created where all relevant influences on driving performance are examined and – as a consequence – the distinct impact of every single factor is revealed. Based on the reviewed literature, relevant influences are driving motivation, driving experience, gender, trait and state anger.

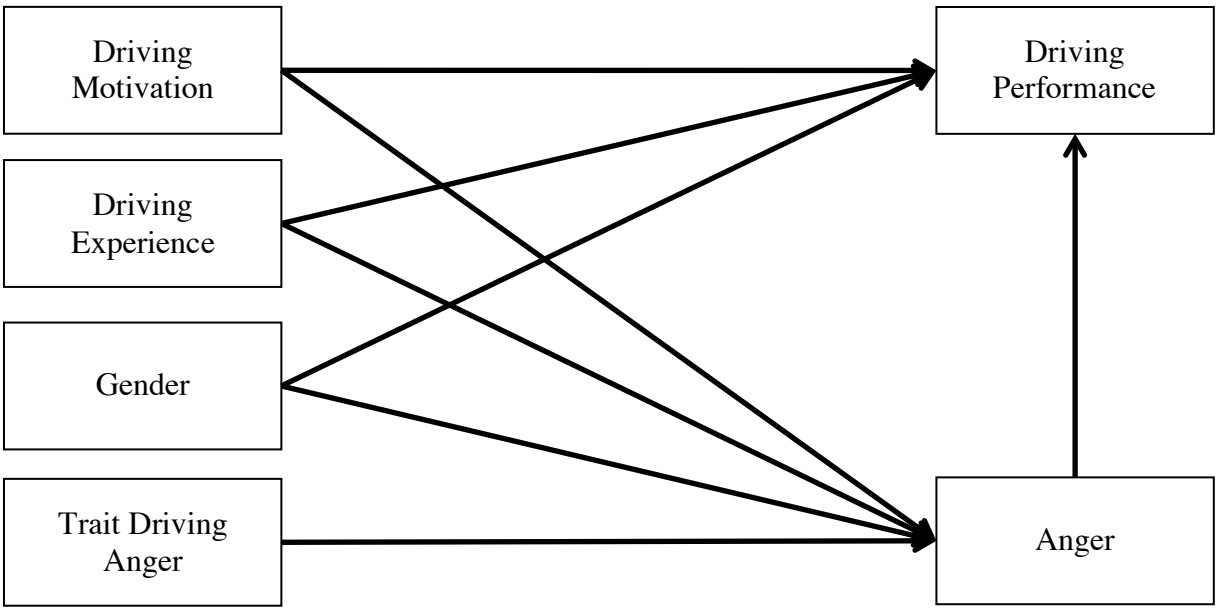


Figure 1: Proposed driving model of personal characteristics, anger and driving performance

4.2 Study 1

The lack of any existing cohesive model led to an explorative approach for the first study. Therefore, the aim was to investigate the relation between the emotion of anger, personal characteristics and driving behaviour in a simulated driving environment. To induce anger in participants, emotion inducing film clips were presented before the experiment. This is considered the most effective method to elicit discrete emotions (Hewig et al., 2005; Westermann, Spies, Stahl & Hesse, 1996; Schaefer, Nils, Sanchez & Philippot, 2010) Participants experiencing strong anger were expected to drive faster, accelerate stronger and demonstrate more speeding. The same impact on driving parameters is expected with lack of driving experience, high driving motivation, and being male. To test these assumptions for the multivariate model, various traffic scenarios were designed. To account for the important driving parameters, means of longitudinal (speed and acceleration), lateral variables (lateral acceleration) and traffic violations (speeding) were assessed.

4.2.1 Method

4.2.1.1 Participants

In the first study N = 74 drivers (60.5% female), recruited on the university campus, took part. Their age ranged from 18 years to 31 years (M = 20.70; SD = 2.88) and the average duration of driving license possession was M = 3.12 years (SD = 2.85). Average yearly mileage was at M = 4,610 km (SD = 10,320 km), total mileage at M = 20,600 kilometres (SD = 62,800km). Participants were compensated for their participation with a small present worth 15 Euro.

4.2.1.2 Stimulus Material

The experimental track was 5,000 m long and consisted of three distinct, mostly rural environments with a general middle European appearance (signs, traffic rules, vegetation). The sequence of the sections was fixed. First, a 2,700 m country road with several curves and a driver ahead who could not be passed for 1,000 m was completed. The participant then entered a village with a 50 km/h speed restriction. After the village, another rural section began with a construction site narrowing the road for about 300 meters. The speed limit by the construction site was 60 km/h.

4.2.1.3 Design

Participants were randomly assigned to one of two groups, ‘neutral’ or ‘emotional’. The neutral group was shown a film-clip of about 70 seconds without emotional content, taken from “All the President’s Men” (Pakula, 1976). The emotional group saw a film clip of about 110 seconds that had anger-inducing content, taken from “Schindler’s List” (Spielberg, 1993). The film-clips were shown before

the drive on the experimental track. They were chosen from a database of emotion-inducing film clips for their ability to elicit strong discrete emotions (Westermann et al., 1996; Schaefer et al., 2010). The two film-clips used in this experiment are evaluated in regard to their ability to induce no emotion (neutral group) and anger (emotional group) (Hewig et al., 2005; Schaefer et al., 2010).

4.2.1.4 Apparatus

The study was conducted with the driving simulator StiSim W100 from System Technology Incorporated. A Volkswagen Golf cockpit with original steering wheel and instrument panel was used to control the car. During the simulation the StiSim W100 registered all driving activities, i.e., velocity, accelerating and lateral position.

