



Enhancing Social Closeness between Drivers by Digital Augmentation

Chao Wang, Jacques Terken, Jun Hu & Matthias Rauterberg

To cite this article: Chao Wang, Jacques Terken, Jun Hu & Matthias Rauterberg (2020) Enhancing Social Closeness between Drivers by Digital Augmentation, International Journal of Human-Computer Interaction, 36:5, 477-494, DOI: [10.1080/10447318.2019.1662635](https://doi.org/10.1080/10447318.2019.1662635)

To link to this article: <https://doi.org/10.1080/10447318.2019.1662635>



© 2019 The Author(s). Published with license by Taylor & Francis Group, LLC.



Published online: 20 Sep 2019.



Submit your article to this journal [↗](#)



Article views: 339



View related articles [↗](#)



View Crossmark data [↗](#)

Enhancing Social Closeness between Drivers by Digital Augmentation

Chao Wang*, Jacques Terken, Jun Hu, and Matthias Rauterberg

Industrial Design Department, Eindhoven University of Technology, Eindhoven, Netherlands

ABSTRACT

Driving is a social activity: Drivers need to coordinate and cooperate with each other to share the infrastructure. The relationship between drivers influences their driving behavior and experience. Lights, horn and speed are the most frequently used means to exchange information, limiting both the range and the bandwidth of the connectivity and leading to isolation, loneliness, and competition. We present “iSticker” and “MusicHound”, two concepts that aim to establish a connection by presenting similarity information between drivers. The two concepts were prototyped and evaluated with users in a driving simulator. The results showed that *iSticker* and *MusicHound* enhance drivers’ social closeness with each other and belongingness during the journey.

1. Introduction

Humans are social by nature. The pursuit of relatedness is one of the three basic motivating principles which underlie social behavior (Baumeister & Leary, 1995). One cannot live for a long time without socializing with others. Social networks such as Facebook fulfill the need of belongingness of people (Seidman, 2013) and mobile internet services enable us to stay in touch anywhere anytime. However, from the social perspective, the car is an isolated space. While driving, people are “encapsulated in a domestic, cocooned, moving capsule, an iron bubble” (Urry, 2007). The car offers a confined space, which allows for individuality and privacy in a public space. However, it detaches drivers from their environment at the same time. This kind of detachment decreases drivers’ belongingness and closeness to other drivers, which may lead to loneliness in a long journey and selfish driving behavior. The advent of everywhere available connectivity and the broad penetration of social network services offers opportunities for changing this situation (Schroeter, Rakotonirainy, & Foth, 2012).

From a previous study of Wang, Gu, Terken, and Hu (2014) in which thirty different “social car” ideas were discussed with more than twenty people, *iSticker* and *MusicHound* emerged as two promising concepts. *iSticker* enables drivers to choose virtual stickers and see nearby drivers who have similar stickers. *MusicHound* matches drivers who have a similar music taste and allows them to share music with each other and enjoy music together. In the studies reported below, the concepts were elaborated, prototyped and experiments were conducted in a driving simulator to investigate the acceptance of the applications and whether it exerted a positive influence on driving experience and social closeness on the road.

2. Related work

2.1. Mix without meet: Lack of closeness between drivers

Social closeness is defined as “the experience of positive emotions toward another individual or set of individuals” (Ratan & Tsai, 2014). While driving, a driver usually encounters tens or hundreds of other drivers on the road. However, the bandwidth of interaction is restricted to signals of cars such as horn, indicator or using the clunky movement of the vehicles as a form of body language (Juhlin, 2013). Drivers are constrained behind their steering wheels and “interact” monotonously with non-human-like machines on the road. Although people “meet” many drivers on the road, perceiving no social bonding or relationship between them will hinder the closeness between drivers (Baumeister & Leary, 1995). Lack of social closeness leads to aggressive driving behavior and less belongingness during of the journey (Baumeister & Leary, 1995; Ratan & Tsai, 2014).

2.2. Lack of closeness between drivers contributes to aggressive driving behavior

In the CSCW (computer-supported cooperative work) domain, social closeness is an important factor that influences the collaborative willingness (Reychav, Ndicu, & Wu, 2016), task effort (Walther, 1997) and outcome (Walther & Bunz, 2005) of the online cooperation. Sharing the road is a form of cooperation (Juhlin, 2013; Renner & Johansson, 2006). As a result, social closeness between drivers also exerts influence on the drivers’ coordination with each other.

A field study by Ellison, Govern, Petri, and Figler (1995) found that drivers behave more aggressively to drivers who use tinted windows. Based on a survey and interview study,

Ratan et al. (Ratan & Tsai, 2014) supported there is a negative correlation between the social closeness and driving aggression. They suggested that when drivers feel socially closer to others, they may “drive in ways that are more considerate of others’ safety”. Research by Caspi et al. (1997) and Gulliver and Begg (2007) suggested that social closeness is a factor that contributes to risky driving behavior between young adults. A simulation study conducted by Mitrevska, Castronovo, Mahr, and Müller (2012) found that establishing social bonding through revealing common personal interests between two drivers reduces their aggressive behavior to each other.

This can be explained by the relation between the social closeness and positive empathy (Morelli, Lieberman, & Zaki, 2015), tolerance (Brosnan, Schiff, & De Waal, 2005) and trust (Podobnik, Striga, Jandras, & Lovrek, 2012). This means when a driver feels closer to another one, he is more willing to understand the driver’s experience (empathy), shows more forgiveness of others’ mistake (tolerance) and believes in reciprocity (trust).

2.3. Lack of closeness between drivers leads to social disconnection

Being related to others is one of the basic human needs (Baumeister & Leary, 1995; Rettie, 2003). However, being constrained behind their steering wheels and “interacting” monotonously with non-human-like machines on the road detaches drivers from their environment and social society, which may lead to loneliness and decrease the pleasure of the journey. According to an interview by Redshaw (2012), some drivers who commute on the same route every day complain about the boredom of spending time on such journey and describe it as a compulsory task. Nowadays, this phenomenon becomes more obvious while we are getting used to “stay always online” using our mobile devices. Therefore, while our bodies are physically constrained in the vehicle, our minds are trying to escape from the “iron cage” and regain the connection with the outside world. People engage in dangerous activities such as calling or texting their friends even though they know this activity may lead to severe distraction from their driving task. A government survey in 2011 (Petroulias, 2009) showed that, despite legislative bans, 59% of Australian drivers used their mobile, with 31% sending text messages while driving.

2.4. Increasing social closeness by digital augmentation

Previous research suggests that the similarity between people is related with closeness (Tesser & Campbell, 1980; Tesser & Paulhus, 1983). Liviatan, Trope, and Liberman (2008) argued that interpersonal similarity can be seen as a dimension of social closeness, based on the experiment result that similarity influences one’s judgment of others’ actions. In the driving scenario, the only clue which reveals the identity of drivers is the appearance of the vehicle. We feel little inclusion as few similarities can be found based on the styling and brand of others’ vehicles.

With everywhere available connectivity and the broad penetration of social network services, the communication between drivers on the road may change fundamentally. Firstly, quality and quantity of information can be transferred

without any limitation, and rich content such as image, voice or text can be sent by digital channels. Secondly, information can be delivered to a specific driver, without being released to irrelevant drivers. As a result, based on analysis of participants’ social media profile, such as Facebook, it is possible to establish social bonding between drivers by exposing their similarity to each other. Some attempts have already made to enhance the social closeness in this way.

Motorcycling is a strikingly social activity, and motorcyclists are also explicit about their interest in other motorcyclists, which is visible in the way they often greet other bikers they meet along the road (Esbjörnsson, Juhlin, & Östergen, 2003). Esbjörnsson et al. (2003) implemented a prototype called “Hocman” which enhances brief traffic encounters between bikers by playing a sound clip and automatically exchanging personal HTML pages. Field study results showed that bikers enjoyed such added value to biking.

Yasar et al. (2010) proposed a system which could exchange traffic information, such as congestion or free parking place between drivers. By combining the social network and the vehicular network, the system enabled such information to be transferred by “a friend-of-a-friend”. This social bonding that increases the closeness between strange drivers makes the information more trustworthy.

Schroeter et al. (2012) proposed a concept of *Visualizing Degrees of Separation*, which would “humanize” cars. By analyzing the drivers’ social network, the degree of separation and avatar of others could be displayed in the augmented-reality windshield, for the purpose of evoking people’s “emotional” response and to decrease anti-social driving behavior. However, there is no further development of this concept, simulator nor field study.

Mitrevska et al. (2012) suggested a system which established bonding between drivers by matching the similarity of their Facebook profile to reduce anonymity. Then, this concept was prototyped into a simplified simulation game where the participants could not drive but could press four buttons (AngryComments, HornHonk, HappyFace or ThumbsUp) to other drivers. The user test showed that participants behaved more politely to the drivers who had common personal information.

So far, most of the studies are limited to concept exploration, questionnaire survey or empirical study, and there is no systematic research conducted to investigate on how digital information influences social closeness. This study tried to establish social bonding between people by matching drivers’ profiles, to increase social closeness between proximate drivers on the road.

3. Application

3.1. Aims and research hypotheses

iSticker and *MusicHound*, which enable the driver to see a virtual sticker and hear the music of nearby cars, were proposed and corresponding prototypes were implemented in a driving simulator. Then, two user tests were conducted to investigate the acceptance of these concepts and whether they exerted a positive influence on social closeness.

