CHAPTER SEVEN

EMOTIONAL DRIVING EXPERIENCES

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1. Introduction

The activity of driving requires the involvement of a variety of human resources. For instance, to drive a vehicle on a busy city road effectively and safely, divers must coordinate their cognitive, physical and emotional capabilities simultaneously (Groeger 2000). If one of these is affected, it will invariably influence the others, as a result affecting the entire driving experience. To complicate things further throughout the driving activity drivers simultaneously interact with the vehicle's interface including radio, air-condition and other on-board equipment. As such, it is essential that the interface is designed appropriately so as not to load the cognitive, physical or emotional resources of the driver.

Research into the physical aspects of the driving experience has been previously reported (Andreoni et al. 2002; Peacock et al. 1993; Regan et al. 2000) and is an established area of research. Typically, the research focuses on the physical ergonomics of the driving posture, vehicle interior relating to the layout and distance of buttons, controls, steering wheel and dashboard, and access into and out of the vehicle for the driver. Due to the type of data involved in this kind of research it is generally conducted in laboratory or virtual environments. Recent studies go as far as modelling the human driver as a computer graphic simulation in virtual environments (Porter et al. 1993; Reed et al. 2002).

Studies into the cognitive aspects of the driving experience have recently become an area of focus (Briem et al. 1995; Haigney et al. 2000; Lansdown et al. 2004; Schneider et al. 2005; Strayer et al. 2001; Stutts et al. 2005). This is due particularly to the advent of the mobile phone and

other on-board electronic interactive systems and their demands on the attention of the driver (Hahn et al. 2000). Typically this type of research involves observing drivers interacting with the vehicle and other equipment in laboratory, virtual or real-world environments.

In comparison, there is limited available literature studying the emotional experience of driving and interacting with the vehicle interface and how to approach the design of vehicle interfaces in order to support positive (and avoid negative) emotional experiences (Angulo 2007; Mesken 2001). This is an important area of research as the emotional state of the driver is a factor in the effectiveness, safety and overall satisfaction of the driving activity (Mesken 2001, 2003; Nasoz et al. 2002).

This chapter presents the findings from an experiment investigating the emotional component of the driving experience during interaction with the vehicle interface. Some of these findings are based on previous papers presented by the authors (Gomez et al. 2004a, 2004b). They report on an exploratory study focusing on the driver's experience during interaction with the vehicle interface in a real-world driving situation. The study was based on a data triangulation approach including interviews, observations, and think-aloud protocols. Participants were asked to perform specific tasks while driving. During the drive they were video and audio taped. Moreover, an interview was performed before and after driving. The aim was to identify aspects of the driving experience that affected their emotions in a positive or negative manner. These initial results identified the context and traffic situation as the critical aspects of the driving experience that enhanced and/or detracted from the overall experience. These aspects were found to have a dominant impact on the driving experience. They are so important that if incorrect tasks were performed in a high traffic context, any negative feelings associated with it appear to be magnified and remembered thus having a significant impact on the overall experience. The same did not apply when incorrect tasks were performed within low traffic context.

Further analysis (Gomez et al. 2004a) of the findings revealed that challenges with the interface under particular conditions in high traffic contexts could bring about positive emotional experiences for drivers. Interestingly it was found that if female drivers were feeling unhappy before driving, were faced with challenging interactions with the vehicle interface in high traffic contexts and could overcome them, they perceived the overall driving experience as positive. The same may apply for males,

however it is hypothesised that the testing method conducted did not allow for male participants to appropriately express their emotions. This suggested that interactions which are challenging or require a certain level of effort to accomplish may impact positively on the experience, depending on the emotional state of the driver prior to driving.

The current chapter expands on these findings and discusses how designers can utilise future technology such as context aware technologies, adaptive interfaces, digital screen technology and ubiquitous computing, within vehicle interface design to support positive emotional experiences in different traffic contexts.