4.2.1.5 Experimental Measures

An adjusted Geneva Emotion Wheel was used as a questionnaire (GEW, Scherer, 2005; Oehl, Roidl, Frehse, Suhr, Siebert et al., 2010). It covers 16 emotions that are frequent in driving contexts. The participants were asked to rate the different emotions within each road section on a Likert-scale ranging from 1 (weak emotion) to 5 (very strong emotion). To investigate the influence of personal characteristics, trait driving anger was measured with a German version of the Driving Anger Scale (DAS; Deffenbacher et al., 1994; Steffgen, Recchia & Ludewig, 2008). It includes 33 items, which measure six subscales: “hostile gestures”, “illegal driving”, “police presence”, “slow driving”, “discourtesy”, and “traffic obstructions”. To assess driving motivation, two items were presented (‘I really like to drive‘ and ‘Driving is important to me’), which were rated on a five-point Likert-scale (1 = not at all; 5 = very much). Age, gender and mileage (kilometres per year) completed the measurement of personal characteristics.

The driving patterns of the participants were recorded throughout the experiment and velocity (km/h) and acceleration (m/s^2) as well as lateral acceleration (m/s^2) were assessed as means (see Stephens & Groeger, 2009). These parameters are recognized as sensitive performance measures in traffic situations (Bouchner, 2006). Driving violations were represented in the form of speeding during the rural (100km/h and 60km/h restricted) and village (50 km/h restricted) sections. The amount of the track covered at illegally high speeds was expressed in a %-share of the whole track.

4.2.1.6 Procedure

At the beginning all participants completed a questionnaire providing personal characteristics and driving history. Three training scenarios were prefixed to the actual driving task so the participants could get used to the steering behaviour and graphical environment of the simulator. Immediately after the training, the group-specific videos were shown for the anger and neutral groups. After the experimental drive, the questionnaire on driving related anger (DAS) was handed out, and during the

experiment participants rated their discrete emotions on the GEW after each section (rural, village, highway).

4.2.2 Results

4.2.2.1 Occurrence of Reported Drivers' Emotions and Personal Characteristics

After inducing the neutral or anger emotion in participants, a manipulation check with the GEW was performed. The anger group reported significantly stronger anger directly after the movie (M = 3.69; SD = 3.16) than the neutral group (M = 0.74; SD = 1.77; $F(1;72) = 24.72$; $p < .001$). But this difference disappeared later in the experiment: In the anger group, anger decreased to M = 0.94 (SD = 1.92) on the rural road, M = 0.89 (SD = 1.91) in the village and M = 1.20 (SD = 1.93) on the highway. At the same time, anger levels of the neutral control group remained relatively constant or were even higher at M = 0.82 (SD = 1.84), M = 1.47 (SD = 2.32) and M = 1.00 (SD = 1.74), respectively (all F-Values for group comparison were not significant anymore and ranged between 0.242 and 0.938). The average mean for driving motivation was M = 3.69 (SD = 0.85), DAS-scores were at M = 3.20 (SD = 0.47).

4.2.2.2 Determinants of the Drivers' Emotion: Personal Factors

The personal characteristics gender, driving experience, driving motivation, and trait driving anger were correlated with anger (Table 1). Neither the demographic variables nor trait driving anger had a significant influence on anger levels. Driving motivation was positively related on scale level ($r = .271$, $p < .019$) indicating a higher annual mileage among those who were highly motivated to drive.

Table 1: Correlations of personal characteristics and anger levels in the first study

	1	2	3	4	5
1 Anger	-				
2 Gender	-.071	-			
3 Mileage	.015	-.054	-		
4 Driving Motivation	-.059	.177	.271*	-	
5 DAS	.006	-.2	-.072	.018	-

* $p < .05$

4.2.2.3 Emotions, Personal Characteristics and Driving Behaviour

In the first part of the analysis, the reported emotions and personal characteristics were associated with the driving parameters with multiple linear regressions (Table 2). As independent variables, gender, driving experience, driving motivation and DAS-Scores were used. For anger, only the measurement points within the experiment were used, but not those from directly after watching the films. Using these reports of anger ensured a close temporal relationship to the measured driving parameters. The four different models represented the dependent variables and focused on longitudinal velocity, longitudinal acceleration, lateral acceleration and speeding which were assessed during the 5,000m drive (Table 2). It was assumed that higher levels of anger and driving motivation, as well as being male and less experienced on the road leads to a decline in good driving performance. This was defined by higher velocity, stronger (lateral & longitudinal) acceleration and more speeding.

Mean driving speeds were affected by experiencing anger, driving motivation and gender. High anger scores (β = .27, t(69; 5) = 2.47; p < .016) and motivated driving (β = .25, t(69; 5) = 2.30; p < .025) as well as male drivers (β = .27, t(69; 5) = 2.43; p < .018) added a significant amount of speed to the population mean of M = 83.15 km/h. The positive acceleration was closely related to the mean velocity with a correlation of r = .75 (p <. 001), but it had a different predictive model: Participants scoring high on anger (β = .32, t(69; 5) = 2.98; p < .004) and being male (β = .38, t(69; 5) = 3.47; p < .001), but not driving motivation, increased the acceleration significantly.

The mean velocity yielded a high correlation with speeding violations throughout the track (mean correlation r = .84; p < .001). This close relationship is only partly reflected by the predictive model for speeding. Driving motivation (β = .26, t(69; 5) = 2.34; p < .002) and gender (again, males violating the speeding restriction more often) (β = .31, t(69; 5) = 2.83; p < .001) but not anger are significant predictors of the outcome.