We tested three hypotheses:

H1: People hold a positive attitude toward *iSticker* and *MusicHound*.

H2: The applications have a positive influence on social closeness.

H3: The applications do not distract from the primary driving task.

In the following sections, the two studies are presented. The outcomes will be discussed jointly in conclusion section.

4. Study one: *iSticker*

4.1. Concepts and rationale

4.1.1. *iSticker*: extending the bumper sticker culture to the avatar on the road

According to social identity and social categorization theory, individuals evaluate others into various groups (Nowak & Fox, 2018), which helps people to organize and understand the social world more efficiently (Fiske, Gilbert, & Lindzey, 2010). People feel more social closeness with and respond more positively to others who are in the same category as themselves (Hornsey & Hogg, 2000; Nowak & Fox, 2018). As a result, it should be possible to enhance the closeness by creating the perception of group affiliation between drivers.

The way people group others is based on demographic features (e.g., sex, age, ethnicity, or religion), personality and interests (Fiske et al., 2010), etc. In the driving environment, bumper stickers and other signs affixed to the vehicles can be seen as a cue for the categorization process. Based on the result of investigation of bumper stickers that communicated candidate preferences during the 1992 presidential election, Endersby and Towle (1996) suggested that: “display of bumper stickers often is an expression, not of individualism, but of group affiliation”, and drivers want to use their vehicle as a “form of identification and solidarity with a group sharing common beliefs”. However, traditional ways, such as physical bumper stickers, ornamentations or “objects” inside windshields, because of being fixed, limit the communication.

The digital form of a bumper sticker is a promising solution. In the computer-mediated environment, an avatar can be defined as a “digital representation of a human user that facilitates interaction with other users” (Nowak & Fox, 2018). It is not surprising that people also engage in similar categorization processes like face-to-face interaction when they perceive avatars as social entities (Nowak, Hamilton, & Hammond, 2009). Several studies suggested that interacting with avatars that have common features or belong to the same social categories bolsters positive impressions of partners or teammates (Nowak & Fox, 2018).

Based on previous research, we proposed *iSticker*, which presents similarity and cues for categorization through avatar, to enhance the social closeness between drivers. The concept of *iSticker* is described in the following scenario:

Peter is a Marvel hero fan. Yesterday he chose the virtual icons “Spiderman” in the “*iSticker*” online service for his car. Now he is on the highway to Berlin. On the road he sees several fellow

drivers who have “Ironman”, “Deadpool” and “Ant-man” badges when they approach. He knows that they can see his badge as well because they chose their icons in same category.

Although the conceptual definition of avatar differs across previous studies, the most liberal definition of the term would entail any representation of any controller (Nowak & Fox, 2018), such as a photograph on a social network, a graphical icon or a 3D virtual body. *iSticker* enables drivers to choose various digital representations, such as movie characters, football teams or cartoon figures. Compared with physical bumpers, *iSticker* has two main differences: First, it does not limit the communication. Drivers can see others’ stickers clearly at far distance. Secondly, only the drivers who have similar interests can see each other’s stickers, as the sticker is only disclosed to people from the same community.

4.2. Apparatus

A prototype based on the concept, which enables participants to see to the other drivers’ “stickers” was designed, developed and integrated in a driving simulator. The driving simulator included a steering wheel, seat, pedals, gears and three 32” screens (Figure 1).

4.3. Design and prototype

For providing visual feedback, an enhanced navigation interface was shown on a 10” screen attached in a driving simulator. The interface which integrated 3D maps was designed to show three layers of information (Figure 2):

- (1) Geography layer: 3D model of the driving scenario (imported from the driving simulator), including roads, lanes, signs, important buildings, etc.
- (2) Vehicle layer: Represents the participant’s vehicle and surrounding vehicles.
- (3) Notification layer: Information such as speed, virtual stickers of other cars and participants’ cars.

There are two states of the interface:

State 1: If there are no drivers with stickers in the same community, the interface shows the own car as well as nearby cars on the road.

State 2: If there is a nearby car with a sticker, an icon appears on top of the representation of the corresponding car in the interface. Furthermore, a ripple animation pops up on the car with the sticker to draw the driver’s attention (Figure 3).

4.4. Evaluation

4.4.1. Evaluation setup

Forty participants took part in this experiment. The participants were divided into two groups, with Group 2 acting as a baseline condition for Connectedness and Social inclusion on the road. In order to get equal groups, we balanced gender and driving age. They had quite equal driving experience, measured in the amount of years that the participants had



Figure 1. A 10" screen was integrated in the driving simulator.

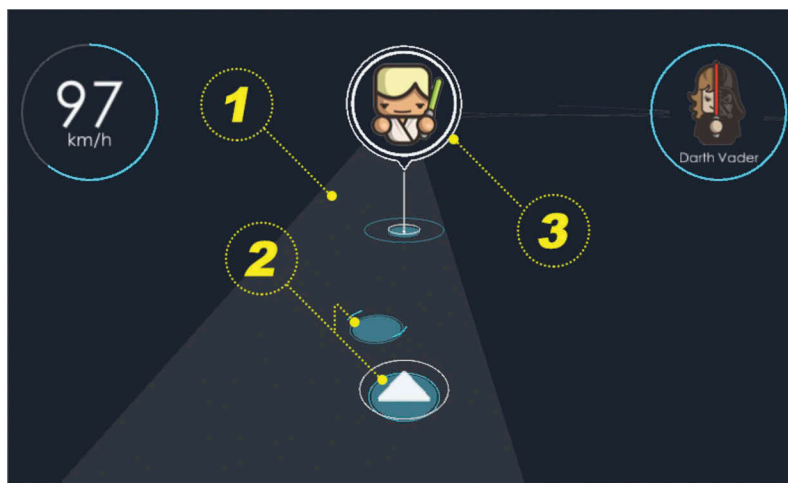


Figure 2. User interface design. 1) Geography layer; 2) Vehicle layer; 3) Notification layer.

a driver's license: 5.95 (SD 2.72) for the sticker group 5.50 (SD 3.53) for the control group. For participating in the experiment, each of them received a 5-euro reward.

4.4.2. Choosing stickers

Before the test, the *iSticker* concept was introduced. Then, the participant was asked to select one virtual sticker to put on their car from a list (Figure 4). The list contained 119 stickers in eleven categories, which included figures from movies, TV play, cartoons, games and football teams. Each category contained at least four Stickers.

4.4.3. Scenario

A highway scenario that included curves, viaducts, entrance ramps, and exit ramps, along with low density of traffic was created for testing. The total duration of the scenario was 10 min. The navigation was disabled in this study. Participants were told to drive straight and not leave the highway.

4.4.4. Experiment procedure

Before the formal test session, each participant was invited to drive in the simulator in a free driving mode for 10 min with

the purpose of getting familiar with the driving simulator. Then, each participant from the sticker group was introduced to the concept.

For each participant in the sticker group, there were three cars, each with a different sticker from the same category appearing in three different segments of the road. The participant was told that there might be some other drivers who had similar "Stickers" appearing on the road. For the other group, acting as a baseline condition, there was no car with a sticker but the interface of 3D maps remained. After the driving session, the participants of each group were asked to fill in the questionnaire and people in group 1 had a semi-structured interview.

4.4.5. Dependent variables

Four questionnaires were used to evaluate the belongingness, social closeness between participants and other drivers, mental effort of the application and the appeal of this application.

To measure belongingness, the *Revised Social Connectedness Scale* (SCS-R) (Lee, Draper, & Lee, 2001) was used. SCS-R was developed by Lee et al., to measure belongingness based on H. Kohut's self-psychology theory (Baker & Baker, 1987). SCS-R includes 20 items. To reduce the length of the entire



Figure 3. The virtual sticker in the interface matches the car in the simulated scenario.



Figure 4. Some virtual stickers which could be chosen by participants. The stickers were designed by Konrad Kirpluk (Kirpluk, 2014) and the usage was authorized.

questionnaire, the number of questions of the SCS-R scale was reduced to 6 including three positively worded and three negatively worded ones. The Connectedness score is the average of the scores for the individual items (after inverting the scores for the negatively phrased items).

To measure the social closeness between the participants and surrounding drivers on the road, the pictorial *Inclusion of Community in Self* (ICS) scale was used (Mashek, Cannaday, & Tangney, 2007). The scale is composed of six pictorial representations of two circles (one representing the community and the other

representing the self). Each of the pictorial representations varies from its neighbor by the size of the intersection surface. An increase in this intersection shows a closer sense of inclusion to the community. In the questionnaire, the community side was described as the other drivers.

To evaluate mental effort, the *Rating Scale for Mental Effort* (RSME) was adopted (De Waard, 1996). RSME is a unidimensional labeled scale. Participants rate invested effort by a cross on a continuous line running from 0 to 150 mm, and every 10 mm is indicated and labeled from “absolutely no effort” to “extreme effort”.

To measure the appeal of the driving situation, we used a semantic differential (Osgood, Suci, & Tannenbaum, 1957), which was constructed by Hassenzahl, Platz, Burmester, and Lehner (2000) and contains items such as “pleasant-unpleasant”, “attractive-unattractive” and “desirable-undesirable” (7 point scales). Participants were asked to evaluate the feeling of their experience of the journey. The Appeal score is the average of the scores for the individual items.

