Driver-to-Driver Communication on the Highway: What Drivers Want

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Abstract. Drivers need to coordinate with each other to share the road infrastructure. The social relationship between drivers also influences the driving behavior. With everywhere available connectivity and the broad penetration of social network services, the relationship between drivers on the road may gain more transparency, enabling social information to pass through the steel shell of the cars and giving opportunities to reduce anonymity and strengthen empathy. In this paper, we investigate what sort of social communication drivers consider useful for a highway scenario and which factors influence their willingness to receive or send the information concerned. We utilized the "CoConstructing Stories" method to investigate 30 novel scenarios with 22 participants. We find that driver-to-driver communication relating to Safety and Efficiency is well accepted. In order to account for the acceptance of driver-to-driver communication concerning the Social relation between drivers and their Identity, additional information is required. Some relevant factors are considered in the discussion, and steps for future research are suggested.

Keywords: Social car · Connected car · Automotive User Interfaces · Interactive Vehicular Applications · Social Computing

1 Introduction

Usually, driving occurs in a situation where there are other road users. Accordingly, drivers need to coordinate with each other to share the infrastructure. Besides, the social relationship between drivers also influences the driving behavior [1]. But when we sit in "iron cages", there are only a few channels to exchange information between drivers. Lights, horn and speed information are the most frequently used tools to exchange information, limiting both the range and the bandwidth of the connectivity. This awkward situation leaves drivers with few ways of understanding the intentions of co-located drivers, and makes them struggle to figure out why other people do what they do [2]. Cars appear as machines, lacking any anthropomorphic (human-like) features [3]. With everywhere available connectivity and the broad penetration of social network services, the relationship between drivers on the road may gain more transparency, enabling social information to pass through the steel shell of the cars and giving opportunities to reduce anonymity and strengthen empathy as well as

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eliminate boredom, loneliness and stress. This connectivity will lead to a boom of social applications on the road, which is gradually drawing attention both from the industry and academia. But this phenomenon has not been interpreted from a social computing perspective, and the acceptance of this trend by drivers is not clear.

Schroeter et al [4] discussed the social and geo-car concept, which enables the exchange of urban information and social expression, offering new opportunities for in-vehicle applications in the future. After an ideation workshop with urban informatics research experts, a rich list of concepts emerged. The authors established a model that combined the geo dimension and people dimension to illustrate the design space of the people layer of social information on the road. But they did not investigate the acceptance of these ideas and the factors that may influence the acceptance. Riener et al. [5] compared the state of drivers' current in-vehicle technology use and investigated their needs and wants for plausible new vehicle area network (VAN) services. But being based on an online survey, it was difficult to extrapolate to the future situation.

In this paper, we conduct s more in-depth investigation of what kind of social information drivers find useful and which factors influence the drivers' judgments.

1.1 Social Graph of the Future Road

The relationship on the road can be represented by a traditional social graph, such as Multigraph [6], which depicts multiple channels of social connection between actors. There are two levels of relationship in the driving situation: The Event layer, which represents the activities based on locations, and the community layer, which represents the social connection between drivers.

Figure 1 shows the current driving situation. From the perspective of location based events: sharing the road infrastructure is the only event that connects drivers on the road today. From the perspective of the community between drivers: when they sit in cars, the drivers see others as machines rather than social actors, lacking any anthropomorphic features. This lack has also been shown to contribute towards aggressive, selfish and anti-social driving behavior [3].

Recently, this situation has been changed by the everywhere available connectivity of the internet and the broad penetration of social network services [4]. Figure 2 shows the possible picture of the future driving activities.