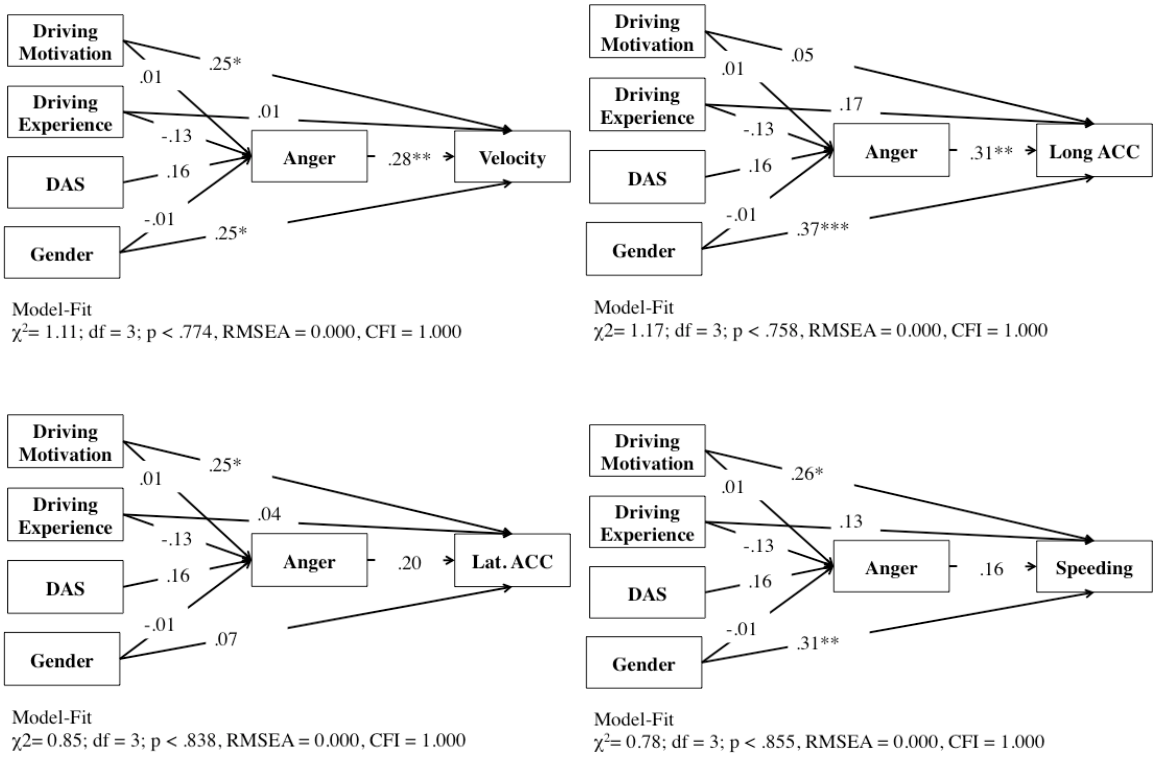
In the domain of lateral acceleration only driving motivation remained as a predictor, as the means rose with increased motivation (β = .25, t(69; 5) = 2.14; p < .036). No influence from other personal characteristics could be observed. In summary anger, driving motivation and gender were strong predictors of those longitudinal and lateral control variables (Table 2).

Table 2: Multiple linear regressions of anger and personal characteristics on driving parameters in the first study

	corr. R^2	F	df	B	β	Sig.
DV Velocity (km/h)	.233	4.132	5, 68			.006
Baseline				71.63		
Anger				**1.26**	**.27**	**.016**
Driving Motivation				**1.92**	**.25**	**.025**
Driving Experience				0	.07	.51
Gender				**3.50**	**.27**	**.018**
DAS				0.89	.06	.558
DV Acceleration (m/s^2)	.241	4.316	5, 68			.002
Baseline				0.38		
Anger				**0.04**	**.32**	**.004**
Driving Motivation				0.01	.05	.643
Driving Experience				0	-.02	.873
Gender				**0.12**	**.38**	**.001**
DAS				0.02	.07	.525
DV Lateral Acceleration (m/s^2)	.120	1.87	5, 68			.152
Baseline				0.12		
Anger				0.01	.19	.099
Driving Motivation				**0.02**	**.25**	**.036**
Driving Experience				0	.04	.724
Gender				0.01	.07	.536
DAS				0.01	.04	.753
DV Speeding (%-share of track)	.224	3.93	5, 68			.007
Baseline				24.96		
Anger				2.02	.16	.145
Driving Motivation				**5.25**	**.26**	**.022**
Driving Experience				0	.10	.355
Gender				**10.92**	**.31**	**.006**
DAS				0.72	.02	.861

Bold F-Values are significant at $p < .05$; Gender was coded with 0 = female and 1 = male

To further account for the influence of single personal characteristics on anger and driving performance, a structure equation model approach with AMOS 19 as the statistical tool was used (Figure 2).



* p< .05; ** p< .01; *** p< .001

Figure 2: Path Models of personal characteristics, reported anger and driving parameters in the first study.

The quality indices for all models were the comparative fit index (CFI, where a value above .90 is acceptable), a root mean square error of approximation (RMSEA, where a value below .005 indicates a close fit between data and the model) and the χ2-Value (where a non-significant value indicates a good fit between sample covariance and fitted covariance) (Bentler, 1990; Arbuckle & Wothke, 1999). Before the analysis was started, Pearson product-moment correlations and multicolinearity statistics among independent variables were calculated. The values of the conditioning index were below .20 indicating no multicolinearity.

The indices for the quality of the model fit were in the expected range: χ2-Values were between 0.78 and 1.14, CFI- and RMSEA-Values of all four models were always at the optimum (1 for CFI and 0 for RMSEA, respectively). Compared to the multiple regressions, the path models showed a similar pattern of influences from personal characteristics and anger on driving parameters. Focussing on driving motivation and gender both were positively associated with higher speeds (β = .25), more speeding violations (β = .26 and .31), longitudinal acceleration (only gender with β = .37) and lateral acceleration (only driving motivation: β = .25). Anger itself couldn't be explained

with the personal characteristics, but it had significant influence on velocity (β = .28) and speeding (β = .31).