2. The activity of driving

Driving requires the management of various human resources while focusing on the surrounding environment. As a result, to drive effectively people need to feel comfortable physically, mentally and emotionally. If drivers are at ease they can concentrate, make decisions and judgements successfully and enjoy a positive driving experience. The immediate driver-vehicle interface consisting of equipment like the radio, steering wheel or seats, is where the application of appropriate design can facilitate comfortable, relaxed, safe and enjoyable driving. The inclusion of existing and future technology in the design of the driver-vehicle interface should not only be ergonomically correct and useable in a physical and cognitive manner but also inspire confidence and make the driver feel emotionally at ease while driving, thus enhancing the overall experience.

2.1 Overall experience framework

Within the driving activity, developing an understanding of the interaction between driver, vehicle interface, and context is critical. There is evidence to suggest that studies relating to the human–artefact relationship have previously been based on cognitive psychology (Hoff et al. 2002). This approach has been criticised for being too systematic whereby the human aspect and the context of the interactivity is overlooked (Gay et al. 2004; Kaptelinin et al. 2006; Nardi 1996). As a result, it has been argued that to design appropriate interfaces for interactive products, consideration must be paid to broader issues of context, situation, moods, emotions, social communication and value systems (Frascara 1999).

To better understand interaction between user and artefact during use, activity theory has been considered. At a fundamental level, activity theory attempts to understand the relation between consciousness and activity. Consciousness refers to intention, a human aspect, while activities refer to the issue of interaction occurring between human and artefact over time. The focus is on *practice* and *doing* which concerns the development of activities through time (Nardi 1996). By concentrating on these issues interaction between driver and vehicle over time is understood in a more comprehensive manner, emphasising the overall experience of the driving activity.

To capture the driving activity an *overall experience* (Gomez et al. 2004a) framework was developed (Figure 7-1). It is based on the activity theory construct (Nardi 1996) which stands on the premise that objects are mediators of human experience (Kuutti 1996). The importance of emotion and context involved during interactions with artefacts or environments is also highlighted within activity theory.

An overall experience (Figure 7-1) is composed of the interaction between human and artefact in conjunction with the activity being performed within a particular environmental context. It is important to note that the surrounding environmental context, in which the human-artefact interaction is situated, forms a critical component of the overall experience.

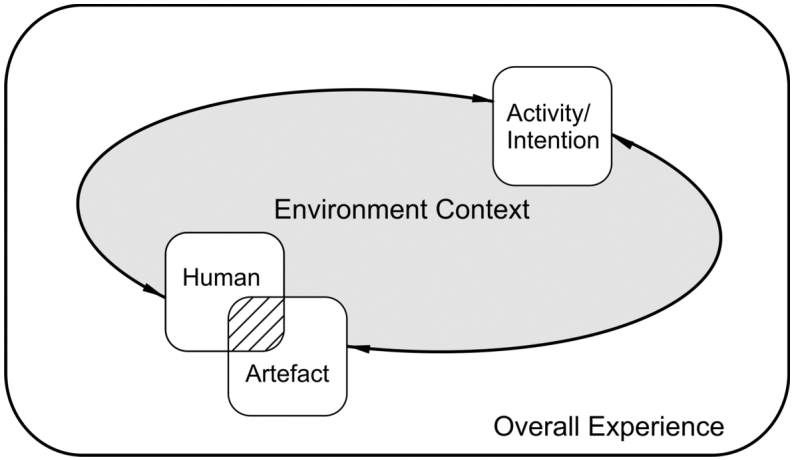

Figure 7-1. Human-Artefact-Activity within context forms an overall experience (Gomez et al. 2004b).

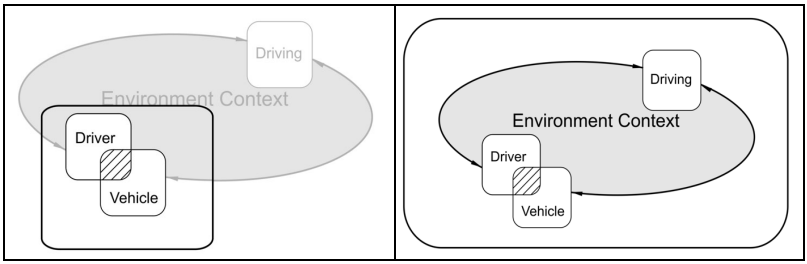

Figure 7-2. Micro (left) and macro (right) interaction levels for the overall driving experience.

