Impact of Voice Variation in Speech-based In-Vehicle Systems on Attitude and Driving Behaviour

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Abstract

Automobile manufacturers are making information systems available in all vehicles. Most systems are screen based, but increasingly systems are either hybrids (screen/speech) or speech based. Speech systems in vehicles may have advantages over screen based in-vehicle systems; literature suggests that speech can be less distracting than screen-based interactions. Nonetheless, using speech systems in the car also introduces social and attitudinal effects. Voices are not neutral! Voices carry socio-economic cues including indicators of gender, age, personality, emotional state, ethniticity, education and social status. Perception of information presented by the voice is influenced by the perception of the voice demographics. This is further complicated by different individuals perceiving voices in different ways. A voice that is seen as positive by one individual can be perceived negatively by another. We present results from a number of driving simulator studies of speech based in-vehicle systems. These studies show that speech based in-vehicle systems can affect drivers' attitude and driving performance. Attitude and performance can be improved, but the effect of the voice can also prove harmful for driving behaviour and driving safety. This makes it important to include the voice as a design parameter of speech-based in-vehicle systems.

Voices and Speech-based In-Vehicle Systems

Automobile manufacturers, electronics and telecommunications companies are making computer based information systems available in all vehicles. Most cars today are fitted with interactive information systems including high quality audio/video systems, satellite navigation systems, hands-free telephony, and control over climate and car behaviour (Floudas, et al., 2004).

Even though most in-vehicle systems are screen-based, speech interactions are becoming more commonly used by in-vehicle systems. The use of speech technology in a vehicle would help increase the number of features and systems that can be controlled. There is limited space on steering wheel and dashboard for buttons. It would also enable drivers to keep their hands on the steering wheel and their eyes on the road during interactions with the system.

Social Responses

The social implications of interactive media have been explored by Byron Reeves and Clifford Nass. In their book "The Media Equation"(Reeves & Nass, 1996), Reeves and Nass regard communicating media such as computers and television as inanimate objects, and demonstrate that despite this, people tend to react to them as if they were real people. They claim that most people, regardless of education and background, are faced with a confusion of real life and mediated life. Their findings show that peoples' attitudes and behaviours when interacting with computers follow the same pattern as evidenced in social science findings (Reeves & Nass, 1996).

Results show typical scripted human responses to communicating computers that implement characteristics such as gender, personality, group association, ethnicity, specialist-generalist associations, distance, politeness and reciprocity.

A compelling explanation for people's tendency to treat computers in a social manner is mindlessness (Nass & Moon, 2000). Please note that the term mindlessness is not a derogatory term, it simply means "automatically without reflecting and thinking" - indicating that people apply social rules and expectations to communicating with computers in the same way they do to communicating with people. Individuals respond mindlessly to computers since they apply social characteristics from human-human interaction to human-computer interaction based on contextual cues (Langer, 1992). Instead of actively making decisions based on all relevant features of the situation, people that respond mindlessly draw overly simplistic conclusions – someone is communicating with me so I will apply all social rules that apply in this situation (even if it is a computer that interacts with me) (Nass & Moon, 2000). Johnson, Gardner and Wiles (Johnson, et al., 2004) found evidence suggesting a link between degree of experience with computers and social responses to computers. Their results, contrary to common belief, show that more experienced participants were more likely to exhibit social responses. Specifically, participants with high computer experience reacted to flattery from a computer in a manner congruent with peoples' reactions to flattery from other humans; the same was not true for participants with low computer experience.

Research on social responses to interactive artifacts suggeste thus that speech communication with the car would also make the relationship between driver and vehicle very different from today. The social implications of introducing interactive media into the vehicle need to be studied. The experiments presented here investigate these effects in cars. In particular, questions of how characteristics of voices such as gender, age, emotion and personality affect drivers' attitude and driving behaviour.

Speech and Driving Safety

The single most important aspect of any system to be used in a vehicle is its impact on driving safety. In addition to investigating how different voices and different ways of expressing information affect attitude, it is therefore also crucial to investigate if and how these cues affect performance. The driver's primary task is safe driving; any other activity performed while driving is regarded as a secondary task.