At last, a 11-point Likert scale about how participants liked the other cars’ “Stickers” appearing in the scenario was also included, for the purpose of examining whether they liked the others’ icons.

4.5. Results

4.5.1. SCS-R scale

An independent T-test was conducted to compare the social connectedness level of the two groups. Results showed that the participants who could see others’ “stickers” felt significantly higher belongingness (Mean = 3.4, SD = 0.48) than the participants in the control group (Mean = 2.8, SD = 0.68), $t(38) = 3.197$, $p = .003$, $r = 0.46$ (Figure 5).

4.5.2. ICS scale

As the scale judgment represent ordinal data, non-parametric test (Mann–Whitney U) was conducted to compare social closeness of two groups. The result shows that participants in the scenarios where they could see “Stickers” felt significantly higher closeness ($Mdn = 3.0$) between themselves and other drivers on the road than the participants in control group ($Mdn = 2.0$), $U = 125.5$, $p = .036$, $r = 0.33$ (Figure 6).

4.5.3. Mental effort

As the RSME scale judgment represents ordinal data, a non-parametric test (Mann–Whitney U) was conducted to compare the mental effort of the two groups. No significant difference was found between the two groups. The median mental effort of the group where participants could see others’ sticker was 31.0, compared with the control group whose mean was 23.0 ($U = 183.0$, $p = .645$).

4.5.4. Appeal

This measure provides insight into the appeal of this application. Based on the Independent T-test, the result of the appeal questionnaire in group 1 (Mean = 5.8, SD = 0.55) is significantly higher than in group 2 (Mean = 2.36, SD = 0.84): $t(38) = 15.506$, $p < .001$, $r = 0.93$ (Figure 7).

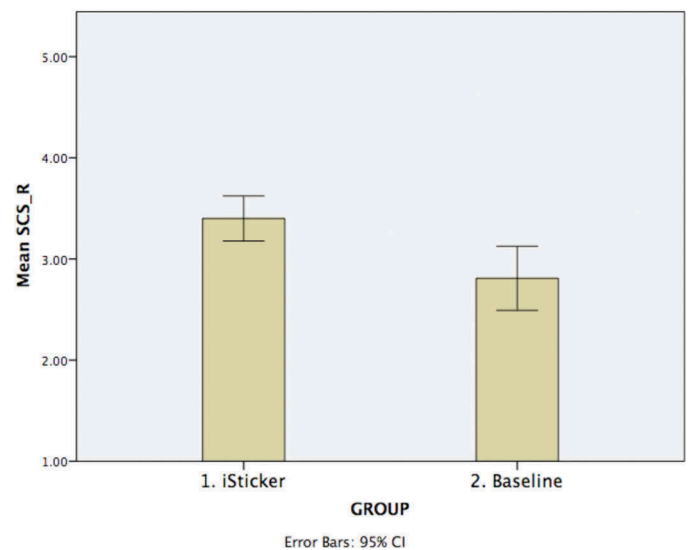


Figure 5. Mean of the result of SCS-R scale (ranges from 1 to 5).

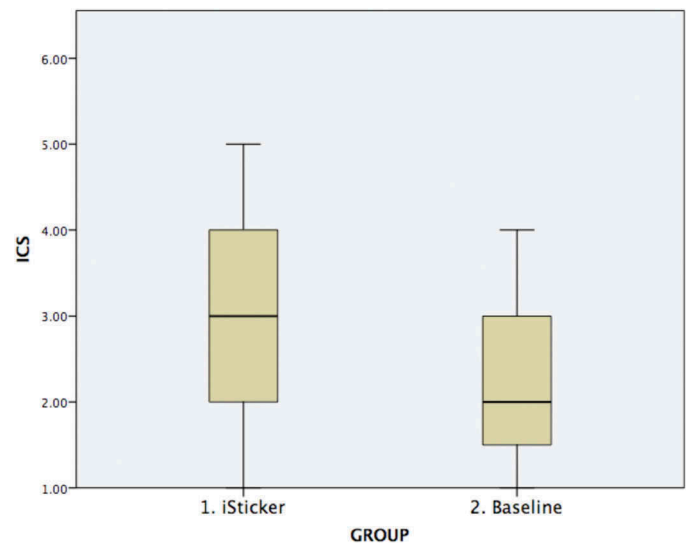


Figure 6. The result of ICS scale (ranges from 1 to 6).

4.5.5. Liking of “stickers”

This scale, which ranges from 1 to 11, shows how participants liked the “stickers” appearing on the others’ cars. Most participants gave a high score of preference (Mean = 9.1, SD = 1.85). Only one participant gave a score below six. The result indicated that most participants liked the others’ “stickers” in the experiment.

4.6. Qualitative research

In order to gain structured insights from our study, we transcribed and analyzed the interview data by qualitative content analysis (Hsieh & Shannon, 2005). In this section, we report on the results of in total 258 textual descriptions. The descriptions were coded by the first author using the following three themes: (1) Factors influencing the acceptance of the concept, (2) Factors influencing the social closeness and (3) Factors influencing the distraction from the driving task (Table 1).

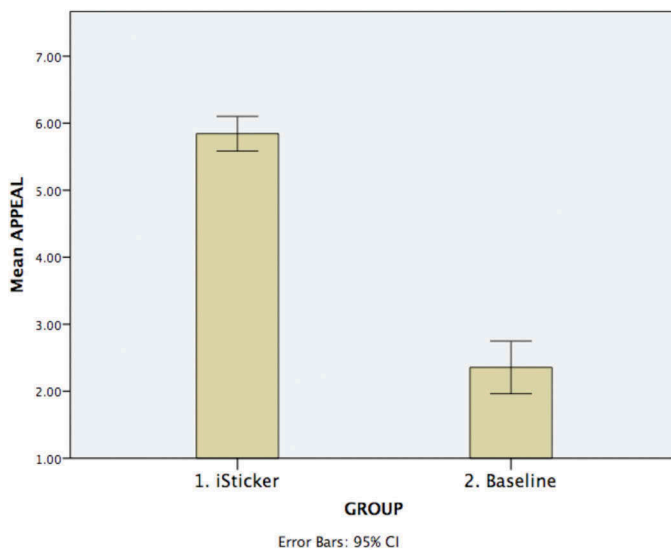


Figure 7. Mean of the result of Appeal questionnaire (ranges from 1 to 7).

4.6.1. Acceptance

Ninety-one quotes in this theme provide insight on peoples' general idea of this application. Participants were firstly asked to "describe this application", then to explain the reason for the descriptions. Three dominant categories were generated from the analysis of the quotes: *general description*, *positive factors*, and *negative factors*. Almost all of the quotes in *general description* were positively worded. This result supported the Appeal questionnaire, which indicated that this application got a high acceptance. After analysis of the *positive* and *negative factors*, we found two main reasons that the participants liked the concept. Firstly, it can reduce boredom, especially for long a journey. Secondly, it fulfills people's social demands on a lonely journey. Regarding the influence of this application on driving behavior, some participants thought *iSticker* could induce them to drive more politely by providing identity information of anonymous drivers. The mostly mentioned negative factor is the distraction, this part is elaborated in the following "distraction" part.

4.6.2. Social bonding

This theme collected 106 quotes describing participants' feeling of social inclusion as well as the reasons behind it. Most participants confirmed that *iSticker* increased their feeling of social bonding, which was in line with the quantitative data. The most mentioned factor that influenced the social bonding was the *similarity*. They thought that others also have the same interest when they saw the stickers. This result corresponds to the social identity theory.

However, about one-third of the participants did not feel much social bonding with other drivers. They stated that the relatedness brought just by stickers is not strong enough and that further interaction and more overlapping of their profile would increase their feeling of connectedness. Furthermore, they were willing to have further interaction with the drivers with stickers, such as saying "hi" or even starting a conversation. Actually, one-third of the participants already tried to interact with the drivers with stickers, such as following the car, intentionally

overtaking the car or looking at the faces of the drivers. This result suggests that only presenting a sticker may not be enough to fulfill people's social demand on the road.

4.6.3. Distraction

Fifty-nine quotes from 20 participants described the distraction issues, which were further separated into three sub-categorizations: *general judgments*, *interface*, and *scenarios*.

About one-third of the participants confirmed that they felt at least a little distraction. Two participants said that they felt moderated distraction. Many participants suggested solving this problem by novel human-computer interaction design. For example, displaying a sticker on the windshield by augmented reality technology would enable the user to map the sticker-car more quickly than just displaying an icon on the cluster screen. It was also recommended using an adaptive interface that can show the stickers only when the driver's workload is low.

5. Study two: Musichound

5.1. Concepts and rationale

5.1.1. Musichound: Music as a social bond connecting drivers

Enjoying and creating music is often a collective activity (Håkansson, Rost, & Holmquist, 2007). Music can meet our social need and plays an important role in how we identify and express ourselves (Frith, 2002). Sharing music with others often fulfills a social function. The content of music may be used to establish new social links and maintain existing ones. Nowadays, thanks to the widespread connectivity of internet and location-based services, portable devices can also be used to connect with other people in physical space. Various projects have been conducted to investigate sharing music in urban environments.