If context is not considered within a framework of interaction the intention and meaning directing the activity can easily be misunderstood (Gay et al. 2004; Kaptelinin et al. 2006; McCarthy et al. 2004; Nardi 1996).

2.2 Framework for the driving activity

The driving activity can now be situated as an overall experience within the suggested framework. It consists of two interrelated interaction contexts; the micro-level context and macro-level context. The micro-level consists of interactions between driver and vehicle (Figure 7-2, left) and the macro-level consists of interaction between driver-vehicle and external environment (Figure 7-2, right).

To understand the overall driving experience, it is important to consider both interaction contexts in which the driver is simultaneously interacting with. Although the surrounding environment within the macro-level context (Figure 7-2, right) is in constant change while driving it is essential to recognise that the design of the vehicle interface needs to support these different driving conditions. In this way the physical design of the vehicle interface becomes a mediator for the overall experience attained by the driver.

2.3 Emotions and experiences

A positive state of mind while driving comes about when the driver is feeling content and relaxed. To achieve this, the driver must be physically, cognitively and emotionally comfortable while interacting with the vehicle interface. These capabilities needed for driving are intertwined and influence one another. As mentioned above research into the physical and

cognitive aspects of driving is abundant in the literature. For example, if drivers are using text messaging on their mobile phone as they drive their capacity to control their physical skills in an emergency decreases. However, there is little available research on the *emotional* aspects of interacting with the vehicle's interface and how this impacts the driving experience (Angulo 2007). There is a particularly gap in research on how to design for positive emotional experiences during human-vehicle interactions (Mesken 2001). Emotions are critical components that will impact on the overall experience attained by the driver, influencing all the aspects of the driving activity. They have been shown to directly affect concentration, judgements, decision-making and other critical cognitive and behavioural processes (Frijda 1986; Picard 1997; Plutchik 2003).

To identify emotions it was necessary to work with a basic construct that was easy, accessible and useful. Russell's (2003) model of Core Affect provides a basic model for articulating emotions. This model has previously been used as a foundation for emotions in studies that relate to emotional response to products (Desmet et al. 2002; Desmet et al. 2000), and emotional expression during mobile phone use (Fagerberg et al. 2004).

Russell suggests that a way to categorise emotions is to understand them as a blend of two dimensions. The first is a measure of feeling, ranging from contentment to discontentment (happy to unhappy) while the second is a measure of energy, ranging from excitement to calmness. The intensity of the emotion can be classified as neutral, moderate or extreme. The Core Affect model was used as a foundation to develop the Emotional Chart (Figure 7-3) (Gomez 2005).

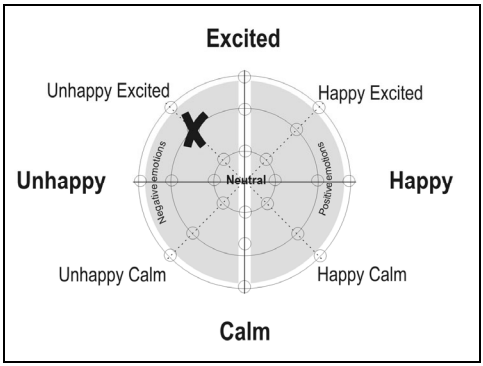

Figure 7-3. Emotional Chart (after Russell, 2003).

The Emotional Chart composes two hemispheres with "positive" emotions situated on the right and "negative" emotions on the left. To illustrate, the emotion *annoyed*, would be somewhere between "neutral" (midpoint) and "unhappy excited" as depicted on Figure 7-3. This Emotional Chart was used in the study and formed part of the questions asked during the initial and retrospective interviews. The labels were used in the coding system during the analysis stage.

3. Experiment: exploring the emotional driving experience

The research was conducted to investigate the driver's emotions with a vehicle interface in a natural driving situation. The aim was to investigate the emotional experience of driving as well as identify unique aspects that influence the overall experience.