Do speech-based in-vehicle systems allow drivers to better focus on driving than screen-based in-vehicle systems? Dahlbäck and Jönsson (2007), pointed out that the requirements for dialogue systems used in vehicles are different than for dialogue systems used, for instance, in the office. The dialogue system is seen as a secondary task, driver might at any time pause in a dialogue to concentrate on the driving task, and when the traffic situation allows it, the driver should be able to resume the dialogue. The design of the in-vehicle dialogue system needs to be modified to handle interrupted and resumed interaction, repetitions, restart of dialogues, misrecognitions, misunderstandings, presence and interruptions from other in-vehicle systems and passengers.

Do Voices Matter?

Choice of voice has long been an important factor for media companies that select TV and radio personalities. Results from media studies show that people unconsciously attribute human characteristics to communicating media and apply social rules and expectations accordingly. Using speech for in-vehicle systems highlights the potential influence of linguistic and paralinguistic cues. These cues play a critical role in determining human—human interactions where people respond to characteristics of voices as if they manifest emotions, personality, gender, and accents (Nass & Gong, 2000;Tusing & Dillard, 2000). An upset and loud voice can for instance be used to focus attention to a potentially dangerous situation - the advantage over a non verbal signal is in information. A happy and cheerful voice can potentially be used to put the driver in a better mood – happy people perform better than dissatisfied people (Hirt, et al., 1996;Isen, 2000;Isen, et al., 1987;Isen, et al., 1991). A well-known and trustworthy voice may be used to convey important information – the benefits of trust include better task performance and willingness to use the system (Lee & Moray, 1994;Muir, 1987;Muir, 1994)

Similarity and Consistency

Two important aspects of how voices influence attitude and perception of messages in communication are *similarity-attraction* and *consistency-attraction*. Similarity-attraction predicts that people will be more attracted to people matching themselves than to those who mismatch. Similarity-attraction is a robust finding in both human-human and human-computer interaction (Byrne, et al., 1967;Nass &

Moon, 2000;Nass, et al., 1995). In human-computer interactions, the theory predicts that users will be more comfortable with computer-based personas that exhibit properties that are similar to their own. Attraction leads to a desire for interaction and increased attention in human-computer interaction (Dahlbäck, et al., 2007;Lee & Nass, 2003). In the same way, consistency-attraction predicts that people will like and prefer those who behave consistently. People are particularly sensitive to discrepancies between contents of a message and non-verbal cues (Ekman & Friesen, 1974). Traditional media companies (TV, Radio, Movies) have long worked on establishing consistency in all aspects of presentation (Thomas & Johnston, 1981). The reduced cognitive load and increased belief in a message resulting from consistency may make people more willing to interact with such a system (Lee & Nass, 2003). People felt better and were more willing to communicate when they heard a computer voice manifesting a personality similar to their own and using words consistent with their personality.

Studies of Speech Systems in Cars

Presented below are results from our studies investigating how different properties of voices affect drivers and their performance. The studies compare the effect of different voices used by the same in-vehicle systems, and how voices affect different groups of drivers.

The studies were all conducted in a diving simulator, STISIM Drive (Systems Technologies Inc, 1990). Drivers sat the car seat and drove using the Sidewinder steering wheel and pedals. The simulated journey was projected on a wall in front of participants. All drivers completed the same driving scenario since a driving scenario in STISIM Drive is static and predetermined; it has a specific length and will take all drivers along the exact same road regardless of left and right turns. Based on this feature of STISIM Drive all participants are guaranteed to drive the exact same route Attitudinal data was collected using a mix of standard and specially designed questionnaires.

Presented below are three studies described in some detail, they are selected to highlight common situations where choice of voice clearly influenced both driver attitude and driving behaviours.

Study 1: Matching Driver Emotion and Voice Emotion

The study presented here focus on emotional voice characteristics. Should an emotional voice be used in to match the emotional state of the driver, and if so what are the effects? To investigate these questions a driving simulator experiment was setup at Stanford University. 60 participants were recruited in the age group of 18-25. Gender was balanced across conditions so that 30 female and 30 male, participated in the study. All participants were native English speakers.

Participants were induced to be either happy or sad at the beginning of the experiment. This was accomplished in five minute inducement sessions (Masters, et al., 2006). 1/3 of the happy and 1/3 of the sad/upset participants were randomly selected to drive and interact with an in-vehicle system with a happy-energetic voice. Similarly, 1/3 of the happy and 1/3 of the upset participants drove and interacted with an in-vehicle system with a sad-subdued voice. The remaining 1/3 of the happy and 1/3 of the sad/upset participants drove without an in-vehicle system.