4.2.3 Discussion of the First Study

The aim of the first study was to explore the relationships between anger, personal characteristics and driving behaviour in a simulator environment. Greater anger was assumed to lead to higher speeds and decreased lateral control. Specific demographics such as high driving motivation, a lack of driving experience and being male were predicted to influence those driving parameters in a maladaptive way. The specific emotion of anger was induced using short film-clips, which was initially successful: compared to the neutral group those who saw the anger-inducing film-clips reported about 6-times higher levels of anger. But the effect vanished quickly. After the first potentially frustrating event on the rural road (car in front of the participant), anger levels decreased to M = 0.70, indicating very low levels of subjective anger. At this point there was no difference between the neutral and the film-stimulated group anymore. One reason for this effect could be the change of contexts from watching a film-clip to driving in the simulator. This implies a change of the emotional object and might have erased the negative emotion induced by the film-clip. Another explanation for the low levels of the observed negative emotion might be that driving in a simulator can be an entertaining and exciting event. Taking this circumstance into account, both groups were taken together and the raw anger reports were analysed regardless of their experimental origin.

The results clearly indicate a repeated relation between the anger emotion experienced during the drive, personal factors and changes in driving pattern. This supports the idea of a coherent model which involves several factors, and which could in turn affect driving behaviour in various situations. Concordant to the literature drivers experiencing anger drove faster and accelerated more strongly (Deffenbacher et al., 2003; Deffenbacher, Lynch, Deffenbacher et al., 2001, Stephens & Groeger, 2009). Furthermore, highly motivated drivers as well as male participants seem to behave in the same manner, regardless of the emotion experienced. It is well-established that male drivers are prone to overestimate their driving skills (DeJoy, 1992; Ulleberg, 2001; Yagil, 1998) and misinterpret the probability of doing harm in potentially dangerous traffic situations, which could lead to higher speeds (Hennessy & Wiesenthal, 2001). The impact of driving motivation on driving performance might be mediated by anger, which was already shown by Philippe and colleagues (2009). But this is not the case in our first study because a) there is no direct relationship between driving motivation and anger and b) even controlled for the emotion, highly motivated drivers still display higher speeds and stronger lateral acceleration. This indicates that being highly motivated to drive a car can lead to stronger longitudinal and lateral driving patterns per se because these drivers might just naturally enjoy such driving or pursue other goals such as achieving a flow state when entering certain speeds.

It's interesting to see that none of the demographic characteristics interacted with the reported anger levels. This is contrary to the literature, which argues for relationships between state anger and the driving anger scale (Deffenbacher et al., 1994; Deffenbacher et al., 2003), driving motivation and

anger (Philippe et al., 2009) as well as gender, age and mileage with at least some aspects of driving related anger (Björklund, 2008, Lajunen & Parker, 2001). This was not the case here, which can be explained by the change in the object inciting the anger. In this study, we used film material that was not related to the traffic situation. After seeing the film and engaging in a driving task, anger levels weren't related to the new context anymore. Driving motivation and trait driving anger predict context specific anger, which has its cause in traffic situations but seems to fail to explain other sources of anger. This raises the question of whether the emotional object and its change during the experiment (from film to driving task) as well as the assessment of the anger emotion in the driving simulator was adequate for our cause.

Therefore a second study was set up with the primary goal to reproduce the results of the first explorative study. Furthermore, the focus of the emotional object was shifted from an external movie to the traffic situation itself, which could ensure the relationship between anger and driving behaviour patterns. The driving segments were standardized in order to make the track segments more homogenous, reduce variances in driving patterns and enhance the precision of measurement.

4.3 Study 2

4.3.1 Method

4.3.1.1 Participants

N = 80 drivers (60% female) took part in this study. The participants' ages ranged from 18 years to 52 years (M = 24.47; SD = 5.99), with an average driving experience of M = 6.49 years (SD = 5.66). They drove on average 7,870 kilometres per year (SD = 9,240) and had a total mileage of 73,980 kilometres (SD = 112,600). Participants were mostly recruited on the university campus. They were compensated for their participation with a small present worth 15 Euro.

4.3.1.2 Stimulus Material

The simulated track was a 17,120 m rural route where four critical events took place. The first situation was a construction site blocking the progress of the participant for two minutes and therefore a significant amount of time. There was no possibility to pass the construction site earlier due to steady oncoming traffic. The second situation was a car driving very slowly in front of the participant. Again, passing the car was not possible until the road broadened, which forced the participant to stay behind the car for approximately two minutes. The third situation consisted of a car in front, braking suddenly and forcing the participant to react quickly. The fourth situation was a barely secured hole in the street in a curve and the participant had to evade in order not to crash. After each scenario, a standardized section 2,200 m in length and with various curves served as the foundation for driving

behaviour analysis. Over the course of the experiment, the scenarios were presented in four different orders to control for sequence effects.

4.3.1.3 Experimental Measures

The driver was questioned about his/her emotion *after* the drive in order not to interrupt the participant and to prevent potential behavioural cues. Four pictures of the critical sections of the experimental drive were provided to help remind participants of the specific situations. Comparable to study 1, every situation was rated with a revised edition of the Geneva Emotion Wheel (GEW, Scherer, 2005; Oehl et al., 2010), covering 16 emotions suitable for the driving context and which had also been used in the first study. The participants were allowed to rate up to three different emotions within each critical situation on a Likert-scale ranging from 1 (weak emotion) to 5 (very strong emotion). The emotions were later analysed and compared with the specific driving behaviours displayed during the four critical situations. The same personal characteristics as in study one were assessed (gender, mileage as kilometres per year, driving motivation, DAS).