3.1 Method

The study utilised a methodological triangulation approach (Denzin 1989) consisting of interviews, observation and think-aloud protocol. According to Robson (2002) triangulation techniques can help to counter particular threats to the validity of the experiment because it offers the researcher a variety of different channels to acquire and analyse data. The only foreseeable disadvantage of using this type of approach is that the information from the different sources may be conflicting; however this was not a problem given that during the analyses stage the data between interviews, observations and think-aloud protocols corresponded with each other. In addition, others researchers recommend utilising the approach of combining methodologies for measuring emotions in driving situations (Angulo 2007; Mesken 2001).

3.2 Participants

Fifteen participants (eight males and seven females), all full time staff members at Queensland University of Technology (QUT), were involved in the study. The participants represented a good cross-section of the driving population with ages ranging from 24 to 50. Every participant was screened to make sure they held a legal Australian driver's license.

Figure 7-4. Mini DV camera and tripod set-up (left) and Webcam and Laptop set-up (right) (Gomez et al. 2004a).

3.3 Equipment

The experiments were conducted using vehicles from Queensland University of Technology (Toyota Corolla–seven experiments; Toyota Camry–one experiment). This was due to the available time and availability of vehicles. Although one experiment used a different vehicle, the interface the driver interacted was very similar.

To record the experiment two video capturing devices were used. A mini DV camera and tripod located on the back seat recorded the participant's activities in the vehicle as well as recording audio (Figure 7-4, left). In addition, a web-cam was located on top of the dashboard attached to a laptop, which positioned on the passenger seat (Figure 7-4, right). This camera was used to videotape the participant's facial expressions during the drive.

Figure 7-5. Sample of two video sources into one file (Gomez et al. 2004a).

The image from the two videos were then mixed into one file (Figure 7-5) and used during the analysis of the experiment.

3.4 Procedure

The experiment focused on a daytime city-driving context. Each participant was required to drive a specified route around the central business district of Brisbane, Australia. The experiment was set-up in three basic steps. First, participants took part in an initial interview that was aimed at identifying their emotional state prior to driving. Second, they were required to drive a specified route while verbally expressing how they were feeling as they performed each task. Third, participants were asked to take part in a retrospective interview regarding their emotional state. Questions were also asked regarding their emotions about each of the activities performed while driving. A more detailed breakdown of the procedure is described below.

Step 1: Initial interview

Prior to driving participants were asked to undertake short interview. This was primarily set up to record their emotional state prior to the drive by noting their emotions on the Emotional Chart (Figure 8-3).

Step 2: Observation and think-aloud protocol

The participants were then asked to drive around a specified route in and around the central business district of Brisbane, which took them through a low-traffic area, a medium-traffic area and a high-traffic area. To keep the study as consistent as possible, the tests for all participants were performed between 11:00am and 2:00pm.

Participants were also asked to perform specific tasks during the drive so as to get detailed qualitative information relating to their interaction with the vehicle interface. These included operating the radio and tuning to a specific radio station, inserting a compact disc, playing a specific track on the compact disc, interacting with the air conditioning and washing the front and back water wipers. The reason for choosing these specific tasks was because they represent common, everyday activities that people perform in vehicles. Participants could perform these tasks in any order they liked and whenever they felt safe to execute them. Participants were also asked to think-aloud and verbally express what they were feeling about the tasks as they performed them. The drive took approximately twenty minutes to complete.

Step 3: Retrospective Interviews

Immediately following the drive a retrospective interview was conducted to gauge the participant's emotional state once more using the Emotional Chart (Figure 7-3). They were asked to provide an explanation about their feelings of the overall drive. Questions concerning how they felt regarding each of the activities they performed were also asked.

3.5 Coding system

The experiments were set up to measure the emotional response by analysing the participants' facial, vocal and bodily expressions in conjunction with their verbal descriptions of their feelings. Data was coded utilising a software program called Observer. This facilitated the coding of relevant elements of the driving experience. The coding system used was split into three categories called *Behavioural Classes* that comprised: *context*, *activities* and *emotions*. Each *Behavioural Class* was broken into *Behaviours*, used to define the categories into more detail (Table 7-1).