Results from the experiment show that matching the voice of the car to the drivers' emotions had enormous consequences. Drivers who interacted with voices that matched their own emotional state (Happy and energetic voice for happy drivers and sad and subdued voice upset drivers) had *less than half* as many accidents on average as drivers who interacted with mismatched voices! Matched cases had M=3.39 versus mismatched cased with a M=8.95, $F(1,36)=9.01$, $p<.005$, see Table 1.

Drivers paired with matched voices also communicated much more with the voice. Please note that although drivers who heard emotion-matched voices interacted (spoke) more, they were nonetheless better able to avoid accidents.

Table 1: Results from Matching Emotions – Two-way ANOVA

		Perceived Attentiveness		Number of Accidents		Amount of Speaking	
		Mean	SD	Mean	SD	Mean	SD
Happy Drivers	Happy Voice	21.6	5.9	1.9	1.6	5.3	2.2
	Sad Voice	9.2	4.1	8.1	7.7	4.1	1.5
	No Voice			2.2	1.4		
	Total	15.4	8.1	4.15	6.2	4.5	2.1
Sad and Upset Driver	Happy Voice	8.2	2.8	9.8	7.5	4.0	1.0
	Sad Voice	20.7	4.2	4.9	4.2	5.3	1.5
	No Voice			3.9	2.1		
	Total	14.5	7.3	5.9	7.6	4.5	1.4

Drivers that heard voices whose emotions were matched to their own emotion rated themselves as significantly more attentive while driving, $F(1,36)=79.1,\ p<.001$. They also perceived that the voice made them more safer and more confident as drivers in matching conditions than in mismatched conditions $F(1,36)=42.5,\ p < .001$, see Table 1. Parts of this study is published in more detail in conference proceedings (Jonsson, et al., 2005c;Nass, et al., 2005) and in a thesis (Jonsson, 2009).

Study 2: Emotional Drivers and Familiar Voices

Should a familiar voice be used for angry and upset drivers, and if so what are the effects? These are important questions, a study by the American Automobile Association (AAA) found that motorists felt more threatened by aggressive drivers than by drunk drivers; 40% of the respondents said that aggressive drivers "most endanger traffic safety," while 33% identified drunk drivers as the primary risk (Connell & Joint, 1996;Joint, 1995;Mizell, 1997).

A driving simulator experiment was setup to investigate how angry and frustrated drivers responded to a familiar voice used by an in-vehicle system. 60 participants, 30 female and 30 male, age group 18-25 were recruited from Oxford Brookes University, UK. All participants were native English speakers.

Participants where first induced to be angry and frustrated in a 45 minute session at the beginning of the experiment (Masters, et al., 2006). After inducement, they were randomly divided into three gender balanced groups of twenty, each group driving with a specific version of the in-vehicle system. Two voices were used for the in-vehicle system, a voice familiar to all students, and a voice unknown to all students, the third version of the system was silent.

Results show that a familiar voice had an overall positive effect on angry drivers. On all measures, the familiar voice was perceived more positively with a positive influence on driving behaviour. For overall driving behaviours - including accidents, traffic rules, and lane keeping - drivers with the familiar voice exhibit a 20% better performance than drivers with an unfamiliar voice (see Table 2).

Table 2: Results: Familiar – Unfamiliar Voice – Two-way ANOVA

		Perceived Attentiveness		Number of Accidents	
		Mean	SD	Mean	SD
Familiar Voice	Female	35.80	9.6	3.4	1.26
	Male	29.53	7.5	5.6	1.96
	Total	32.67	9.0	4.5	1.96
Unfamiliar Voice	Female	21.30	6.2	6.4	2.95
	Male	23.10	10.2	6.5	2.88
	Total	22.20	8.3	6.4	2.84

Data show that drivers with familiar voice drove safer than drivers with the unfamiliar voice. The effect for accidents is $F(1,36) = 6.8$, $p < .02$. Drivers also perceived the in-vehicle system with the familiar voice to have a positive influence and they rated themselves as significantly more attentive while driving, $F(1,36) = 15.0$, $p < .001$, than drivers interacting with the unfamiliar voice, see Table 2. This study is described in more detail in a thesis (Jonsson, 2009).