Driving behaviour during the 2,200m was recorded after each of the four critical situations and, as in the first study, means of velocity (km/h) and longitudinal as well as lateral acceleration (m/s^2) were assessed as driving patterns. Speeding was measured as a % of how much it exceeded the speed limit over two sections of the track (700 m zone 70 km/h and 900 m zone 100 km/h after each event).

4.3.1.4 Apparatus & Procedure

As in the first study, the StiSim 100 was used to carry out the experiment. Three training scenarios preceded the experimental drive. Directly after the experiment, the DAS was filled out and the emotions experienced were assessed using photos of the critical situations to help the participants to remember the specific situations (Gray & Watson, 2007).

4.3.2 Results

Similar to study one, the data was analysed by using correlations (between anger and personal characteristics), multiple linear regressions and path analysis using SEM.

4.3.2.1 Occurrence of Drivers' Reported Emotions and Personal Characteristics

Anger was reported M = 2.23 times (SD = 1.08) (of a maximum of four situations) during the experiment. The mean intensity of anger experienced was M = 1.65 (SD = 1.01), which indicates a low intensity (compared to the 1 to 5 possible range of the GEW) but is slightly higher than anger levels in study one (M = 1.09). The means for the DAS M = 3.19 (SD = 0.50) and driving motivation in the tested population was at M = 3.97 (SD = 0.91), respectively.

4.3.2.2 Determinants of the Drivers' Emotions: Personal Factors

As also done in study one, the personal characteristics and anger were correlated with each other (Table 3). The means for trait driving anger measured with the DAS correlated positively with anger ($r = .272$; $p < .015$). Furthermore, among highly motivated drivers more intense anger was observed ($r = .314$, $p < .005$).

Table 3: Correlations of personal characteristics and anger levels in the second study

		1	2	3	4	5
1	Anger	-				
2	Gender	-.119	-			
3	Mileage	.074	.14	-		
4	Driving Motivation	.314**	-.214	.349***	-	
5	DAS	.272*	-.196	.036	.160	-

* p<.05; ** p< .01; *** p< .001

4.3.2.3 Emotions, Personal Characteristics and Driving Behaviour

The relationship between self-reported anger and the driving parameters of the participants were analysed by employing multiple linear regression (Table 4) and SEM models (Figure 3). As independent variables, driving motivation, driving experience, gender and DAS-Scores as well as anger were used. The dependent variables were the same driving performance parameters as in study 1 (velocity, (longitudinal and lateral) acceleration and speeding), which were recorded for each 2,200 m after all four critical events.

Table 4: Multiple linear regressions of anger and personal characteristics on driving parameters in the second study

	Corr R^2	F	df	B	β	Sig.
DV Velocity (km/h)	.320	6.97	5, 74			.001
Baseline				**81.79**		
Anger				**2.39**	**.30**	**.006**
Driving Motivation				**3.18**	**.35**	**.003**
Driving Experience				0	-.02	.875
Gender				**6.32**	**.37**	**.001**
DAS				-1.05	-.06	.538
DV Acceleration (m/s^2)	.155	2.71	5, 74			.026
Baseline				0.37		
Anger				**0.03**	**.31**	**.010**
Driving Motivation				0.01	.13	.293
Driving Experience				0	-.17	.163
Gender				0.04	.22	.065
DAS				-0.03	-.14	.216
DV Lateral Acceleration (m/s^2)	.250	4.96	5, 74			.007
Baseline				1.14		
Anger				**0.11**	**.33**	**.003**
Driving Motivation				0.07	.18	.137
Driving Experience				0	-.11	.309
Gender				**0.27**	**.38**	**.001**
DAS				-0.09	-.13	.235
Speeding (%-share of track)	.359	8.27	5, 74			.001
Baseline				42.11		
Anger				**5.56**	**.31**	**.003**
Driving Motivation				**6.76**	**.33**	**.003**
Driving Experience				0	-.01	.947
Gender				**16.54**	**.44**	**.000**
DAS				-2.69	-.07	.468

Bold F-Values are significant at $p < .05$; Gender was coded with 0 = female and 1 = male

As in study one, mean driving speeds were positively affected by reported anger (β = .30, t(75; 5) = 2.85; p < .006), driving motivation (β = .35, t(75; 5) = 3.11; p < .003) and gender (males drove faster; β = .37 t(75; 5) = 3.62; p < .001). Longitudinal acceleration was only influenced by anger levels and people driving angrily speeded up more quickly (β = .31, t(75; 5) = 2.63; p < .010); all other determinants were not significant. The model for lateral acceleration could identify anger (β = .33, t(75; 5) = 3.04; p < .003) and gender (again, males; β = .38, t(75; 5) = 3.49; p < .001) as positive influences for higher lateral acceleration.

The longitudinal driving parameters yielded a high correlation with speeding (mean correlation r = .48; p < .001). This is mirrored by the set of factors influencing this violation and it encompasses anger (β = .31 t(75; 5) = 3.05; p < .003), driving motivation (β = .33, t(75; 5) = 3.04; p < .003) and male drivers β = .44, t(75; 5) = 4.34; p < .001).