At any time throughout the analysis the researcher could code the *Behavioural Class* (context, activity and emotion) and its corresponding *Behaviour*. This resulted in information that was both detailed and comprehensive. With this type of information the software was able to construct a *time-event table* and *time-event plot*, which depicted the coded

Behavioural Class	**Context**	**Activities**	**Emotions**
Behaviour	Low Medium High	Correct Interaction Incorrect Interaction Visual Interaction Driving	Neutral Excited Happy Excited Happy Happy Calm Neutral Calm Unhappy Calm Unhappy Unhappy Excited

Table 7-1. Behavioural Classes and associated Behaviours.

Start Time (hh:mm:ss)	Behavioural Class	Behaviour	End Time (hh:mm:ss)	Duration (hh:mm:ss)
00:15:00	Context	High traffic	00:21:00	00:06:00
00:16:30	Activity	Visual interaction	00:16:33	00:00:03
00:16:31	Emotion	Neutral excited	00:16:35	00:00:04
00:16:33	Activity	Correct interaction	00:16:35	00:00:02
00:16:35	Emotion	Happy excited	00:16:40	00:00:05

Table 7-2. Portion of time-event table and corresponding portion of time-event plot.

information in a table and plot format (Table 7-2). For instance consider an instance where a driver is attempting to turn the radio on in high-traffic context. The driver looks at the interface for a few seconds attempting to find the "on" button. A few seconds later the driver finds the button expressing satisfaction as the radio is switched on. Table 7-2 depicts an example of this sequence.

The top portion of Table 7-2 illustrates (from left to right) the start time of a code, the behavioural class, its corresponding behaviour, the end time, and the overall time duration of the code. The corresponding image is a time-event plot of the same information. It illustrates the context (top

bar), activities (middle bar) and emotions (bottom bar) in different coloured segments along a timeline (in seconds). In each timeline different coloured bars were produced representing different behavioural classes of the corresponding behaviour. In activities, grey represents driving, light blue represent visual interaction and purple represents correct interaction. In the emotions timeline white represents neutral calm, red represents neutral excited and orange represents happy excited. The images represent an example of the corresponding video stills of the activities performed.

The time-event table and time-event plots were used to analyse how emotions during interactions in different contexts affected the overall driving experience (Gomez et al. 2004b).

4. Findings

The findings support the two levels of interaction relating to an emotional experience described in section 2.2. Figure 7.6 situates the experience framework within the driving activity.

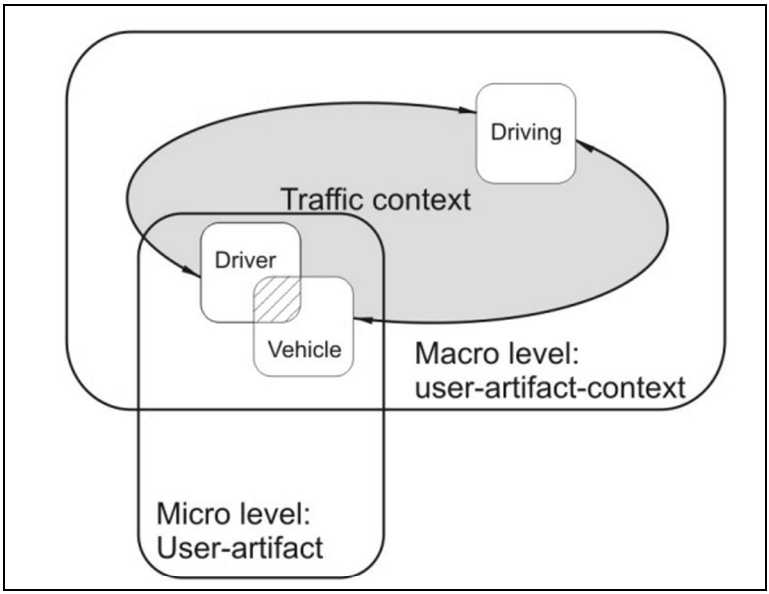

Figure 7-6. Micro and macro levels of the driving activity.

On a micro level, issues relating to the specific interaction between the driver and the vehicle's interface were identified. In this case, the participant's emotions were a reflection of how they felt while driving but did not reflect the overall emotional experience. On a macro level, issues relating to specific interactions within specific contexts were identified. Situated within this broader context, the participant's emotions were an indication of how they felt about the overall driving experience.