The ethnographic project *Underground* (Bassoli, Brewer, Martin, Dourish, & Mainwaring, 2007) provides an application for music exchanging in London Underground. It allows artists to upload songs in specific points, and the user can download these songs from these points or from collocated users, browse profiles of users in the vicinity, and send messages. The *Compass* (Tanaka, Valadon, & Berger, 2007) project uses mobile phones to exchange music with collocated people. A compass metaphor is applied as user interface on the cell phone to visualize nearby networks, people, and music. The application enables users to exchange music when both users are within Bluetooth or wireless network transmission range. The mobile application *Capital Music* (Seeburger, Foth, & Tjondronegoro, 2012) enables real-time sharing of song choices with collected urban dwellers. People can exchange metadata of music as well as the artwork of the currently played song with nearby users. Besides, this application enables users to send text messages and "Like" messages.

As the automobile is the most popular and frequently reported location for listening to music (Brown, Sellen, & Geelhoed, 2001), we utilize the music as a media to establish social bonding on the road. The concept *MusicHound* is described as follow:

Table 1. Categorization of textual descriptions with the numbers of quotes and participants for each (sub-)category indicated within parentheses.

Category (N of quotes/participants)	Sub-Category (N of quotes/participants)	Exemplar quotes
<i>Theme 1: Acceptance: Which factors influence people's attitude toward the concept?</i>		
General Description (23/20)	Positive (20/17)	"Actually, I like it a lot. It's funny to see another person who is also interested in 'Star Wars'."
	Negative (3/3)	"It gives us opportunity to do something instead of just driving."
Positive Factors (52/13)	Reducing boredom and loneliness (34/15)	"Rather than 'horning' him. I will be more tolerant, not get angry."
	Improve driving behavior (7/5)	"As a co-pilot, you can do anything you want. As a co-pilot, you can socialize. But as driver, you must put your eyes on the roads, otherwise you crash."
Negative Factors (16/9)	Distraction (6/3)	"But how does it relate to driving"
	Necessity (2/1)	"But in this scenario, I think there is a log in the screen"
	Limitation of simulation (2/2)	"Just cartoon, there is no further interaction ... not so interesting"
	No further interaction (2/3)	
<i>Theme 2: Social bonding: Which factors influence the social closeness?</i>		
Existing Social Bonding and related reasons (24/14)	Similarity of Stickers (16/8)	"I don't know what person the other guy is, but I know I do have a relation with him because he is also a Star Wars person."
	Others (8/7)	"When it appears, it would be different."
No Social Bonding and related reasons (11/6)	Not strong bonding by sticker (9/6)	"I wouldn't say exactly related ... The movie interest maybe too small to ... really think of ... relation."
	Others (2/2)	"It just appears like any other things passing by."
Behavior (17/9)	Looking at face (9/8)	"I just following that person, and being like, okay, being curious to see who is this person."
	Following (5/4)	"He drove so slow, I was waiting him. I contact him physically."
	Overtaking (3/3)	"He tried to give some feedback to me, kept distance with me, I tried to horn, overtake him etc. ... But I think he knows me, and tried to interact with me ... "
Increasing Social Closeness (56/17)	Overlapping of the profiles (37/12)	"For example, you can give several badges all together, the sports, super hero, at least two or three, then your feel more related."
	Further interaction (19/12)	"... So, I just click on the screen and say 'hi' and start the conversation, could you let me know what place to visit or something."
<i>Theme 3: Which factors influence the distraction from the driving task?</i>		
General judgment (22/20)	No distraction (12/12)	"... this just lasts a few seconds, so I don't think it's distracting. That's just like navigation."
	Certain distraction (8/7)	"It is a sort of distracting over there. Because I found I was not continually looking at the screen showing who has a badge."
	A lot distraction (1/1)	"It is too much distraction for me."
Interface (18/7)	Mapping stickers (18/7)	"It was a big difficulty, especially when the car is ahead and there is a bit of traffic. I couldn't get from the screen which one it was."
	Design detail (/3)	"I have to pay attention to recognize the other's figure."
Scenarios (19/8)	Density of traffic (5/5)	"Yes, but it depends, in some scenarios with a lot of traffic, it may distract me. But in the traffic jam or red light ... very appropriate."
	Traffic jam or traffic light (6/4)	"In the traffic jam, rush hours, it is very appropriate."
	Speed of vehicle (3/2)	"I think the speed is also an important thing."
	Others (5/4)	"If there are cars on the all three lanes maybe it is kind of distracting."

Donald has been driving alone for 2 hours on the highway. There are not many cars on the road at this moment, the long tedious journey makes him a little bored and lonely. He decides to opens the "Music-Around-Me" application of his car. Then the system scans his music list to analyze his preference of music for better matching. Several minutes later, when approaching a car in front of him, a slight rhythm of "Only Love" is rising in his cabin. The text indicates that the music is played by the front car. "It's my style", he thinks. So, he waves his hand to get the song playing in his own car. Then the two cars start to play the music together.

MusicHound links to drivers' social media profile and matches drivers based on their music taste. If a nearby driver is playing music, other drivers who have the same music taste can hear that and "get" the music to play in their cars.

5.2. Apparatus

The concept *MusicHound* was prototyped in the same driving simulator as study 1 (Figure 1).

5.3. Design and prototype

5.3.1. Interface design

Similar to study 1, the interface was designed to show three layers of information: 1) *Geography layer*, 2) *a vehicle layer*

and 3) *notification layer* (Figure 8). However, instead of stickers of other cars, an icon representing the sharing-music car and the visual animation of synchronizing music was shown in the *notification layer*.

5.3.2. Procedure of getting-music operation

After a meta-analysis of 43 studies, Burke et al. (2006) concluded that in the visual-auditory system, sound captures the user's attention more quickly with less workload than visual cues alone and leads to quicker reaction times and better performance scores. Therefore, for the system output, an auditory-visual feedback system was adopted. Two speakers were implemented in the front of the simulator not only to play the music but also to deliver auditory feedback of two kinds of information:

- (1) Availability to get music. When a driver who shares music is approaching, the volume of music is increasing according to the distance between the participant and the sharing-music car.
- (2) Confirmation of "get" music from other vehicles: An auditory icon (Gaver, 1986) (sound clip) that represents a confirmation message is played as a confirmation of successful "got" other music and the volume of the music increases to standard value.



Figure 8. User interface design. 1) Geography layer; 2) Vehicle layer; 3) Notification layer.

For receiving music, gestural interaction was adopted using a LeapMotion sensor. The use of gestural interfaces for in-car interaction can reduce visual demand and thus increase safety (Riener, 2012). Zobl, Nieschulz, Geiger, Lang, and Rigoll (2003) suggested that a gestural command style is more intuitive and simple than knobs and touch screen command styles. Another advantage of gesture is that it does not require physical interaction with another surface (Fujimura, Xu, Tran, Bhandari, & Ng-Thow-Hing, 2013). We utilized the “wave hand in” gesture to represent the operation of getting others’ music (Figure 9).

The flow of getting others’ music can be separated into three steps (Figure 10):

Step 1: If there is no recommended music playing by surrounding drivers, the interface shows the own car as well as nearby cars on the road.

Step 2: If there is a nearby car playing music matching the driver’s music preference, an icon appears on top of the corresponding car on the map. Furthermore, the speakers of the participant start to play the recommended music in low volume.

Step 3: Participants wave their hand in front of the LeapMotion sensor to enable the other driver’s music to play in their own car. After getting the music, an auditory icon is played to confirm the transmission and the volume of the music increases at the same time. Besides, a visual effect appears and a white line between the two cars emerges to inform participants with which car they are synchronizing music.

5.4. Evaluation

5.4.1. Evaluation setup

Forty participants took part in this study. The participants were divided into two groups, with Group 2 acting as a baseline condition for Connectedness and Social inclusion on the road. In order to get equal groups, we balanced gender, driving experience and age. The average age of the first group was 25.80 (SD 3.98) and the second

group 25.25 (SD 4.03). They had quite equal driving experience, measured in the amount of years that the participants had a driver’s license: 5.93 (SD 3.53) for the first group and 5.50 (SD 3.53) for the second group. For participating in the experiment, each of them received a 5-euro reward.

5.4.2. Experiment procedure

Before the formal test session, each participant was invited to drive in the simulator in a free driving mode for 10 min with the purpose of getting familiar with the driving simulator. Then, each participant from group 1 was introduced to the concept of the music sharing system. Furthermore, he/she was asked to practice “get”-ting music from other cars by waving the hand in front of the LeapMotion.

Before the test, participants were instructed to accept (“get”) all the music emerging in the scenario. They were told that there might be some other drivers who would play music on the road. There were three cars which played music matching the participant’s music preferences appearing in three different segments of the road for each participant in group 1. After the participant accepted the music, it played for 2 min then faded out. For group 2, acting as a baseline condition, there was no other car playing music but the music played three times at the same locations as for group 1, for the same duration. Furthermore, the interface of 3D maps remained. After the driving session, the participants of each group were asked to fill in questionnaires and people in group 1 had a semi-structured interview.

5.4.3. Recommended music

Before the test, each participant was asked to provide three songs they favored while driving. Then, these songs’ names were put into the music website Spotify (www.spotify.com). The “Recommend Songs” feature was used to generate one related song for each song, which would be played in the experiment, for the purpose of simulating the recommended music in the application.