The results were very similar to those from the first study and they strongly indicated that highly motivated angered males were prone to drive faster, accelerate stronger and show a tendency to higher lateral accelerations. Path analysis revealed similar model fits compared to study one and all in all, they were very strong: The range of the χ^2 -, CFI- and RMSEA- Values of all four models was between 2.31 – 4.80, 0.961 – 1.0 and 0.0 – 0.087 respectively. Analogous to the multiple regressions, the path models revealed a consistent influence between anger levels and driving parameters (coefficients range from β = .27 - .29). Anger itself was influenced by trait anger tendencies (β = .22 - .23) and driving motivation (β = .24 - .29) but not gender (β = 0.0 - .01) or driving experience (β = .04). Still, gender had a direct positive effect on all driving parameters (β = .24 - .44), meaning that males were driving faster (and over the legal limit) and accelerating more strongly (longitudinal and lateral). The same positive pattern could be observed with driving motivation (β = .23 - .37).

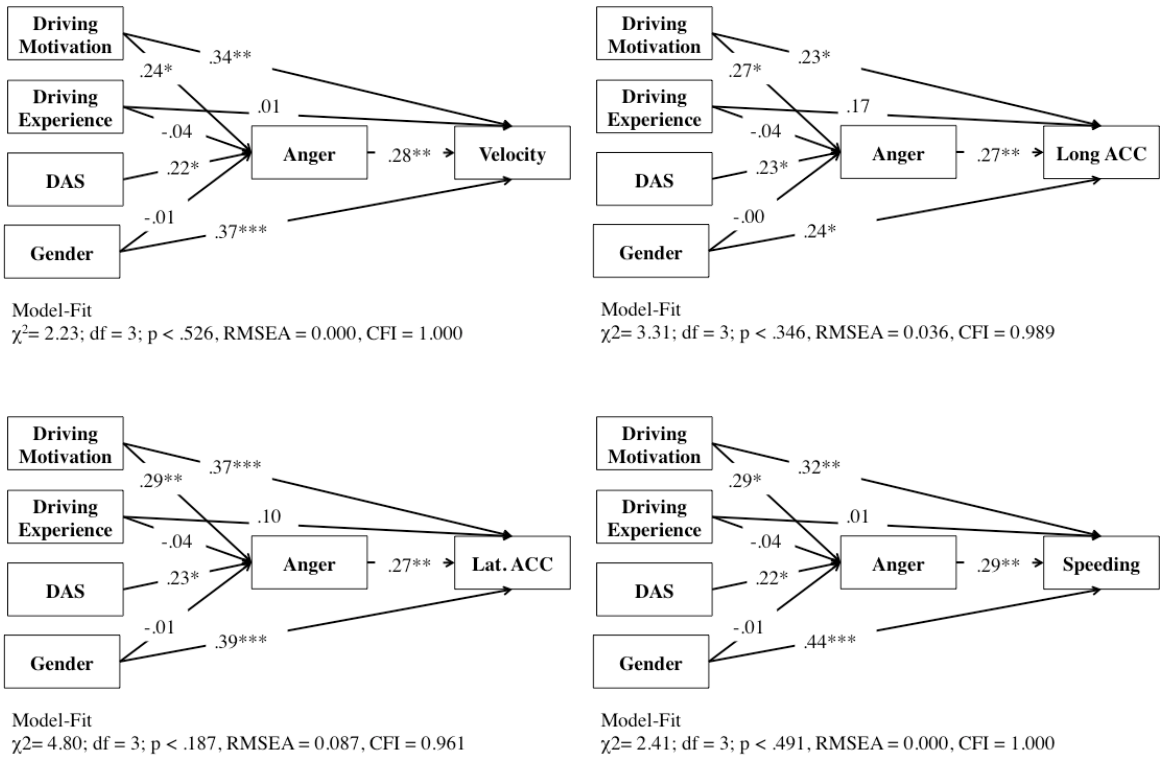


Figure 3: Path Models of personal characteristics, reported anger and driving parameters in the second study.

4.3.3 Discussion of the Second Study

The aim of the second study was to validate the findings of the first and to test another anger inducing method in a simulated driving environment. The basic results from study one were successfully repeated: High levels of anger, driving motivation and being male led to higher speeds, stronger longitudinal and lateral acceleration and more speeding violations.

The elicitation of anger in the driving situation worked better than in study one, in which film-clips were used to induce emotions. The reported anger increased from approximately 1.09 in study one to 1.65 in study two. This might be the reason for the occurrence of more frequent and stronger effects: Lateral acceleration as well as speeding behaviour was influenced significantly by anger levels in the second but not in the first study. This might be an indicator that there is an anger threshold, suggesting the theory that the traffic participant has to experience a certain level of anger well above zero-level before he will perform risky driving behaviours. If the level of anger is the defining factor, the quality of the anger could be neglected for these kinds of analyses and different kinds of anger could lead to similar driving outcomes (Nesbit et al., 2007).

The analysis of correlations between personal characteristics and anger revealed that driving motivation and DAS-Scores were related to heightened anger. The first relationship has been stated by researchers such as Philippe and colleagues (2009), who have shown that obsessively passionate

drivers are prone to experience stronger anger and as a consequence show more aggressive driving behaviours. Analysing DAS scores indicate that this was not influenced by any other personal characteristic. Furthermore, MANOVA Analysis for moderator effects revealed that the DAS-Score was not a direct predictor of maladaptive driving. Therefore, DAS scores seem to have inferior predictive validity compared to the measures of state emotion, namely the GEW, in traffic situations.

4.4 General Discussion and Conclusion

The aim of this paper was to reveal the influence of emotions on driving with regard to other personal characteristics of the driver. Therefore, two studies were conducted with different approaches to eliciting emotion and various traffic events and driving environments. Both studies showed that anger and personal characteristics are two distinct factors influencing longitudinal and lateral driving parameters in specific ways. The first study induced the emotion via short film-clips, which was successful at the beginning of the experiment, but the effect decreased fast during the experiment, leaving both groups with similar emotional levels. Yet participants who felt any anger at all due to the situational characteristics drove faster and accelerated more strongly.