Three main findings in respect to the emotional experience of driving are outlined. First, the emotional condition before driving had an impact on the overall emotional experience. Second traffic context was found to be of critical importance when exploring the overall emotional experience attained by the user. Third, analysis suggests that extensive visual interaction with the interface in high traffic context leads to negative emotions experienced within the driving situation. The first two findings will be briefly outlined as they are detailed in other previous presentations (Gomez et al. 2004a, 2004b), while the third finding will be discussed in more detail.

4.1 Effect of context on the driving experience

The most important finding of the entire study was the significance of context on the entire experience. It was found that the surrounding context completely dominated the emotional driving experience.

At the micro-level, emotions experienced within the driving situation fluctuated; however, the findings suggest that they did not determine their overall emotional experience. The *traffic context* in which the emotions were elicited however; had a critical impact on the overall emotional experience attained by the drivers (Gomez et al. 2004b). The context thus became the critical component in determining their overall emotional experience. In low-traffic contexts, emotions experienced while interacting with the interface did not influence the overall experience and were not remembered after the drive. In high-traffic context, emotions experienced appeared to be magnified and influenced the overall emotional experience. Participants particularly remembered any negative emotions experienced in high-traffic contexts.

4.2 Effect of emotional condition prior to driving

It was interesting to note that the emotional condition of the participant prior to driving influenced their overall emotional driving experience (Gomez et al. 2004a). The emotional condition before the drive served like a baseline value which would then influence the way they were to perceive positive and negative experiences later in the driving activity.

Drivers in a positive emotional condition before driving who experienced challenging interactions in a high-traffic context perceived the overall experience as negative. Drivers in a negative emotional condition before driving, able to overcome challenging interactions in high-traffic contexts, perceived the overall experience as positive. This finding suggests that in high-traffic contexts the emotions of achievement and accomplishment associated with overcoming challenging interactions help those in a negative emotional condition feel positive overall experiences.

4.3 Extended visual interaction with vehicle interface

An additional finding is that extensive visual interaction with the vehicle interface in high-traffic contexts often resulted in negative emotions expressed by the driver. It appears that when drivers focused too much attention away from the road in high traffic contexts they instinctively became anxious and displayed signs of stress and negativity; expressed by their facial expression and their verbal descriptions of their feelings.

Figures 7-7 and 7-8 show a consecutive set of still images of participants 13 and 14 respectively during interaction with the vehicle interface in high-traffic context. In each of the examples the participant is looking at the vehicle interface for an extended period of time trying to work out how to perform a particular task. As illustrated, the facial expression demonstrates the negative emotions experienced.

Figure 7-7 shows participant 13 trying to adjust the air-conditioning in high-traffic context. The left image shows the participant looking at the vehicle interface in high-traffic context experiencing concentration. Five seconds later (middle image), the participant is still looking at the vehicle interface but her emotions have become one of annoyance and irritation as

she tries to figure out how to perform the task. Four seconds after (right image), the participant has worked out how to perform the task but is still

Figure 7-7. Still-images of participant 13 experiencing negative emotions after prolonged visual interaction with the air-conditioning system.

exhibiting negative emotions associated with the extended visual interaction. When asked about this particular task during the retrospective interview she commented on the problems encountered:

> …Can't see marker on open-close control, did not realise the air-condition light was off until later… was not bright enough (referring to the air-condition light indicator).

Figure 7-8 illustrates participant 14 attempting to turn on the back windscreen wipers in high-traffic context. The first image (left image) shows the participant looking at the vehicle interface in high-traffic context. A few seconds after (middle image) the participant is still focusing on the vehicle interface expressing more intense emotion of confusion and irritation as she tries to figure out how to perform the task. Four seconds later (right image) the participant has not worked out how to perform the task and continues to express negative emotions associated with the extended visual interaction. The participant also commented on the problems experienced in the retrospective interview:

> …Annoying cause it's hard to do. Did turn it [on] but only water came on, expected the wipers to come on as well except it didn't work like the front one (referring to front windscreen wipers).