Figure 9. Wave hand in to “get” the music of other cars. The LeapMotion sensor is visible at the bottom right.

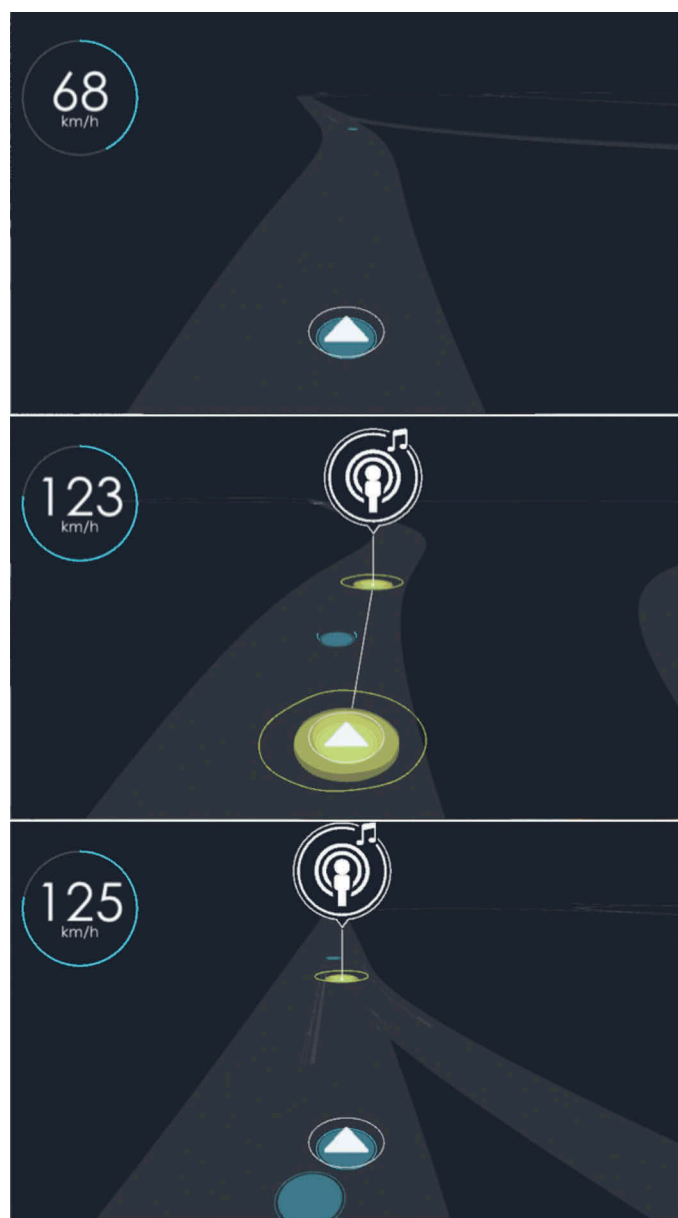


Figure 10. Interface of 3 steps of getting others' music.

5.4.4. Dependent variables

The same questionnaires as in study 1 were used to evaluate the belongingness, social closeness between participants and other drivers, mental effort of the application and the appeal of this application: Revised Social Connectedness Scale (SCS-R), Inclusion of Community in Self (ICS) scale, Rating Scale for Mental Effort (RSME) and Appeal questionnaire (Appendices A, B, C). Furthermore, a Likert scale about how participants liked the suggested music playing in the scenario was also included, for the purpose of examining the accuracy of the recommendation.

5.4.5. Scenario

The same highway scenario as in study 1 was used for this experiment. The total duration of the scenario was 10 min.

5.5. Results

5.5.1. Liking of music

This scale, which ranges from 1 to 11, shows how participants liked the music playing in the experiment. Most participants rated a high score of liking for both group 1 (Mean = 8.8, SD = 2.20) and group 2 (Mean = 8.7, SD = 1.84). The result indicated that most participants liked the music playing in the experiment and the preference of music in group 1 and group 2 were quite close.

5.5.2. SCS-R scale

An independent T-test was conducted to compare the social connectedness level of the two groups (Figure 11). The results showed that the participants who could see others' music felt significantly higher belongingness (Mean = 3.4, SD = 0.69) than the participants in the control group (Mean = 2.8, SD = 0.71), $t(38) = 2.793$, $p = .008$, $r = 0.41$.

5.5.3. ICS scale

Based on the Mann-Whitney U Test, participants in the scenarios where they could get music felt significantly higher closeness ($Mdn = 3.0$) between themselves and other drivers on the road than the participants in the

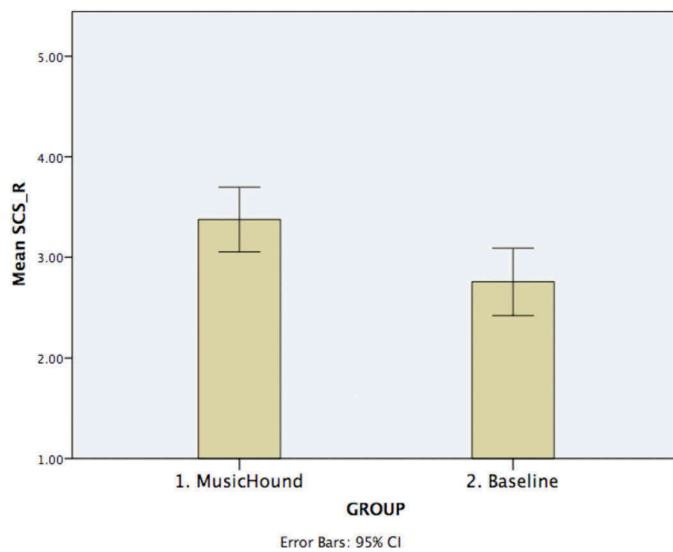


Figure 11. Mean of the result of SCS-R scale (ranges from 1 to 5).

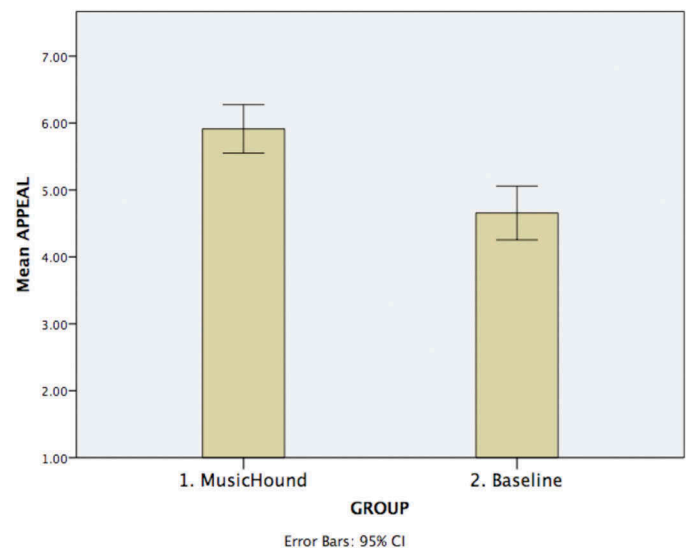


Figure 13. Mean of the result of Appeal questionnaire (ranges from 1 to 7).

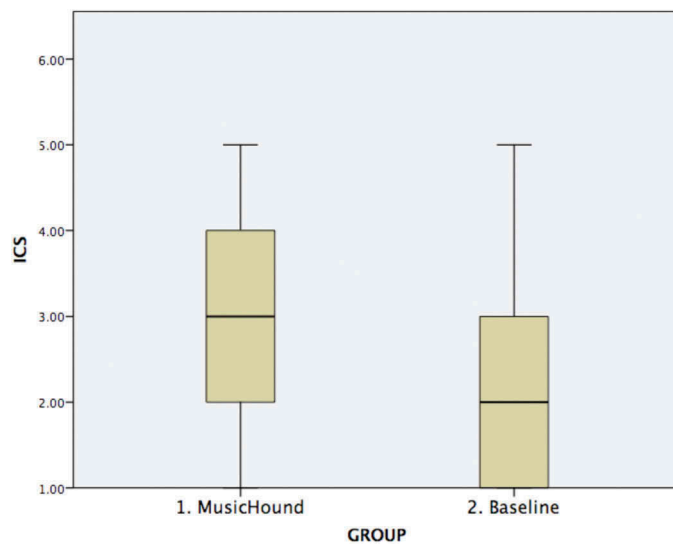


Figure 12. The result of ICS scale (ranges from 1 to 6).

control group ($Mdn = 2.0$), $U = 127.5$, $p = .044$, $r = -0.37$ (Figure 12).

5.5.4. Mental effort

As regards the mental effort of participants, which was measured by the RSME scale, no significant difference was found between the two groups based on the Mann-Whitney U Test. The mean mental effort of the group where participants could get music was 34.8 with a SD of 21.75, compared with the control group whose mean was 29.9 with a SD of 15.85.

5.5.5. Appeal

This measure provides insight into the appeal of this application. Based on the Independent T-test, the result of the appeal questionnaire in group 1 (Mean = 5.9, SD = 0.77) is significantly higher than in group 2 (Mean = 4.66, SD = 0.86): $t(38) = 4.859$, $p < .001$, $r = 0.62$ (Figure 13).