Those results were largely repeated in the second study. The emotional inducement was changed, so that the traffic event itself should elicit the anger felt. Therefore a slow car, a construction site, a braking car and a dangerous hole in the street were presented. The emotional intensities were slightly higher than in study one (Study one: M = 1.09 vs. Study two: M = 1.65). Furthermore, in the second study anger is positively influenced by driving motivation. Participants who show a high motivation to drive might be more angered due to the goal blocking nature of the traffic environment. This led to the assumption that the anger elicited in study one might not have been directly related to the traffic environment. This idea is supported by the fact that there was no relationship between the DAS scores and driving anger in study one in contrast to the second study. Therefore, the anger quality of study one could be described as largely independent of the traffic environment, whereas in study two it is much more connected to the driving task at hand. In both studies, though, reported anger levels influenced various driving parameters such as velocity, acceleration and lateral control in a negative way. This leads to the assumption that anger, regardless of how it is elicited is suitable as a predictor of a decline in specific performance parameters. This supports the statement by Nesbit and colleagues (2007), who found in their meta-analysis similar effect sizes between various types of anger and driving behaviour.

The main effects of driving motivation and gender were strong in both studies, with participants scoring high on driving motivation showing the same maladaptive behaviour as angered participants. Even when controlled for anger experienced, they drove faster and showed stronger lateral acceleration. This supports the frustration-aggression hypothesis of Dollard et al. (1939) and the assumption that there is a chain reaction starting with the (potentially frustrating) traffic events to the importance of driving to elicited anger to aggressive driving patterns (Stephens & Groeger, 2009; Philippe et al., 2009). But as our research indicates, there is another direct route to maladaptive driving

and no frustration or anger is needed to elicit higher speeds. Drivers who value driving as an important activity seem to enjoy driving at higher speeds and taking the risks that accompany this behaviour.

This is especially true for the male participants in both studies. The discussion in study one has already pointed out that males are prone to underestimate the dangers of a possible harmful situation (Laapotti & Keskinen, 2004; Hennessy & Wiesenthal, 1999) and are constantly overestimating their driving skills (Ulleberg, 2001; Yagil, 1998). This was valid in both studies. Independently from anger and driving motivation, males were driving faster, accelerating more strongly, speeding more and demonstrating more intense lateral acceleration (the last indicator only in study two). They did not show more driving motivation than female participants, which indicates the importance of other motivations, and moves the focus to subjective skill levels and risk perception processes of this group.

Trait driving anger as measured with the DAS did not have any effects on observed driving behaviour. This is concordant with the findings of Stephens & Groeger (2009), who showed that situational aspects and online-appraisals of the situation such as in frustrating or angering events are far more effective for predicting driving behaviour. Therefore, it can be said that in the simulated environment of both studies, the DAS score loses some predictive validity (in contradiction to Deffenbacher et al., 2003) and more proximal measures of state anger like the GEW gain influence. Therefore, future research should employ a context specific, sensitive measure of anger like the GEW in order to validate state anger and its influence as distinct from trait anger and personal characteristics.

Another interesting outcome of this research is that driving experience did not have a significant impact on driving performance. This is partly counterintuitive because novice drivers should be prone to maladaptive driving behaviour such as poor lateral control (Krahé & Fenske, 2002). But this was not the case in the two simulator studies. It is possible that the driving behaviour assessed was not sensitive to differences at those low levels of driving experience and therefore describes a range restriction effect (Hunter, Schmidt & Le, 2006). This might have been different if a focus had not been on driving speeds and accelerations but on attention processes and braking reaction times. Those driving behaviours also require a sophisticated mental model in the first place but benefit vastly from extra exposure to traffic early in the driving history of the individual (Crundall, Underwood & Chapman, 1999).

The limitations of this study were threefold. First, the drive was simulated in the laboratory and the situations were artificial. Real traffic is less simplified and yields a greater variation of possible situations, leading to different emotional levels and influences on driving patterns. The traffic situations in study two were designed to overcome this problem, presenting four completely distinct situations to evoke anger. The results suggest that this general pattern of effects can be predicted in all contexts. Nevertheless, only rural / village roads were used, which is important to keep in mind if results are aggregated and generalized. A congested highway or a rush-hour city setting might reveal different patterns and new effects, which can easily disappear when averaged with other contexts.

The second limitation is that this study gives no explanation of *why* an emotion, high driving motivation or being male changes driving behaviour. Every construct has possible mediating features, such as poor risk assessment under high anger (Lerner & Keltner, 2001; Mesken et al., 2007; Richer & Bergeron, 2012), or an overestimation of subjective skill levels among male participants (DeJoy, 1992; Ulleberg, 2001). The anger-risk relationship was only derived from driving patterns in order to minimize interaction with the participants and not to make the participants consciously aware of this construct. Contrary to Mesken et al. (2007), Stephens and Groeger (2009) did not find any relationships between anger and threat evaluations within their simulator study, which makes it plausible that emotions and risk assessment are highly dependent on the given situation. The hypothesis that an overestimation of own skills and a wrong assessment of risk in a given situation is one characteristic of male participants might be supported by the fact that even controlled for anger, driving motivation and driving experience, the driving performance of men is still worse than that of women. It would be fruitful to add subjective skill level as measured in the driver skill inventory (Lajunen & Summala, 1995) to this kind of research in order to shed some light on this issue.