The examples illustrate how extended visual interaction with vehicle interface can lead to negative emotions within the driving situation. This occurs most significantly in high-traffic contexts.

Figure 7-8. Still-images of participant 14 experiencing negative emotions after prolonged visual interaction with the windscreen wiper controls.

5. Discussion and conclusion

To drive a vehicle safely and effectively and to create a sense of enjoyment within the driving activity, the driver needs to be physically, mentally and emotionally comfortable. This paper presented an experiment conducted which specifically focused on the emotional aspect of the driving activity within a daytime inner-city driving situation. It is important to note that the findings are indicative at this stage.

How do the results influence the design of vehicle interfaces, and how can current and future technologies support positive emotional experiences? To begin with, the main points identified from the findings were:

- Emotions experienced during interaction with vehicle interface in low-traffic context do not affect the overall emotional driving experience.
- Emotions experienced during interaction with vehicle interface in high-traffic context are critical in forming the overall emotional driving experience.
- The emotional condition before driving influences the overall emotional driving experience.
- Challenging interactions in high-traffic contexts, under certain conditions, appeared to result in positive emotional experiences.
- Extended visual interaction with the vehicle interface in high-traffic contexts seem to result in negative emotions within the driving situation.

A relevant question that arises from these findings is how can the traffic context overwhelm the overall emotional driving experience and why does the emotional condition before driving influence the overall experience? Cheng (2004) offers a theory to explain this by noting

> …our total affective experience is larger than the sum of positive, negative and neutral moments […] A positive experience which has little or no effect ordinarily would go a long way at hard times. On the contrary, when life is smooth, the effect of adding more positive experiences may just be marginal.

This suggests that people's perception of their overall emotional experience is not simply about the sum of individual experiences, but rather has to take into account the contrasting effects *between* individual experiences. Consequently there is a contrasting effect between positive and negative emotions on the overall emotional condition of an individual. For instance, if a negative experience is followed by a positive experience, the difference between the contrasting emotions creates a noticeably positive *overall* experience. If a positive experience is followed by a negative experience the difference between the contrasting emotions creates a noticeably negative *overall* experience.

The contrast theory helps to explain why participants in a negative emotional state before driving experienced overall positive experiences when overcoming challenges during interaction in high-traffic contexts. In this case, the positive emotions associated with overcoming the challenges were in stark contrast to the participant's negative emotions prior to driving. The same applies to participants in a positive emotional state prior to driving that experienced challenges in high-traffic contexts; the contrast between the two events resulted in an overall negative emotional experience.

Moreover, this theory also indicates that a positive experience followed by another positive experience creates only a marginal positive *overall* experience. This explains why participants in a positive state before driving that experienced no significant challenges with the interface in high-traffic contexts underwent neutral overall experiences. The positive emotions prior to driving followed by the positive emotions of completing tasks without difficulty produced minimal emotional change between the two events and thus the driver perceived the overall emotional experience as neutral.

5.1 Implications for vehicle interface design

These findings have implications for the design of vehicle interfaces. They also offer some directions for interaction between driver and vehicle interface that support positive emotional experiences and reduce negative emotional experiences in a variety of ways. Some directions include:

- Vehicle interfaces should allow for various kinds of interaction depending on the surrounding context.
- Vehicle interfaces may encourage interaction within a low traffic context, as the emotions experienced in this context will not critically affect overall emotional driving experience. Additionally, rather than being static, the element of fun could be introduced by presenting a variety of ways to interact with the interface.
- If the driver is in a positive mood prior to driving vehicle interfaces may discourage unnecessary interaction within a high-traffic situation. In this case any negative emotions elicited in a high traffic context will impact negatively on the overall emotional experience perceived by the driver.
- If the driver is in a negative mood before driving, vehicle interfaces may encourage certain interactions within a high traffic context. In this case positive emotions associated with overcoming challenging interactions will elicit positive overall emotional experiences.
- In high-traffic contexts, the interface may adapt and discourage unnecessary extended visual interaction. In doing so, it will decreases the chances of eliciting negative emotions from the driver.