For the event layer, connectivity allows drivers not to be restricted by physical time and space, which means drivers are able to participate in activities on other places and asynchronously. For example, driver A (Figure 2) who is currently involved in driving event 1, encountered ice on the road in driving event 2. The drivers C in event 2 are able to interact with the "shadow" of A (A1 in Figure 2) to receive a warning about the icy road. Furthermore, other kinds of information based on location may be generated, such as information about landscape, fuel discount and weather. These events provide opportunities for cooperation rather than competition on the road. For the community layer, a series of communities will be established to bring more transparency to the relationship between drivers. Different levels of relatedness humanize the car, evoking social awareness and preventing anti-social driving behavior. In addition, the communities allow personal expression, which is another way of identity besides the styling of the car.

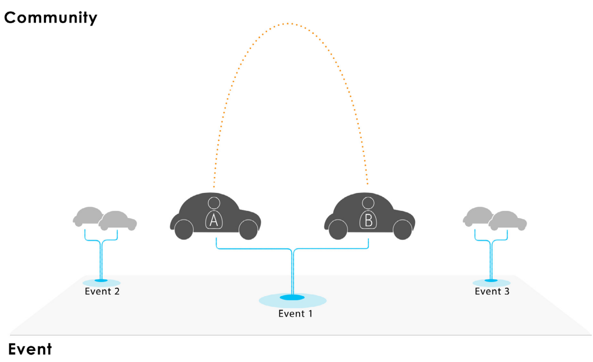

Fig. 1. Social graph of current driving activity

According to this social graph, if the connection between cars is established, plenty of information and social activities will emerge, which results in a boom of applications on the road.

1.2 Existing Initiatives Toward the Social Car

Nowadays, millions of social status updates and photos with location information are uploaded through Twitter, Facebook and Flicker etcetera every day. As a part of mobile Internet/Web, this wave is also emerging in the automotive domain. During the CES 2012 in Las Vegas, Mercedes Benz with its 2013 SL-Class model, showed an in-car platform able to connect and interact with Facebook. Drivers were able to insert messages by selecting pre-set messages with touch screen interfaces. In 2013, Volkwagen and Google launched an Android app called SmileDrive (smiledrive.vw.com), which enabled drivers to share their travelogue, filled with the captured photos, maps of the trip, status updates, as well as other memories that are collected on a single URL. Waze (www.waze.com), which has been acquired by Google at 1.1 billion dollars [7], is a highly engaged community of users willing to provide real-time traffic information. Beside apps based on the smart phone, automotive companies, IT companies and web companies have the ambition to establish platforms that provide an SDK for third party developers to create applications for the road. Although the understanding of connected cars in the future may be different, GM AppShop, Ford SYNC and the latest Apple's CarPlay allow third party apps running on their system, which may tremendously enrich in-vehicle applications.

The amount of applications will boom with the enhancement of the connectivity between drivers. But different organizations have distinct understanding of the future services based on the connected car. Because of the lacking of general rules underlying the structure of the social graph on the road and the difficulty in investigation of future concepts, it's hard to make predictions which direction will offer more opportunities among users.

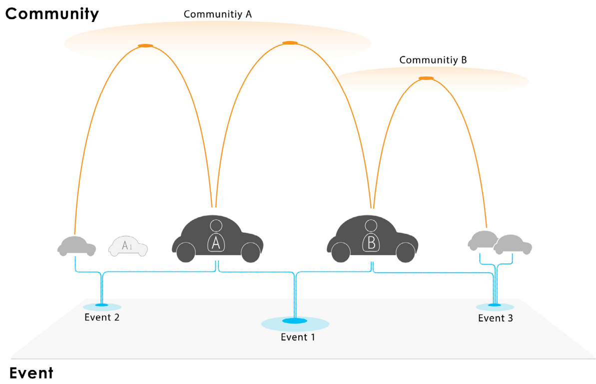

Fig. 2. Social graph of future driving activity

In this study, we applied the "CoConstructing Stories" Method [8] and integrated a group brainstorming method to generate initial concepts for social activities on the road, aiming to identify factors that influence people's acceptance as a reference for innovative design of social applications on the highway.

As the diversity of driving scenarios makes the research more complex, this research only focuses on highway driving, which requires less mental effort of drivers and concerns fewer elements (no pedestrians, traffic lights etc) than urban scenarios.