5.6. Qualitative research

In order to gain structured insights from our study, we transcribed and analyzed the interview data by qualitative content analysis (Hsieh & Shannon, 2005). In this section, we report on the results of in total 221 textual descriptions. The descriptions were coded by the first author using the following three themes: 1) Factors influencing the Acceptance of the concept, 2) Factors influencing the Belongingness 3) Factors influencing the distraction from the driving task (Table 2).

5.6.1. Acceptance

Quotes in this theme provide insight on peoples' general idea of this application. Participants were firstly asked to "describe this application", then to explain the reason of the descriptions. Three dominant categories were generated from the analysis of the quotes: *general description*, *positive factors*, and *negative factors*.

Similar with *iSticker*, *MusicHound* got very high acceptance by people, which supported the quantitative research result. The most mentioned reason by the participants was that *MusicHound* enabled social activities during the journey, and music was a good media for that without releasing too much private information. Some participants also mentioned a more practical benefit: finding new music. There are a lot of music apps, such as Spotify, which can recommend new music based on Facebook friends' listening record (Bozdog, 2013). But *MusicHound* provides a location-based clue for the recommendation. People are driving in the same area, in the same traffic and under the same weather condition. Furthermore, it can also collect people's feedback (people wave hand to "get" the music) to improve the accuracy. Besides, two participants thought *MusicHound* could cultivate pro-social driving behavior by providing the identity of anonymous others and the music sharing could "calm them down".

Table 2. Categorization of textual descriptions with the numbers of quotes and participants for each (sub-)category indicated in the parentheses.

Category (N of quotes/participants)	Sub-Category (N of quotes/participants)	Exemplar quotes
<i>Theme 1: Acceptance: Which factors influence people's attitude toward the concept?</i>		
General Description (28/20)	Positive (26/19)	"It's very nice, very interesting. (I am) looking forward to see it in the real road".
	Negative (2/1)	
	Social Activity (18/9)	"I looked at the screen, there is a tag on the car, then I know, yes, another prey is coming!"
	Finding Music (9/7)	"It gives you a little pleasure that you haven't listened to the music maybe for 1 or 2 years, then suddenly it's a nice song."
Positive Factors (36/13)	Improve driving behavior (9/4)	"Your mind tends to add up some value, not pay attention on the road while you are alone ... it doesn't distract me but draws my attention back to the road."
	Distraction on driving (6/3)	"Actually, I have to be 100% focused on driving. I don't have like 20 years driving experience ... But that's about me. If I have 10 years' experience, it would be definitely changed."
	Limitation of Simulator (4/2)	"The simulator brought me a little bias about the scenario. Maybe in a real situation I feel better."
	Unnecessary (3/2)	"... but you have internet all the time, you can find music and play the music at any time."
<i>Theme 2: Social bonding: Which factors influence the social connectedness and closeness?</i>		
Existing Social Bonding (34/15)	Similarity of Music Taste (16/8)	"... that's maybe the only thing I have in common with other drivers at time."
	Synchronization of Music (18/12)	"(The music) it's not my style, but I like the fact that ... you are listening to the music with people around you. I really think that creates a little bonding to the others."
No Social Bonding (12/5)	Enjoying Music Only (9/4)	"... I just focus on enjoying the music itself. It's just like you pass by a shop and take a book. You don't have so much relatedness with the shop."
	Others (3/2)	"if I experience it in real situation and socialized with real people, maybe I would like it better."
<i>Theme 3: Which factors influence the distraction from the driving task?</i>		
General judgment (21/20)	Positive (12/12)	"I think it is pretty clear which car is playing the music."
	Negative (9/8)	"Yes, I feel a little distraction."
Visual interface (27/12)	Positive (21/9)	"It was just like I am going with the navigation system."
	Negative (6/6)	"I have to pay 1 second to match the dot in the small screen to the surrounding car."
Auditory feedback (8/7)	Positive (4/3)	"I hear the music then wave my hand, that's it."
	Negative (4/4)	"For the interaction, maybe when the car is going further, the sound should get lower. While in the simulator, there is no feeling that the car is going further."
Gestural interaction (18/10)	Positive (10/6)	"The waving part is perfect, it's very straight forward."
	Negative (8/4)	"When I try to move my hand at first time, I just feel the car go to a little right of the road because I didn't hold the steering wheel."
Suggestions (23/8)		"I don't want to know where he lives or where he is heading. That's just a strange company for small period of time"

5.6.2. Social bonding

This theme collected 46 quotes describing participants' feeling of social inclusion as well as the reason behind it. Most participants confirmed that *MusicHound* increased their feeling of social bonding, which was in line with the quantitative data of the social inclusion questionnaire. The quotes in this theme were divided into two categories: *existing social bonding and related reasons*; *no social bonding and related reasons*.

Anonymity and lack of interaction hide the personality and identity of drivers on the road. As mentioned above, people were very interested in adding social features instead of interacting monotonously with other road users. *MusicHound* is a tool to expose drivers' profile without leaking sensitive information. "*Surrounding drivers become alive*" when they were sharing music. The most mentioned factors that influenced social bonding was a common preference of music. They felt "attached to" others when others played the music they liked. Besides the similarity of the music taste, listening to music simultaneously with others seemed also essential for enhancing social connection. Twelve participants said that they enjoyed synchronizing music with others.

However, one-quarter participants felt little social bonding with other drivers. They enjoyed the rhythm of the music but did not care about who shared the music. Some participants even saw the visual interface that showed the source of the music as unnecessary and distracting.

5.6.3. Distraction

Seventy-four quotes in this theme described the participants' opinion of driving distraction caused by *MusicHound*. Four dominant categories emerged from the analysis: *general judgment*, *visual interface*, *auditory feedback*, and *gestural interaction*. Each category contained positive and negative descriptions about the distraction by *MusicHound*.

Many participants confirmed that they felt a little distraction. The quotes indicate that the participants who felt distraction had less driving experience. Surprisingly, in contrast to distraction, some participants stated that the application kept them more focusing on the road, because the application could decrease boredom and draw their attention back to the driving task in a long journey.

Human-machine interaction was the mostly mentioned factor related to distraction. From an output perspective, the visual interface and the auditory feedback helped people to locate the vehicle which was broadcasting music. But both of them could be more natural. Drivers are used to mapping the roads, intersection, and buildings in the real world to the GUI (graphical user interface) elements on the screen of a navigation. However, "match the dot in the small screen to the surrounding car" increased the workload and distraction. As a result, augmented reality technology was suggested. Regarding the auditory feedback, participants mainly complained about the insufficiency of information

that auditory feedback contained. In *MusicHound*, the volume of music could indicate the distance between the participant and the sharing-music car. But participants suggested spatial auditory feedback: the sound could be delivered spatially through multiple speakers to indicate the spatial location of the music source.

Gestural input was implemented in *MusicHound*. However, one-quarter participants held a negative attitude toward the interaction of waving the hand to get music. They were concerned about the danger of lifting one hand from the steering wheel while the car was at a high speed. Other ways of input were suggested, such as putting a button on the steering wheel or speech input.

5.6.4. Suggestions

Besides the three themes above, other aspects of this application were also mentioned, such as the mechanism of sharing music, privacy and whether willing to sharing music, etc. Some participants suggested that they were willing to share music and expected others to get their music as well. And they did not think the music preference is specific enough to leak their private information. Another interesting finding was the attitude of further interaction beside sharing music. Some participants were quite positive about sharing music and would like to have further social interaction on the road, for example, speeding up to pass a driver who is sharing the music and “wave hand or smile to him”. However, they all did not want further contact with these people afterward, for example, joining them on Facebook.

6. Conclusion and discussion

In this study, we investigated how drivers feel about establishing social bonding with anonymous other drivers by exposing their profile information. The following hypotheses were evaluated:

H1: “People hold a positive attitude toward these concepts.” H1 is supported by both quantitative data and qualitative research: Participants who can see others’ stickers or “get” music gave higher scores in the appeal questionnaire; and most of the participants held a positive attitude to these concepts.

H2: “The applications have a positive influence on social closeness.” This hypothesis is also supported. According to the result of SCS-R scale and ICS scale, people feel more social closeness and belongingness if they can see others’ stickers or “get” others’ music. The interview results also show that most of the participants felt there was social bonding between them and other drivers on the road.

H3: “The application does not distract from the primary driving task.” The results do not support H3. According to the RSME scale, there is no significant difference between two groups. However, the results of the interview show that more than one third of the participant felt certain distracted, although only few of them stated that the distraction is unacceptable and that it is unsafe to use this concept.

Nowadays, most of the car manufacturers are trying their best to improve the driving performance, comfort or styling design. The result of the experiment indicates that there are some other demands that can be fulfilled to enhance the user experience of the journey. *iSticker* and *MusicHound* got high acceptance by participants as they enable social activities and reduce boredom on the road. On one hand, human are social in nature, being related to others is a basic human need (Baumeister & Leary, 1995). Social interaction has been implicated as a potential determinant of happiness (Cooper, Okamura, & Gurka, 1992). Therefore, the traffic environment can also be a public space for social activities. On the other hand, the in-depth interviews also revealed another benefit that contributes to the appeal of the application: Eliminate boredom. Mikulas (Mikulas & Vodanovich, 1993) defined boredom as a “state of relatively low arousal and dissatisfaction, which is attributed toward an inadequately stimulating environment”. Boredom is an “unpleasant” status (Geiwitz, 1966) which negatively influences the experience of a journey. Furthermore, it may lead drivers to increase their speed for seeking sensations or diverting their attention away from the driving task (Fuller, 2005). According to the interview, *MusicHound* and *iSticker* may provide stimulation to keep drivers’ attention on the road.

