Utilizing a Digital Game as a Mediatory Artifact for Social Persuasion to Prevent Speeding

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Abstract. In this paper we present a game-based approach to stop a driver from speeding by means of social persuasion. The approach utilizes a digital game played by a passenger inside the car. The game serves as a mediatory artifact, which translates the speed of the car into in-game events, thus, nudging the passenger to communicate with the driver about his/her driving behavior. As a game we used Tetris, which was coupled to the speed of a virtual vehicle in our driving simulator. We designed four different in-game representations of the real car data and examined, which of these designs is most suitable to trigger an intuitive, understandable linkage between the speeding behavior and the corresponding in-game events in order to enable a prompt intervention of the passenger. We evaluated the four designs in an exploratory user study. Our findings highlight the feasibility of our approach, as even passengers, who were rather uninvolved in the driving task, were successfully encouraged to slow down the driver. Based on our study results, we recommend a hybrid design strategy for the game, between designing for a dynamically increasing in-game challenge to foster passenger engagement based on fun, and simultaneously intervening dynamically in the playability of the game to foster communication with the driver to pave the way for social persuasion in the car.

Keywords: Persuasive game design · Social persuasion · Automotive domain

1 Introduction

Understanding and designing games as socially influencing systems can be an insightful perspective and fruitful opportunity for researchers and designers of persuasive technology, in particular in the automotive domain, because the car is an inherently collaborative and social space that creates social interdependencies between the co-located persons in the car [7]. Yet, the car is also a safety critical environment where incautious driving behaviors such as speeding can result in dangerous, or even fatal incidents, not only affecting the driver but all people in the car. Hence, having a means of persuasion in order to prevent drivers from speeding is an important design challenge for persuasive technologies in the automotive domain.

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Games and play (both digital and physical) have the ability to create a social setting and connect people within the boundaries of this setting. Through collaborative gameplay social couplings are formed by which people communicate and interact with each other for an underlying, common goal [9]. In many games, gameplay is inherently based on combining various social influence principles such as competition, cooperation, recognition, and learning. Thus, interweaving game design and persuasive system design by incorporating these principles into specific game mechanics offers great potential for designers of persuasive technology to generate impact and induce behavior change.

Following this assumption we present an approach that incorporates the real speed of a car in a digital game. With this linkage we are deliberately intervening in the social setting between the driver and a passenger with the aim to utilize the passenger as a resource for social persuasion in order to keep the driver from speeding. Our approach is based on the following scenario: A person is driving a car accompanied by a passenger. The passenger is playing the tile-matching, digital puzzle game Tetris during the car trip. Some features of the game are linked to the actual speed of the car in real time. Thus, when the driver starts speeding, his/her driving style is immediately incorporated in the game. As a consequence the game gets harder to master or even unplayable, and the passenger is alerted that the driver is exceeding the speed limit. By communicating the status of the game to the driver, the passenger consequently persuades the driver to reduce the driving speed – first and foremost, for the safety of the two, but also for keeping up a positive gaming experience.

In terms of interaction design, there are several ways of how to link the car's driving speed to in-game changes. This inlcudes, e.g., directly coupling the game speed with the driving speed (i.e. the faster the driving speed is, the faster the Tetris tiles fall down) or even pausing the game when the car exceeds a certain speed limit. We implemented four different game designs and evaluated their effect in a driving simulator study. We aimed at answering two main research questions:

1. Does a digital game, whose game mechanics are based on real car-data (i.e., speed), serve as a useful mediatory artifact to foster communication as a means of social persuasion in the car to prevent speeding?
2. Which of the four game designs are the most useful and promising ones in order to foster social persuasion in the car?
    i. Which game designs create the most intuitive and easy to understand linkage between the real-world misbehavior of speeding and the in-game consequences/events?
    ii. Which game designs do the passengers prefer and for which reasons?

In the following, we present the theorectical background of our research and describe the development process of the four different game designs we used for our study. To examine our approach and identify the most promising game design(s), we evaluated the designs with 16 participants in an exploratory user study in a car-simulator. We report on the study procedure, the data analysis and discuss the findings of the study with regard to the research questions and future work.

2 Related Work

2.1 Games as Socially Influencing Systems

Digital games are information systems that are highly social and collaborative often incorporating a variety of social influence principles such as social learning, cooperation, or competition. Oinas-Kukkonen et al. [10] highlight the role of social influence as a persuasive strategy by providing a framework with a variety of principles also prevalent in most games (i.e., social learning, social comparison, normative influence, social facilitation, cooperation, competition, recognition). In a similar direction, Bogost argues that the persuasive effect that games create can be understood by seeing them as *procedural rhetorics,* i.e., "the art of persuasion through rule-based representations and interactions" [2].