2 Methodology and Approach

The research involved two steps. In the first step, a brainstorm was conducted to obtain a set of ideas to discuss with potential users. In the second step, interviews were conducted with potential users using the "CoConstructing Stories" method. The CoConstructing Stories method is a participatory design technique for early, formative concept evaluation to elicit in-depth user feedback and suggestions. The development of the technique was motivated by the link between experiences, memories and dreams [8], and was based on the assumption that users are better prepared to judge whether novel design concepts will enable valuable experiences in the future if they revive their past experiences first. The social communication on the highway which is made possible by the development of ITS (Intelligent Transport Systems) technology, auto- pilot technology and novel HMI (Human-Machine Interface) technology, does not exist in current driving. As a result, we consider the CoConstructing stories method as an appropriate method by which researchers may create and evaluate fictional scenarios with participants.

2.1 Approach

Group Brainstorming and Categorization

The purpose of group brainstorming was to generate sufficient ideas for extensive analysis in the phase of CoConstructing stories. Three rounds of group brainstorming sessions were run with 16 researchers and students of different disciplinary backgrounds (including bckgrounds such as industrial design, and computer science).

First, a warming-up session was conducted, in which participants were asked to write down 10 things they like/dislike about driving. Then they were asked 2 questions that guided the ideation: What kind of ideas you would like to exchange with other people on the highway? What kinds of information and data could you imagine to be conveyed to drivers in the future? The participants were required to write down these ideas on paper cards and pass on the cards to the person sitting next to them every 2 minutes for three times. They were encouraged to freely think of any ideas inspired by their own past experience.

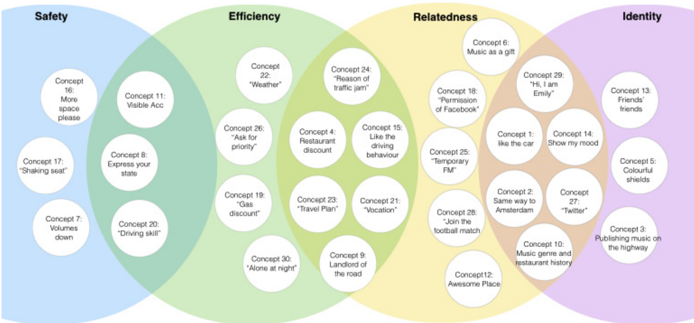

Fig. 3. The classification of concepts

After data clustering through all three brainstorming sessions, 30 ideas were generated in total. Initially, the ideas were categorized into briefly 8 themes: safety, comfort, efficiency, lifestyle, skill rating, sharing trips, free offers and communication. Later, the 8 categories were combined into 4 according to different levels of need [9] (see Figure 3). The hierarchy of categories from basic needs to higher needs is: Safety, Efficiency, Relatedness and Identity. The bordered categories are overlapping, because some of the concepts belong to both of them. Table 1 shows the description of all the concepts and the categories they belong to.

Table 1. Description of all the concepts. S, E, R, I indicate the category each concept belongs to. S: Safety; E: Efficiency; R: Relatedness; I: Identity. Some concepts belong to more than one category

S	E	R	I	Concepts
●				Imagine that you can remind the car behind you to keep distance..
●				Imagine that your seat vibrates from left to right to indicate that a car is going to overtake you from your rear of your left.
●				Imagine that your music volume goes down once the car in front of you suddenly breaks.
●	●			Imagine that you can discover a car running near yours cruises its way through automatic cruise control, self-driving etc.