Study 3: Information accuracy and Female or Male Voices

Driving requires focused attention and timely decision making for appropriate manoeuvres and relies to some extent on well-timed and accurate information. When designing an in-vehicle information system it is important to ensure that the information given to the driver does not negatively affect cognitive processing and driving performance, and that the information is presented in a way that does not distract attention from the driving task.

To investigate how driving related accurate and inaccurate information affects drivers performance and attitude, a study was setup with an-vehicle system that with levels of accuracy ranging from 65% to 100%. The in-vehicle information system consisted of 33 speech prompts. Scripted to inform and warn about activities, features and hazards related to the road or the driving environment (Jonsson, et al., 2004). The voice prompts for the in-vehicle information system were recorded by a female speech talent that spoke in a neutral tone of voice. There were a total of 100 participants in the age group 18 – 25, 50 female and 50 male, recruited from Stanford University to participate in the study. All participants were native English speakers.

Table 3: Results from Female Voice and Information Accuracy

	Collisions		**Off-road Accidents**		**Disobedience to traffic rules**	
Accuracy	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
100 %	2.0	1.3	0.8	0.9	0.7	0.7
88%	2.2	1.9	0.7	0.7	0.6	0.7
76%	2.4	1.4	0.8	0.9	0.6	0.6
64%	2.9	1.2	0.9	0.8	0.7	0.7
Silent	2.9	1.8	1.3	1.1	0.5	0.6
TOTAL	2.5	1.6	0.89	0.93	0.63	0.73

Perhaps the most striking result in this study is the dramatic differences between females and males with respect to the effects of the accuracy of the in-vehicle system on their driving behaviour. For female drivers, greater accuracy improved all three measures of driving performance: collisions, off-road accidents, and obedience to traffic rules. Even for low levels of information accuracy, the mere presence of the in-vehicle system helped female's driving behaviour with respect to reducing collisions and off-road accidents. Female drivers had 50%-100% less accidents with a system than without a system. The situation for male drivers was very different. The accuracy of the in-vehicle system had a positive effect on the number of collisions and the presence of an in-vehicle system had a positive effect on off-road accidents, but there were no other effects. Male drivers show 30% less off-road accidents with a system – no difference for collision. Thus, while accurate in-vehicle systems can be of benefit for all drivers, they are clearly helpful for females even when their accuracy is limited.

Why should females and males be so differently affected by the in-vehicle system? One explanation that can be ruled out is that the gender differences are due to differences in perceived accuracy or credibility. All participants were sensitive to, and reported inaccuracies in the in-vehicle information system. The data show no gender differences in drivers' assessments of how accurate the systems were. The explanation for these results must thus be found elsewhere and there are two main theories that can explain why female drivers would be more sensitive to the statements of the system as well as its accuracy. Below are three possible explanations:

- A series of studies, conducted in the US, by Meyers-Levy (1989) demonstrates that women feel more responsible for attending to information from other sources--they will listen even when the source is considered unreliable. Consequently, even a somewhat inaccurate in-vehicle system to be better than none at all for women.

- Tannen's (1990) work on gender and communication (in the US) provides a different explanation. According to Tannen, women use speech as a means of establishing relationships, while men use speech to establish status and a hierarchy of superiority. Under this view, males would simply see the system adopting a position of hierarchical superiority. Women would welcome the information in that the system is clearly trying to be helpful.
- An alternative third theory, based on studies in the US, is related to the gender of the voice of the in-vehicle system. This theory predicts that since the voice of the in-vehicle system was female, males tends to be more dismissive of the system than females (Nass & Brave, 2005;Nass, et al., 1997). If males dismiss the female voice, they would be less likely to be influenced by its accuracy and less likely to be influenced by even the voice's presence.

The study is published in more detail in conference proceedings (Jonsson, et al., 2008;Jonsson, et al., 2005a) and in a thesis (Jonsson, 2009)

Addition studies

In addition to the studies described above, other studies have been conducted to investigate other voices and linguistic properties of in-vehicle systems. Some of these studies are: The effects of age of voice on different age groups of drivers (Jonsson & Zajicek, 2005;Jonsson, et al., 2005b;Jonsson, 2008). How personality of voice interacts with personality of driver (Jonsson, 2009). How to phrase messages about bad driving behaviour to improve attitude and performance (Jonsson, et al., 2004). How in-vehicle systems are perceived by busy drivers (Jonsson & Chen, 2007;Jonsson, 2008).