Essentially this indicates that the design of vehicle interfaces should be able to adapt according to the context as well as take into account the emotional condition of drivers prior to driving. This may be achieved by designing vehicles with context-aware interfaces as well as vehicle interiors that are sensitive to the emotional state of the driver before and during driving. These technologies would allow the vehicle to adapt appropriately according to the surrounding environment in a dynamic style so as to enhance the overall driving experience; however there is always the need for the driver to be in control of these systems at any given time.

Ubiquitous, embedded or ambient technologies could be applied within interior vehicle designs to make interfaces aware of their surrounding context as well as interiors sensitive to the emotional condition of drivers.

Digital screens as well as smart materials could be used as adaptable interfaces between the driver and vehicle. Currently, digital screens are used in vehicle interiors. However, they could be designed in such a way so as to adapt to different surrounding context or user inputs. Navigation systems are a simple example of digital screen technology that responds to its changing surrounding. Within the context of this paper another way digital touch screens could be applied is in the design of the entire centre console (including radio and CD, air-condition, navigation, speedometer or fuel gauge) whereby the entire interface including colour, shape, sensitivity, sound, form of buttons and other features could change and adapt depending on the surrounding context. There is evidence to suggest that this type of technology is already being considered by major car manufacturers for implementation in future vehicles thus enhancing the safety and enjoyment for the driver (Walker et al. 2001). Essentially the benefit of digital screens is that they allow for customisation by the driver or other passengers in the vehicle, as well as permit the vehicle itself to utilise context-ware technologies to inform the digital screen how to adapt in different contexts.

Similarly smart materials are another type of technology that could be utilised within vehicle interiors. The term "smart" refers to materials such as thermochromic materials, shape memory alloys and polymers, and electro-rheological fluids (Friend et al. 1999). These materials have the ability to change and adapt dynamically to their environment. They offer versatility depending on the surrounding environment, as well as adaptability to the driver's wishes. For example, there are polymers that are able to change dynamically to respond to different stimuli, changing from a high level of stiffness to a low level of stiffness depending on the circumstances. Also, there is ongoing experimentation on conformable elastic materials that can change shape, adapting to the users grip or force applied (Friend et al. 2003). These materials could be utilised on steering wheels, buttons, control knobs, paddle shifts and other areas of the vehicle interface to enhance comfort as well as enjoyment in different situations.

Technology also exists to develop interiors that are sensitive to the emotional state of the driver (Nasoz et al. 2002; Teller 2004). Sensitivity to the driver's emotional condition does not imply that the interface can identify a specific emotion; nevertheless, identifying whether a driver is in a negative or a positive mood is possible. At this point in time however; the technology to achieve this is still at an early stage of development as is too intrusive to be implemented in a suitable manner.

5.2 Implications for design

The study has some implications for the Design fields, both research and practice. Principally, the methodology employed can be applied to develop new ways of understanding the human-artefact interaction in real-life contexts. Furthermore, the outcomes can help stimulate the design practice as they offer new ideas and directions for future product development.

The methodology used was driven by the interest to explore the human-artefact interaction over time, rather than a single interaction, and across contexts, rather than in a laboratory situation. Furthermore, the focus was on interaction in life-like situations, in an attempt to reflect as much as possible what would naturally occur for people in their everyday interactions.

This approach produces interesting outcomes, but also poses challenges. Perhaps the biggest challenge is in the difficulty to understand and measure emotional responses during human-user interaction without interfering with the episode itself. This is true for any experimental technique; nevertheless there are ways to mitigate this. One method is to try and use multiple techniques to attain the required data, in this case a triangulation methodology consisting of interviews, observations and think-aloud protocols. Furthermore, in the researcher's experience, it was important to help the participant relax before the actual study began. This was achieved by the use of some straightforward and simple questions during the initial interview, thus helping the participant feel comfortable.

In conclusion, this research is significant as it has opened up the area of emotional driving experiences for further study. The findings have identified ways in which vehicle interfaces can be designed to enhance and support positive emotions and reduce negative emotional within the driving experience. The appropriate application of technology will allow for the flexibility needed in vehicle interfaces to support positive emotional experiences in the driving activity. It is important to consider the application of these technologies into vehicle interface designs as the emotional condition of the driver will affect the overall performance, safety and enjoyment of the driving activity.

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