Table 1. (*continued*)

●	●			Imagine your car can express your state: "I'm really in hurry!"
●	●			Imagine that you can check the driving skill of the driver whose car is in front of yours.
	●			Imagine that you are driving on the highway at night and can discover the nearest cars in front of you.
	●			Imagine that a driver whose child is seized with a serious sickness asks for priority on the emergency lane.
	●			When you are nearing your destination, you can get weather information there from other drivers in real time.
	●			Imagine that you can get fuel discount information if your fuel is low.
	●	●		Imagine that a driver on the road invites you to group with him for "group discount" in a restaurant.
	●	●		Imagine once you are caught in the traffic jam, you can see the road condition in front of you through the front camera of the cars ahead of you.
	●	●		Imagine that if a driver gives you the way to pass, you can "like" his driving behavior.
	●	●		Imagine that you and your friends will meet in a city; you can discuss the travel plan with your friends while driving.
	●	●		Imagine that you can discover that the driver nearby is working in a similar position or in the same industry as yours and that you are separated by two professional connections.
	●	●		Imagine that you can ask the landlord of the road for help
		●		Imagine that there is a platform for drivers to post some information on the road, and you can get filtered information that is relevant to you.
		●		Imagine that when you see a trendy car, you can ask for permission of his Facebook.
		●		Imagine that you can discover places that are recommended by other drivers or where drivers come often.
		●		Imagine that you can send a music track to the front car as a gift.
		●		Imagine you are caught in a traffic jam and having nothing to do. But you are invited to someone's personal FM. This time it is initiated by a driver with the topic "The match AJAX vs PSV tonight".
		●	●	Imagine that a car smiles to you, because it is the 10th times you pass each other on the highway. And you can get to know each other
		●	●	Facial expression of car to show the driver's mood: tired, angry
		●	●	Imagine that you can "like" the trendy car on the road.
		●	●	Imagine when you are on the road, the twitter messages of nearby drivers can be displayed.
		●	●	Imagine that you spot a trendy car on the road, you can check its music genre or restaurants history it often visits.
		●	●	You can get informed if a car nearby is from the same city and heading to the same destination as you.
			●	Imagine cars around you display the separation of friends between you and other drivers
			●	Imagine that some drivers can generate colorful "virtual shields" as decoration by augmented reality technology to show their personalities.
			●	Someone can publish the music that he is listening to.

Investigating User Opinions About Social Activities on the Highway Through the Co-constructing Stories Method

The CoConstructing stories method consists of two phases (Figure 4): sensitization and envisioning. The sensitization phase aims to make participants think about their past driving experiences, so that in the elaboration phase they can better envision the future. In the current study, in the sensitization phase pictures of relevant scenarios which were based on real driving experiences (Figure 5, Context Layer) were shown to the participant on the screen. After explaining each scenario, the researcher asked the user whether he recognized the story, and why or why not, engaging in a dialogue with the user and aiming to evoke relevant past experiences. Through questions the researcher encouraged the user to supplement the basic story with real life contents. As a result of this dialogue, user stories revealing past driver experiences were elicited that enriched the researcher's understanding of the current context of driving behaviors.