The third limitation of this study is that the reported emotions in both experiments are very weak, which seems to be the problem of many studies within a driving simulator or even in real live traffic experiments (Hennessy & Wiesenthal, 2009; Stephens & Groeger, 2009). This could hamper important associations between emotion and behaviour. From a quality perspective, a comparison between the first study, with its unspecific anger levels, and the second study, with context specific anger, revealed a more consistent pattern of the anger to driving performance relationship in study two. But there might be an intensity threshold which lies well above the levels of anger assessed, and perhaps exceeding this threshold could lead to even more and stronger changes in driving behaviour.

In conclusion, the research presented in this paper has shown that the emotion of anger, high driving motivation and being male are, independently of each other, significant predictors of risky driving such as high velocity and speeding. This could impede safe driving and therefore increase the risk of accidents in traffic.

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5. General Conclusion

This section discusses important findings of the three papers, implications for research and practice and possible directions for future research.

All three studies showed that many topics still remain to be addressed within the domains of emotion and driving. The results showed that, within the experimental settings, anger was still the most important emotion because of its strong prevalence and its impact on driving behaviour. However, other emotions are also present (see Chapter 2) and show distinct impacts on driving patterns (see Chapter 3). Furthermore, these emotions are not the only important sources of these maladaptive changes, and a complex interaction exists among personal characteristics, emotions and driving patterns (see Chapter 4). Combining the results and discussions of all three papers, the following conclusions can be derived from this research:

1. There are a variety of emotions in traffic beyond just anger and anxiety. Based on the appraisal-theory-framework, many different emotional qualities were extracted in the two online studies in the first paper. Positive feelings, such as satisfaction, joy and happiness, can be easily triggered with goal-promoting outcomes. Those outcomes could be the gentle behaviour of other drivers (clearing a parking spot) or fast and unobstructed driving. Pride as a positive emotion also occurs due to self-aware actions which promote one´s goals in traffic. This could include the successful handling of difficult road conditions or navigation through an unfamiliar city. Shame and guilt are present when the driver's own goals, or those of other drivers, are negatively affected. When comparing arrival vs. security related goals in traffic, the latter induce stronger moral emotions due to the possible dangerous consequences of one's behaviour. These new variants of emotional experiences in everyday traffic lead to a set of new questions:

- What cognitive mechanisms such as risk-perception or attention-deployment are affected because of the 'new' emotions?
- How do the results of these mechanisms differ from those of anger or anxiety experiences?
- Can we assume that there is similar critical impact of pride or shame on driving patterns, as is the case with anger or anxiety?

2. In the domain of negative traffic emotions, anger and anxiety could be elicited with typically generic traffic situations. However, there are semantically similar emotions that also can cause interesting effects on driving behaviour. When another driver is blocking our intentions, for example, anger and contempt can be elicited. Anxiety tends to occur in similar situations as fright does for example if a potentially dangerous event was totally unexpected. Looking at two phases of driving behaviour following the emotion-inducing event (short and long-term), the direction of anxiety-related

impact is similar with anger (higher velocity, more speeding and stronger lateral accelerations). Fright appears to be a highly adaptive emotion, leading to immediate reductions in velocity and stronger braking but also more weaving (supposedly an attempt to dash the obstacle). No accidents occurred during the experiment (the forgiving track design promoted safety), although common sense suggests that driving at higher speeds is more dangerous than driving carefully. The split between short and long-term effects poses new questions for the domain:

- Which emotions are effective immediately after an emotional event (such as fright)?
- Which emotions unfold their impact later – even after kilometres of driving – (such as anxiety)?
- Is there a change in the influence of cognitive mechanisms over time (e.g., first risk-perception followed by selective attention or vice versa)?
- At what threshold of emotion and under what situational circumstances is the possibility of an MVA greatly enhanced?

3. Specific groups of drivers are prone to driving faster and more aggressively; yet this propensity is due only partly to the (stronger) emotional responses observed in that specific group. The personal characteristics at the centre of attention were gender (especially males) and persons with a high driving motivation (e.g., those who incorporated driving in their daily lives). They tended to show more overt risky driving behaviours, including driving at higher speeds with stronger (lateral) accelerations. These effects were partly mediated by stronger experienced anger, but there was also a standalone impact. Therefore, a specific group of people on the road may experience a 'double dip' in driving performance decline. The first dip is due to personal characteristics (e.g., being male and highly motivated), and the second dip is reflective of an increased probability to experience (stronger) anger. This finding that both personal characteristics and emotions yield similar effects on driving behaviour leads to new questions in the field.

- To what extent are cognitive processes (risk perception, attention-deployment) influenced by emotion and how much variance do personal characteristics explain?
- How are those cognitive processes linked to driving behaviour in various situations?
- Similar to the second study, at what threshold of emotion and under what situational circumstances is the possibility of an MVA greatly enhanced?
- To what extent do the social environment (beyond the blame factor of the appraisal framework) and its variables (identification, evaluation, judgement and criticism) influence emotion elicitation and expression in traffic situations and how is this influence related to personal characteristics such as fear of evaluation or type A behaviour?

These questions are awaiting further research in traffic psychology, and to accomplish this, they must be approached with multiple methodologies. This includes simulated and real driving experiments, which could connect emotions and influenced cognitive processes to subsequent driving behaviour.

The first foundation, how to elicit a wide range of emotions, was targeted in the first paper. Building on that, different scenarios containing several diagnostic intervals can be developed in future experiments and tested within a standardised simulated environment or directly on the road. Objective assessments related to cognitive processes, such as eye-tracking for attention-deployment, and subjective statements of perceived risk in specific situations can complete the experimental setting. This approach will hopefully lead to a much better understanding of the emotional richness found in experiences of vehicular traffic and the impact of emotions on driving behaviour. The three articles presented in this work comprise one important step in this direction.