Regarding enhancing social closeness, the result is in line with the self-categorization theory, which suggests that the feeling of being a group member can be founded upon shared characteristics, or similarities, among their members (Turner, Hogg, Oakes, Reicher, & Wetherell, 1987). And groups can provide their members with feelings of belonging (Gardner, Pickett, & Brewer, 2000). The quantitative result shows that there are correlations between social closeness, belongingness, and appeal of the journey. However, it seems that the social bonding is not the only factor that contributes to belongingness. According to Baumeister and Leary (1995), in addition to perceived social bonding, positive interaction and contact also contribute to the belongingness between people. In *iSticker*, there is a social bonding between participants and other drivers who are in the same sticker-community. But there is no further interaction between them in the digital layer. People tried to look at the other drivers, follow and overtake them for physical “contact”. In the following interview, almost all the participants would like to have digital interaction with other drivers, which indicates the needs of further interaction. It is also supported by the interview result of *MusicHound*, which shows that more than half of the participants appreciated the synchronization of music with others. As some participants mentioned, when they “got” others’ music and enjoyed it together with others, they felt that they were “dancing with them”.

On another side, the qualitative results suggest that the concepts reduce driving aggression by increasing social closeness between drivers, which confirms previous research (Nagler, 2013; Ratan & Tsai, 2014). By the digital augmentation, the drivers have the opportunity to establish links to the drivers that they encounter, which may evoke empathy and increase trust, and decrease the incidence of aggressive driving

behavior. In our case, the participant feels closeness not only by receiving other's identity information but also by exposing information: In *iSticker*, when people see others' stickers, it is also indicated that other people can see their stickers; in *MusicHound*, when people "get" others' music, they expose that they are in the same music group. As a result, the participants may recognize that their driving behavior affects their reputation (Ratan, Chung, Shen, Williams, & Poole, 2010). In another perspective, by exposing that they are in the same group, they may more adhere to the social norms of this group, which regularize the behavior (Hogg & Terry, 2000). However, further experiments are required to validate these assumptions.

For the aspect of distraction, these applications may draw the driver's attention back to the road in a long and boring journey. At the same time, however, interaction with other road users may also distract from the driving task. Some novel interaction design was suggested by participants, including spatial audio interface, augmented reality display on the windshield or even disabling this feature if drivers' workload is too high. Nevertheless, social applications such as *MusicHound* and *iSticker* may cause minimal distraction. Furthermore, advanced driver assistance systems, autonomous driving, and augmented reality may release drivers' attention resources, which may stimulate the development of social features in vehicles.

7. Limitations and future work

This study yielded rich quantitative data and vivid qualitative information by the user test on the driving simulator. However, there are some limitations to the research. Firstly, participants' driving behavior and emotional status may be biased by the limitations of the driving simulator. The performance of maneuvering the vehicle may be different in the real world. Moreover, "others" who share music may have been seen as a computer agent rather than a real person, which might make the simulated scenarios different from a real social situation. Thirdly, each driving session only lasted 10 min, therefore this study was not able to investigate participants' attitude toward this application in the long term. At last, subjective questionnaires and qualitative content analysis were adopted for investigation in this study. However, several objective data such as bio-signal (heart rate variability, skin conductance, etc.), gaze tracking and facial expression recognition and driving behavior data (acceleration, speed and brake, etc.) could also be used to evaluate participants' feedback of this application.

In this study, we utilized two novel applications as probes to explore the possibility of adding social features into connected vehicles in the future. The results indicate that the social bonding by digital augmentation may enhance the closeness and belongingness between drivers. Other insights are also generated by this study, such as reducing driving aggression and boredom by social interaction on the road. These will be further investigated in future research.

Acknowledgments

This research has been funded by the Chinese Scholarship Council. We thank Konrad Kirpluk for support in designing the stickers.

References

- Baker, H. S., & Baker, M. N. (1987). Heinz Kohut's self psychology: An overview. *American Journal of Psychiatry*, 144(1), 1–9. doi:10.1176/ajp.144.1.1
- Bassoli, A., Brewer, J., Martin, K., Dourish, P., & Mainwaring, S. (2007). Underground aesthetics: Rethinking urban computing. *IEEE Pervasive Computing*, 6(3). doi:10.1109/MPRV.2007.68
- Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, 117(3), 497. doi:10.1037/0033-2909.117.3.497
- Bozdag, E. (2013). Bias in algorithmic filtering and personalization. *Ethics and Information Technology*, 15(3), 209–227. doi:10.1007/s10676-013-9321-6
- Brosnan, S. F., Schiff, H. C., & De Waal, F. B. M. (2005). Tolerance for inequity may increase with social closeness in chimpanzees. *Proceedings of the Royal Society of London B: Biological Sciences*, 272 (1560), 253–258. doi:10.1098/rspb.2004.2947
- Brown, B., Sellen, A. J., & Geelhoed, E. (2001). Music sharing as a computer supported collaborative application. In *ECSCW 2001* (pp. 179–198). Springer.
- Burke, J. L., Prewett, M. S., Gray, A. A., Yang, L., Stilson, F. R. B., Covert, M. D., ... Redden, E. (2006). Comparing the effects of visual-auditory and visual-tactile feedback on user performance: A meta-analysis. In *Proceedings of the 8th international conference on Multimodal interfaces* (pp. 108–117). ACM.
- Caspi, A., Beggs, D., Dickson, N., Harrington, H., Langley, J., Moffitt, T. E., & Silva, P. A. (1997). Personality differences predict health-risk behaviors in young adulthood: Evidence from a longitudinal study. *Journal of Personality and Social Psychology*, 73 (5), 1052. doi:10.1037/0022-3514.73.5.1052
- Cooper, H., Okamura, L., & Gurka, V. (1992). Social activity and subjective well-being. *Personality and Individual Differences*, 13(5), 573–583. doi:10.1016/0191-8869(92)90198-X
- De Waard, D. (1996). *The measurement of drivers' mental workload*. Groningen University, Traffic Research Center Netherlands.
- Ellison, P. A., Govern, J. M., Petri, H. L., & Figler, M. H. (1995). Anonymity and aggressive driving behavior: A field study. *Journal of Social Behavior and Personality*, 10(1), 265.
- Endersby, J. W., & Towle, M. J. (1996). Tailgate partisanship: Political and social expression through bumper stickers. *The Social Science Journal*, 33(3), 307–319. doi:10.1016/S0362-3319(96)90026-9
- Esbjörnsson, M., Juhlin, O., & Östergen, M. (2003). Motorcycling and social interaction: Design for the enjoyment of brief traffic encounters. In *Proceedings of the 2003 international ACM SIGGROUP conference on Supporting group work* (pp. 85–94). ACM.
- Fiske, S. T., Gilbert, D. T., & Lindzey, G. (2010). *Handbook of social psychology* (Vol. 2). John Wiley & Sons.
- Frith, S. (2002). Music and everyday life. *Critical Quarterly*, 44(1), 35–48. doi:10.1111/crq.2002.44.issue-1
- Fujimura, K., Xu, L., Tran, C., Bhandari, R., & Ng-Thow-Hing, V. (2013). Driver queries using wheel-constrained finger pointing and 3-D head-up display visual feedback. In *Proceedings of the 5th International Conference on Automotive User Interfaces and Interactive Vehicular Applications* (pp. 56–62). ACM.
- Fuller, R. (2005). Towards a general theory of driver behaviour. *Accident Analysis & Prevention*, 37(3), 461–472. doi:10.1016/j.aap.2004.11.003
- Gardner, W. L., Pickett, C. L., & Brewer, M. B. (2000). Social exclusion and selective memory: How the need to belong influences memory for social events. *Personality and Social Psychology Bulletin*, 26(4), 486–496. doi:10.1177/0146167200266007
- Gaver, W. W. (1986). Auditory icons: Using sound in computer interfaces. *Human-Computer Interaction*, 2(2), 167–177. doi:10.1207/s15327051hci0202_3