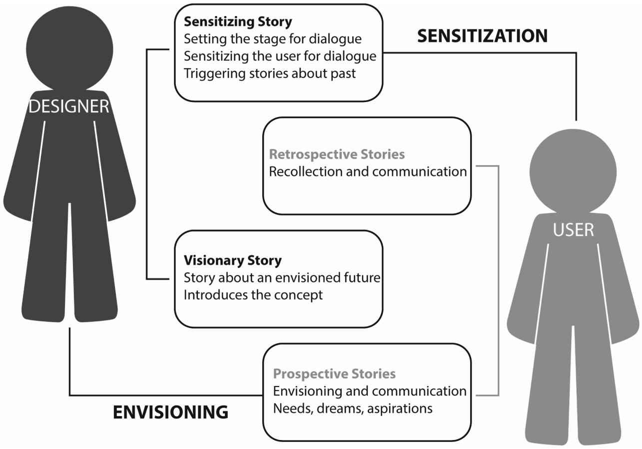

Fig. 4. Phases of CoConstructing Stories interviews

The second phase started with a 20 minute driving video in which 15 ideas were merged. The participants were seated in front of a TV and watched the video showing a driving situation. The video played until an image showing an idea appeared. Then the researcher paused the video, and told the story about this idea with the frame on the screen. Each frame consisted of 3 layers (Figure 5): 1. Context layer, which is an image clipped from the video. 2. Visualized information layer, which shows the social information in a visually augmented way. 3. Envisioning layer, which is the verbal description of each concept. After the explanation of the story, the researcher elicited positive and negative feedbacks about the concept by asking what the user liked and disliked in the story, and why. With these questions, the researcher encouraged the participant to supplement the basic story about the concept with contents representing anticipated future driving experiences, based on his needs, dreams and aspirations. At last, they were asked to fill three 7 points Likert type scales (ranging from -3 to 3), for Useful, Pleasant and Interesting. Additionally, they filled a summary scale for Degree of Liking, expressing the user's overall impression of the concept. The whole session lasted about forty minutes and was audio recorded. 22 participants attended the Co-Constructing stories sessions. They were divided into 2 groups of eleven participants each. One set of fifteen concepts was presented to group one, and the other set of fifteen concepts was presented to group two. All the participants were between 25-30 years old, and had more than 5 years driving experience. An impression of the setup is shown in Figure 6.

Fig. 5. Three layers of information presentation for the CoConstructing Stories method: 1. Context layer, which is an image clipped from a video showing a driving scenario. 2. Visualized information layer, which shows the social information in a visually augmented way (e.g. "Join me!" with icons for discount and restaurant). 3. Envisioning layer, which is the verbal description of each concept.

3 Results and Discussion

3.1 Analysis of Quantitative Data

For each idea, 11 participants gave ratings on four scales, Usefulness, Pleasure, Interest and Degree of Liking.

Correlations

To begin with, inter-scale correlations were calculated to see whether the different scales represented different constructs. Pearson correlations of the 4 dimensional data were found to be all quite high. The correlations between interest and Degree of Liking (0.919), usefulness and Degree of Liking (0.916) were a little higher than between pleasure and Degree of Liking (0.840) (Table 2). This suggests that Degree of Liking is related more to whether a concept is considered useful and interesting than whether it is considered pleasant.

Fig. 6. Setup for CoConstructing Stories method

Inspection of the correlations for the individual categories (Safety, Efficiency, Relatedness and Identity) indicate that the correlations between Degree of Liking and usefulness in the higher levels of hierarchy of needs ("relatedness" and "identity") are lower than in the lower levels of the hierarchy of needs ("safety" and "efficiency"). On the other hand, the correlations between Degree of Liking and pleasure, and Degree of Liking and interest in the higher levels of the hierarchy of needs are higher than those in the lower levels of the hierarchy of needs.

Descriptive Statistics

Figure 7 shows the average Usefulness, Pleasure, Interest and Degree of Liking score, ranging between -3 and +3, of the different concepts grouped by hierarchical need categories: Safety, Efficency, Relatedness, Identity (from left to right). Per category, individual bars represent individual ideas (some concepts belong to two categories and are included in both categories). Almost all concepts in the Safety and Efficiency groups receive positive ratings by the participants. The opinions for the concepts in the Relatedness and Identity categories fluctuate very much.

Table 2. The correlations of 4 dimensional data

		usefulness	pleasure	interest	likeness
usefulness	Pearson Correlation	1	.788**	.881**	.916**
	Sig. (2-tailed)		.000	.000	.000
	N	330	330	330	330
pleasure	Pearson Correlation	.788**	1	.816**	.840**
	Sig. (2-tailed)	.000		.000	.000
	N	330	330	330	330
interest	Pearson Correlation	.881**	.816**	1	.919**
	Sig. (2-tailed)	.000	.000		.000
	N	330	330	330	330
likeness	Pearson Correlation	.916**	.840**	.919**	1
	Sig. (2-tailed)	.000	.000	.000	
	N	330	330	330	330