Emerging Patterns

The data show, in all three studies described in detail and as well as in the studies only mentioned, that the voice of the system affects both attitude and performance. An emerging pattern demonstrates that attitudinal measures are linked to the behavioural measures. In general, drivers that are pleased with and trust the in-vehicle information system also show better performance than drivers that dislike the system.

One voice does not fit all! The data from the study on matching driver emotion to voice emotion clearly indicates that drivers' state of mind interacts with how a particular voice is perceived and influences performance. With a system that monitor and detect driver emotion, a system could be designed respond to that emotion. One useful strategy is to exhibit empathy and change the voice of the system in step with the driver. Empathy greatly fosters relationship development, as it communicates support, caring, and concern for the welfare of another. Although rapid response to emotion (or predicted emotion) of the driver can be effective, there are a number of dangers in this approach. In the human brain and body, emotion can change in seconds (Picard, 1997). If someone tells a joke to a sad person, he or she may become momentarily happy but will fall back into their sad state relatively quickly. Conversely, happy drivers may become frustrated as they must slam the brakes after expecting to zoom through a yellow light, but their emotion may quickly switch back to feeling positively. If the voice in the car adapted immediately and forcefully to the driver's emotions, drivers would experience such bizarre occurrences as the voice of the in-vehicle system potentially changing its characteristics in mid-sentence. This would constantly activate new emotions in the driver and most likely be perceived as psychotic. While this can be entertaining when performed by manic comedians like Robin Williams or Jim Carrey, it is psychologically exhausting and disturbing when encountered in daily life. An in-vehicle system with these properties and behaviour would immediately be marked as manic-depressive and hard to interact with as opposed to empathetic!

Data from study 2 clearly shows that a familiar voice has a positive influence on attitude and driving performance. Once again, one voice does not fit all! Still remaining is the question on how to select the appropriate familiar voice for each individual driver? The voice has to have the right positive connotations and properties for each driver. Furthermore, what makes a voice familiar? How familiar should a voice be – family – authoritative figure –friend? When does a voice shift from being unfamiliar to familiar? Can a voice used in the car lose its good connotations due to mishaps by the system, so that a previously trusted familiar voice becomes a disliked familiar voice? What will be the effect of this in car? And more importantly, what would be the effect in real life? Can this result in liked person becoming disliked? The opposite is of course also possible where a person whose voice is used in the car, makes some blunders that shifts the associations from positive to negative. Will this affect drivers' attitude and performance?

The third study highlights the effect of male and female voice on attitude and performance. The data show that the even though the female voice had a positive influence on male drivers when the information accuracy was high, the effect was significantly less than for female drivers. What remains to be investigated it which type voice would produce the same positive effect the female voice used in the study would have on the male drivers.

Discussion on Limitations

All studies presented here have been done using driving simulators. Driving behaviours such as accidents and failure to adhere to traffic regulations were used to measure driving performance. These measures are less fine grained than the conventional brake behaviour and lane deviation measures used in most test track studies. Nonetheless, driving is a complex activity that continually tests drivers' abilities to react to the actions of other drivers, traffic and weather conditions, and unexpected obstacles. Therefore, the driving setup used in the studies presented here chose to challenge people with hard and complex driving scenarios. In this way, the participants were subjected to a higher rate of potentially risky situations than they would be within a lifetime of driving. Mishaps and accidents in the driving simulator (as in real life) are signs of critical breakdowns in driver attention, judgement, and vehicle management. These driver mishaps and accidents were correlated with the use (or lack of use) of in-vehicle systems as measures of how these systems influence driving behaviour.

Can the results from these studies of in-vehicle information systems conducted in driving simulators be applied to cars? We would argue that the driving simulator can be seen as a screening device, and that in-vehicle systems that make a favourable impression on drivers and driving performance in the simulator should be tested in real cars to see if they are equally beneficial to drivers in real traffic. We would also argue that lapses in driver attention, judgement and vehicle control visible in driving simulator studies due to the influence of in-vehicle systems, would be present also in real driving. These lapses will hopefully not cause an accident in real traffic as it did in the driving simulator, but there will definitely be less severe expressions of bad driving. This could for instance be swerving, loss of speed, hard braking etc. These behaviours might not in a low density traffic situation lead to an accident, but could in a high density traffic situation have severe consequences. Based on this, it is my belief that lapses in safe driving behaviours and perception of in-vehicle systems and cars do transfer from driving simulator studies to real cars in real traffic. The open question is how severe would the consequences of these lapses in safe driving be?