- Geiwitz, P. J. (1966). Structure of boredom. *Journal of Personality and Social Psychology*, 3(5), 592. doi:10.1037/h0023202
- Gulliver, P., & Begg, D. (2007). Personality factors as predictors of persistent risky driving behavior and crash involvement among young adults. *Injury Prevention*, 13(6), 376–381. doi:10.1136/ip.2006.013946
- Håkansson, M., Rost, M., & Holmquist, L. E. (2007). *Gifts from friends and strangers: A study of mobile music sharing*. In ECSCW 2007 (pp. 311–330). Springer. doi:10.1094/PDIS-91-4-0467B
- Hassenzahl, M., Platz, A., Burmester, M., & Lehner, K. (2000). Hedonic and ergonomic quality aspects determine a software's appeal. In *Proceedings of the SIGCHI conference on Human Factors in Computing Systems* (pp. 201–208). ACM.
- Hogg, M. A., & Terry, D. I. (2000). Social identity and self-categorization processes in organizational contexts. *Academy of Management Review*, 25(1), 121–140. doi:10.5465/amr.2000.2791606
- Hornsey, M. J., & Hogg, M. A. (2000). Assimilation and diversity: An integrative model of subgroup relations. *Personality and Social Psychology Review*, 4(2), 143–156. doi:10.1207/S15327957PSPR0402_03
- Hsieh, H.-F., & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research*, 15(9), 1277–1288. doi:10.1177/1049732305276687
- Juhlin, O. (2013). *Social media on the road*. Springer.
- Kirpluk, K. (2014). *Simple fanarts*. Retrieved from <https://www.behance.net/kirpluk>
- Lee, R. M., Draper, M., & Lee, S. (2001). Social connectedness, dysfunctional interpersonal behaviors, and psychological distress: Testing a mediator model. *Journal of Counseling Psychology*, 48(3), 310–318. doi:10.1037/0022-0167.48.3.310
- Liviatan, I., Trope, Y., & Liberman, N. (2008). Interpersonal similarity as a social distance dimension: Implications for perception of others' actions. *Journal of Experimental Social Psychology*, 44(5), 1256–1269. doi:10.1016/j.jesp.2008.04.007
- Mashek, D., Cannaday, L. W., & Tangney, J. P. (2007). Inclusion of community in self scale: A single-item pictorial measure of community connectedness. *Journal of Community Psychology*, 35(2), 257–275. doi:10.1002/(ISSN)1520-6629
- Mikulas, W. L., & Vodanovich, S. J. (1993). The essence of boredom. *The Psychological Record*, 43(1), 3.
- Mitrevska, M., Castronovo, S., Mahr, A., & Müller, C. (2012). Physical and spiritual proximity: Linking Car2X communication with online social networks. In *Proceedings of the 4th International Conference on Automotive User Interfaces and Interactive Vehicular Applications* (pp. 249–256). ACM. doi:10.1094/PDIS-11-11-0999-PDN
- Morelli, S. A., Lieberman, M. D., & Zaki, J. (2015). The emerging study of positive empathy. *Social and Personality Psychology Compass*, 9(2), 57–68. doi:10.1111/spc3.v9.2
- Nagler, M. G. (2013). Does social capital promote safety on the roads?. *Economic Inquiry*, 51(2), 1218–1231. doi:10.1111/ecin.2013.51.issue-2
- Nowak, K. L., & Fox, J. (2018). Avatars and computer-mediated communication: A review of the definitions, uses, and effects of digital representations. *Review of Communication Research*, 6, 30–53.
- Nowak, K. L., Hamilton, M. A., & Hammond, C. C. (2009). The effect of image features on judgments of homophily, credibility, and intention to use as avatars in future interactions. *Media Psychology*, 12(1), 50–76. doi:10.1080/15213260802669433
- Osgood, C. E., Suci, G. J., & Tannenbaum, P. H. (1957). *The measurement of meaning*. University of Illinois press.
- Petroulias, T. (2009). *Community attitudes to road safety: 2009 survey report*. Canberra: Department of Infrastructure, Transport, Regional Development and Local Government.
- Podobnik, V., Striga, D., Jandras, A., & Lovrek, I. (2012). How to calculate trust between social network users? In *2012 20th International Conference on Software, Telecommunications and Computer Networks (SoftCOM)* (pp. 1–6). IEEE.
- Ratan, R. R., Chung, J. E., Shen, C., Williams, D., & Poole, M. S. (2010). Schmoozing and smiting: Trust, social institutions, and communication patterns in an MMOG. *Journal of Computer-Mediated Communication*, 16(1), 93–114. doi:10.1111/j.1083-6101.2010.01534.x
- Ratan, R. R., & Tsai, H. S. (2014). Dude, where's my avacar? A mixed-method examination of communication in the driving context. *Pervasive and Mobile Computing*, 14, 112–128. doi:10.1016/j.pmcj.2014.05.011
- Redshaw, S. (2012). *In the company of cars: Driving as a social and cultural practice*. Ashgate Publishing, Ltd.
- Renner, L., & Johansson, B. (2006). Driver coordination in complex traffic environments. In *Proceedings of the 13th European conference on Cognitive ergonomics: trust and control in complex socio-technical systems* (pp. 35–40). ACM.
- Rettie, R. (2003). *Connectedness, awareness and social presence*.
- Reychav, I., Ndicu, M., & Wu, D. (2016). Leveraging social networks in the adoption of mobile technologies for collaboration. *Computers in Human Behavior*, 58, 443–453. doi:10.1016/j.chb.2016.01.011
- Riener, A. (2012). Gestural interaction in vehicular applications. *Computer*, 45(4), 42–47. doi:10.1109/MC.2012.108
- Schroeter, R., Rakotonirainy, A., & Foth, M. (2012). The social car: New interactive vehicular applications derived from social media and urban informatics. In *Proceedings of the 4th International Conference on Automotive User Interfaces and Interactive Vehicular Applications* (pp. 107–110). ACM.
- Seeburger, J., Foth, M., & Tjondronegoro, D. (2012). The sound of music: Sharing song selections between collocated strangers in public urban places. In *Proceedings of the 11th International Conference on Mobile and Ubiquitous Multimedia* (p. 34). ACM.
- Seidman, G. (2013). Self-presentation and belonging on Facebook: How personality influences social media use and motivations. *Personality and Individual Differences*, 54(3), 402–407. doi:10.1016/j.paid.2012.10.009
- Tanaka, A., Valadon, G., & Berger, C. (2007). *Social mobile music navigation using the compass*. In *Proceedings of the International Mobile Music Workshop* (Vol. 9), Amsterdam.
- Tesser, A., & Campbell, J. (1980). Self-definition: The impact of the relative performance and similarity of others. *Social Psychology Quarterly*, 341–347. doi:10.2307/3033737
- Tesser, A., & Paulhus, D. (1983). The definition of self: Private and public self-evaluation management strategies. *Journal of Personality and Social Psychology*, 44(4), 672. doi:10.1037/0022-3514.44.4.672
- Turner, J. C., Hogg, M. A., Oakes, P. J., Reicher, S. D., & Wetherell, M. S. (1987). *Rediscovering the social group: A self-categorization theory*. Basil Blackwell.
- Urry, J. (2007). *Mobilities*. Polity.
- Walther, J. B. (1997). Group and interpersonal effects in international computer-mediated collaboration. *Human Communication Research*, 23(3), 342–369. doi:10.1111/hcre.1997.23.issue-3
- Walther, J. B., & Bunz, U. (2005). The rules of virtual groups: Trust, liking, and performance in computer-mediated communication. *Journal of Communication*, 55(4), 828–846. doi:10.1111/j.1460-2466.2005.tb03025.x
- Wang, C., Gu, J., Terken, J., & Hu, J. (2014). Driver-to-driver communication on the highway: What drivers want. In *European Conference on Ambient Intelligence* (pp. 315–327). Springer.
- Yasar, A.-U.-H., Mahmud, N., Preuvenciers, D., Luyten, K., Coninx, K., & Berbers, Y. (2010). Where people and cars meet: Social interactions to improve information sharing in large scale vehicular networks. In *Proceedings of the 2010 ACM Symposium on Applied Computing* (pp. 1188–1194). ACM.
- Zobl, M., Nieschulz, R., Geiger, M., Lang, M., & Rigoll, G. (2003). Gesture components for natural interaction with in-car devices. In *International Gesture Workshop* (pp. 448–459). Springer.

About the Authors

Chao Wang works as a senior research scientist in Honda Research Institute Europe. He is passionate about HCI in smart vehicle and cooperative robot. He received a Ph.D. degree in the Eindhoven University of Technology, focusing on social applications of connected vehicles and autonomous driving.

Jacques Terken was trained as a Cognitive Psychologist/Psycholinguist. He received a PhD from Leyden University in 1985. His research interests include the user experience for autonomous vehicles. He was an associate professor in the Department for Industrial Design since 2001 at Technische Universiteit Eindhoven, The Netherlands, and retired in 2019.

Jun Hu is Associate Professor of Social Computing and head of the DI group in the Department for Industrial Design at Technische Universiteit Eindhoven, The Netherlands. He has interests in the fields of social cyber-physical systems, Internet of Things, human-computer interaction, industrial design, computer science and design education.

Matthias Rauterberg is Full Professor of Designing Interactive Systems in the Department for Industrial Design at Technische Universiteit Eindhoven, The Netherlands. Rauterberg is interested in designing interactive systems to address the cultural sub- or even unconscious layer of the user. Rauterberg has over 450 publications in international journals, conference proceedings, books, and more.

Appendix A

Revised Social Connectedness Scale (SCS-R)

1. I don't feel related to other drivers.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

2. I see myself as a loner while driving.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

3. I feel disconnected from the drivers around me.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

4. I feel understood by other drivers.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

5. I see other drivers as friendly and approachable.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

6. I have little sense of togetherness with other drivers.

☐ Strongly Agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly Disagree

Please answer the following questions by using the scale below them

Appendix B

Inclusion of Community in Self (ICS) scale

Please circle the picture that best describes your relationship with the other drivers around me (S = Self, C = other drivers)



Appendix C

Rating Scale for Mental Effort (RSME)

Please indicate, by making the vertical axis below, how much effort it took for you to complete the task you've just finished.