**. Correlation is significant at the 0.01 level (2-tailed).

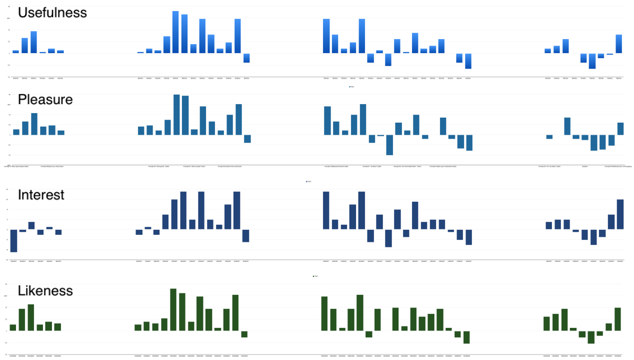

Fig. 7. Average ratings for the individual concepts, grouped by category. From left to right: Safety, Efficiency, Relatedness, Identity. Per category, individual bars represent individual concepts. Ratings range between -3 (minimum) and +3 (maximum). All ratings based on ratings from 11 participants.

Quantitative data provide the general feedback of acceptance of all the concepts from different categories, but what factors influence people to evaluate the concepts? The CoConstructing Stories method elicits in-depth feedback that is specific to the concepts. Some clues emerged from the conversation between the researcher and the participants. There are several main factors that appear to influence participants' feedback of the concepts. For different levels of needs, people pay attention to different aspect of concepts.

3.2 Analysis of Qualitative Data

For Safety concepts, people appear to have little tolerance of others' negative feedback. Receiving negative feedback while driving is considered very frustrating, especially if it comes from other drivers. For instance, if we take concept No.16 ("People can remind other drivers to keep distance"), participants believed they would dislike receiving this feedback from other drivers, but would be open toward being able to send the message themselves. In this category, encouraging people to display certain behavior, appreciating behavior or apologizing for certain behaviour are considered-more helpful to enhance the on-road tolerance (Figure 8, concept No.15: "liking the driving behavior") than disliking other drivers' behavior.

For Efficiency concepts, people care very much about the simplicity of the information. They see spending attention on road information as an investment. Only efficient solutions that are properly timed gain acceptance. For example, the concepts No.19 ("People can get "fuel discount" information when their fuel is low") received a high score for Degree of Liking. But some complicated applications, such as concept No. 23 ("The driver can make a travel plan with their friends when driving") obtained less acceptance. Some participants said, "It's not the right place to discuss so complicated issues on the highway."

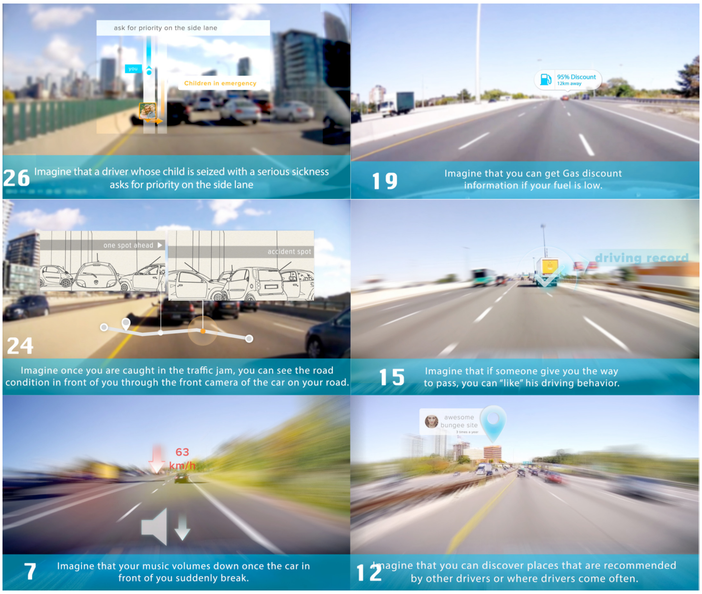

Fig. 8. Top 6 concepts which gained most acceptance: Concept 26 "Ask for priority"; Concept 19 "Fuel discount"; Concept 24 "Reason of traffic jam"; Concept 15 "Like the driving behavior"; Concept 7 "Volume down"; Concept 12 "Awesome Place".