Conclusions

Voices are important, and people are good at recognizing and differentiating between different voices Using voices in the car introduces social cues that influence drivers' attitude and interpretation of messages. In particular, voices are associated with emotional responses and judgments of (dis)trust and (dis)liking. This is known by the media industry (radio, TV and movies) where voices are selected so that people are willing to listen to them, to communicate with the, or to elicit certain responses. Results from media studies are based on one-to-many communication and the in-vehicle information system is a one-to-one communication system. Even so, our results show that these findings transfer to the car. Findings indicate that there is not one effective voice for all listeners and all situations. This also suggests that drivers benefit from in-vehicle information systems that knows its driver(s) and possibly also adapts to its driver(s).

Continued Work

Investigating more properties of voice and linguistic features of in-vehicle systems, some studies clearly show that similarity attraction does not necessarily hold in the car. This is highly surprising since media studies show that similarity attraction and homophily are important and solid findings, people tend to like and trust people that are like themselves (Dahlbäck, et al., 2007;Lydon, et al., 1988;McCroskey, et al., 1974;Nass & Lee, 2001). Findings from the study on personality and age of voice show that the dominant voice is preferred by all drivers regardless of personality, and that the young voice is preferred by all age groups of drivers. These results clearly do not confirm similarity attraction, so why? What makes the driving environment different?

A possible explanation for the car being different is linked to "critical control rooms". In the car the driver is an operator, controlling a vehicle speeding through space and time. It is possible that the differences found in the data presented here are based on the difference in immediate feedback and the potential threat to life and limb – compared to an office setting. We am not belittling consequences of bad investments or less fortunate online choices, but instead trying to set the scene for an operator controlling an object where mistakes can have immediate life threatening consequences. It is after all is in this setting that the data from the studies presented here deviate from studies in social sciences.

It is also possible that the driving environment is a situation where the difference between reflective and experiential or reactive cognition (Norman, 1993) influences behaviour. Norman (Norman, 1993) makes a distinction between experiential and reflective cognition, where experiential cognition is associated with expert/skilled and reactive behaviour and reflective cognition with slow/planned and reconsidered behaviour. Driving is an activity that is seemingly done with ease and skill by the experienced driver. The driver continually takes in multiple information streams, through the windshield, from instruments, tactile feedback from seat, steering wheel and pedals, and the sound of the engine. The drivers responses seems effortless and without delay. The same behaviour is true for all domain experts; even though enormous amounts of processing are necessary the responses are generated without conscious effort. Even though driving is most often a data-driven reactive knee-jerk activity, there are complex situations where reflective planning and assessment is necessary. This seems to be properties that hold for all "critical control rooms" systems.

It is important to note that even though the studies presented here indicate that there are gains to be made, both in driving safety and attitude, from knowing and adapting to the driver. Current vehicles and current driving environment lack the technology to fully implement all of these findings. Even if technology existed to design a system to accurately monitor and detect drivers' behaviour and state, there are still many important research questions associated with selecting appropriate voices and dialogues. Even though voices need to be selected so that people are willing to listen to them or communicate with them, results presented here also indicate that there is a trade-off between liking and performance. Emphasizing the importance of selecting voices that are attractive enough that drivers listen, but not too attractive so that drivers talk instead of driving.

Data furthermore also show that dialogues and conversational systems should be designed with care. Combining attractive voice selection with a secondary task design of the dialogue system, and in-vehicle system could time the conversation to situations with light traffic where drivers can safely split their attention between driving and talking. Results from a study on conversational systems (Jonsson, 2008) show that interruptions by in-vehicle systems are considered socially unacceptable (as they are in human-human dialogue) and have a detrimental effect on performance.

For a system to know when to talk and when to be quiet, the system needs the technology and know-how to monitor and adapt to both operator and environment. If a system can be designed to do this, it will most likely be safe to use by operators of any vehicle, be it a car, a ship or a plane. With clever and strategic references to all of the different rationales for behaviour change, cars and other technologies might dramatically enhance safety while encouraging positive feelings. What more could a designer want?

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