With regards to the concepts belonging to the Relatedness and Identity categories, the Transparency and the type of Connection between drivers appeared to play a role. Transparency concerns the nature of the information that will be exchanged between drivers: with High Transparency, drivers share personal information like which restaurants they visit and their driving skill, mood or emotion. With Low Transparency, the nature of the information is more impersonal, like which music they like. Usually, the social activity on the highway is a social activity between strangers. Maintaining this social distance is considered very important. Some intermediary like music (Concept No. 24), which prevents leaking personal information but conveys personal identity could be useful to establish a temporary relationship.

With respect to Connection, Existing Connection concerns whether drivers have certain characteristics in common, such as when they work in the same company or whether they have passed each other several times before; it should be noted, though, that the drivers may not be aware of this existing connection. No Existing Connection concerns cases where such common history does not exist. Inspection of the pattern of results indicated that people don't like to interact with people with whom they share no common points. Concept No. 27 ("Twitter message of nearby drivers can be displayed") gains a very low score. " I don't care about the people I don't know" some participants said. But concept No. 2 ("You can get informed if a car nearby is from the same city and heading to the same destination as you") is more accepted by drivers. Also, most participants were not interested in strangers' expression of identity on the highway. They are confused to know the inner feeling of a stranger and they see the decoration of the strangers' car as distraction. On the other hand, for concepts involving the sharing of information between drivers between whom there is an existing connection, for example, if this personal expression is sent by family or friends, participants were more positive about the concept.

4 Conclusions and General Discussion

We investigated which types of concepts for social interaction between drivers are considered useful, pleasant, interesting and liked by drivers. Degree of liking was used as a summary rating. Looking at the Degree of Liking ratings, generally all the concepts belonging to the Safety and Efficiency categories received positive ratings by the participants.

As regards the concepts on the Relatedness and Identity groups, the results were mixed: some concepts were approved while others were clearly rejected. Closer inspection of the pattern of ratings and of the qualitative remarks suggested that for these categories additional factors are at hand. At least two such factors were identified: Transparency and the type of Connection between drivers. It appears that concepts involving the sharing of High Transparency information were liked less because of privacy considerations, and that the absence of an Existing Connection decreases the likelihood of a concept being liked: most participants were not interested to receive information about strangers on the road, especially in the Identity category. Combining the two factors, it appears that concepts which combine Low Transparency and Existing Connection have a high probability of being liked. A decision tree, shown in Figure 9, was created to summarize these results. However, as is clear from the decision tree, the additional factors by no means provide a complete understanding of the pattern of like and dislike, so that further research is needed.

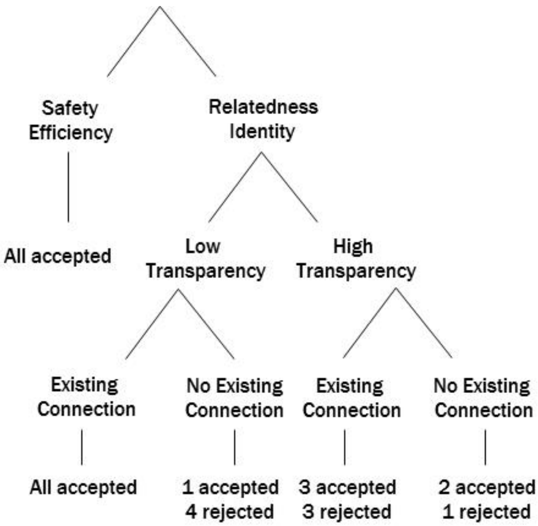

Fig. 9. Decision tree for liking of social car concepts

A set of 30 concepts is a very small sample comparing with the countless applications on the highway in the future. Considering additional concepts may provide clues for additional factors and may help to formulate more precise hypotheses about factors influencing whether concepts will be considered useful and will be liked by drivers. In addition, the scenarios considered were only highway scenarios. Concepts for other contexts such as urban environments will extend the research. Furthermore, the acceptance of applications depends on three distinct perspectives: utility, usability and cost. In this paper, we only considered utility. In future work, new prototypes will be made to investigate contributions of usability and cost, which is related to another important topic of acceptance: How can the information be conveyed to drivers in an appropriate way that balances safety, convenience and joy? Finally, all the efforts are helpful to generate insights about future transportation services for carmakers, governments and researchers.

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Preface

The annual Ambient Intelligence conference is the prime venue for research on ambient intelligence, with an international and interdisciplinary character. It brings together researchers from the fields of science, engineering, and, design working toward the vision of ambient intelligence.

Volume 8850 of Springer's LNCS series is the formal proceedings of the 11th event in the Ambient Intelligence series, an event that took place in Eindhoven, the place where the conference first started in 2003 as a European Symposium on Ambient Intelligence. The return of the conference to its birthplace is not a superficial coincidence. It reflects the need for this conference and the community of researchers it serves to define their own identity and direction for the future, and the realization that while much of the original ambitions for this research field have been realized a lot remains still to be done.

Since the emergence of ambient intelligence as a vision on consumer electronics, telecommunications, and computing technologies for the time frame 2010–2020 much has changed. The original conceptions of the field discussed, e.g., by Harwig and Aarts[1] still drive current developments." Researchers are still working towards embedding technology in the environment, supporting context awareness, personalization, and adaptivity of ambient intelligence technologies, and even adapting system behavior autonomously to meet user's needs. These ambitions take new meaning and a higher complexity nowadays as they pertain to more numerous, miniaturized, and complex devices than foreseen in the early days of the field. On the other hand, early scenarios of ambient intelligence, as for example those of the ISTAG advisory group which Europeans researched for more than a decade, are starting to reach the consumer market and to become a part of our daily lives. As ambient intelligence is applied in different application domains and new themes arise for the field, it became necessary to explore in-depth some of the most vibrant areas of research in ambient intelligence.

In 2014, the AmI conference was thus organized along a set of thematic tracks, which cover current areas of research in ambient intelligence. These tracks were led by each of the editors of this volume, who recruited specialized reviewers. Track chairs proposed rankings of articles which were merged in a process moderated by the program chairs of the conference. The tracks for AmI 2014 are the following:

- Ambient Assisted Living
- Internet of Things
- Ambient Play and Learning
- Smart Buildings and Cities
- Intelligent Driving
- Data Science

[1] Harwig, R., & Aarts, E. (2002). Ambient intelligence: invisible electronics emerging. In Interconnect Technology Conference, 2002. Proceedings of the IEEE 2002 International (pp. 3–5). IEEE.

- Smart Healthcare and Healing Environments
- Ambient Persuasion
- New and Emerging Themes

Full and short papers were reviewed in a single review process, where reviewers were advised to adjust their expectations on completeness of the work and the contribution expected from each paper to its length. Each paper was reviewed by at least two reviewers, and the median number of reviews was 3. On the basis of this review, a ranking was made and a selection of the papers suitable for inclusion in the proceedings and for presentation at the conference resulted in accepting 26 out of the 59 papers submitted (acceptance rate 46 %).

We hope that this collaborative effort has resulted in a rewarding volume that captures current trends and evolving themes in this field, and helps as a reference point for researchers, students, and industry.

We wish to thank all authors for contributing their work, and the reviewers for the effort they have put in the selection process and in providing feedback to help authors improve the presentation of their work.

October 2014

Emile Aarts
Boris de Ruyter
Panos Markopoulos
Evert van Loenen

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