In our approach, the game uses and embodies the real car speed, thus forming a procedural rhetoric around translating this data related to driving misbehavior into changes within the game (i.e., a rule-based representation of real world data).

2.2 In-Car Technology and Collaboration

Today, cars are pervaded with technology like entertainment systems, or navigation devices. These technologies are often not designed around the social nature and collaborative mechanisms within the car, though. Perterer et al. [7] highlight how the sharing of information (e.g., making it visible for both driver and passenger) can have large impact on the collaborative nature of driving. Previous research has in particular focused on investigating concepts around driver-passenger cooperation e.g., for navigational tasks [3, 4, 7], while Shepherd et al. [8] investigated the influence of the social setting within the car on the driver's behavior itself. They examined a scenario with peers posing as passengers who provide verbal feedback in order to persuade the driver to change his/her driving behavior. Their findings show how effective the influence of peers as passengers can be in risk-related driving scenarios.

Our approach differs from these approaches, though, as we design for the passengers as a means for social persuasion. In providing the passenger with a digital game, which incorporates real-car data, we assign him/her to take the role of a social persuader, who influences the driver. With the game serving as a mediatory artefact in this process, we connect the persuasive powers of digital gaming and social influence in order to change the driver's driving style and keep him/her from the gas pedal.

3 Approach

The motivation for our approach originated from the results of a probing study we conducted to investigate the persuasive potentials of in-car interfaces [5]. This study identified the potential of creating technology driven social spaces within the car for persuasive purposes. Inspired by the design ideas presented in this paper, we developed our approach to use a game to create a social coupling between driver and passenger.

We use and intervene in this coupling based on different embodiments of real car data that are translated into different in-game interventions. The game serves as a mediatory artifact the social coupling is formed around and facilitates social communication as a persuasive means. When the driver starts speeding the game adapts to this problematic behavior, and as a consequence becomes a lot harder to master or even unplayable. This urges the player of the game (i.e., the passenger) to actively communicate with the driver, which potentially results in persuading the driver to stop speeding. In order to make that happen, the passenger, who is playing the game during the ride, is supposed to link the in-game changes to the actual driving behavior. Therefore, one major challenge in the design process was to find a suitable way of translating the problematic, real-world driving behavior of speeding into in-game events and changes in gameplay. This linkage not only had to work on a technical but also on a semantic level for the passenger in order to enable him/her to persuade the driver effectively. Another challenge was to find an accurate balance between maintaining the safety of the driver and passenger, as well as creating a positive gaming experience, which keeps the passenger engaged with the game, hence aware of the driver's behavior.

3.1 Game Design

As a starting point for the different game designs we wanted to explore, we chose the tile-matching game Tetris as it is well known, skill-based and relatively easy to play. As it is also a rather abstract game with little theming, we were able to pursue our approach and adapt the game mechanics according to our design goals (i.e., creating different levels of game interventions) without breaking the aesthetics and recognition value of the game. We used an open-source version of Tetris (www.openprocessing.org/sketch/34481) to develop the prototype and adapt the game towards the different designs. As it would have been an interfering factor for two of our designs (acceleration and deceleration), we decided to remove the possibility for the player to drop the tiles immediately, in contrast to the implementation of the original game. Thus, we ensured that players could not bypass the speed dependent game mechanics, because that would have otherwise made it difficult for them to recognize the linkage between the real-car speed and the in-game changes. In the following the four different game designs we created are described in detail. In each design the car's speed has a different effect on the gameplay. These effects vary in the strength of their consequences on the gameplay. More precisely, the designs are ranked in descending order, from the most severe to the least severe interference regarding the game's playability (see also Fig. 1):

- **Freeze:** The game freezes, when the driver is speeding (i.e., the playing area turns black, tiles are not visible anymore and the game is paused). Playing is no longer possible for the passenger, until the driver reaches accurate driving speed again. The goal of this design was to completely interupt the player in the playing experience.
- **Blocking Input:** The passenger cannot move the tiles to the left or right, or both, or rotate them anymore on a gradual level depending on the severity of the speeding violation (i.e., the faster the driver is driving, the more control elements are blocked). This design aims at removing the player's input capabilities stepwise in order to create a notion of *loss of control* and simultaneously increase the difficulty level.

- **Acceleration:** The speed of the falling tiles is changing according to the actual speed of the car. The faster the driver gets, the faster the tiles fall and the harder the game gets to master. The goal was to gradually increase the challenge for the player up to a point where the game actually becomes unplayable, depending on the severity of the speeding.
- **Deceleration:** This design is similar to the aforementioned design, but this time in reverse manner. The faster the car is driving, the slower the tiles are falling. Our goal with this design was to explore how we could make the game "less fun" for the passenger if the driver is speeding (i.e., making it extremely slow in order to completely remove the challenge aspect of the game as well as the typical expected game progress of tiles falling faster and faster).

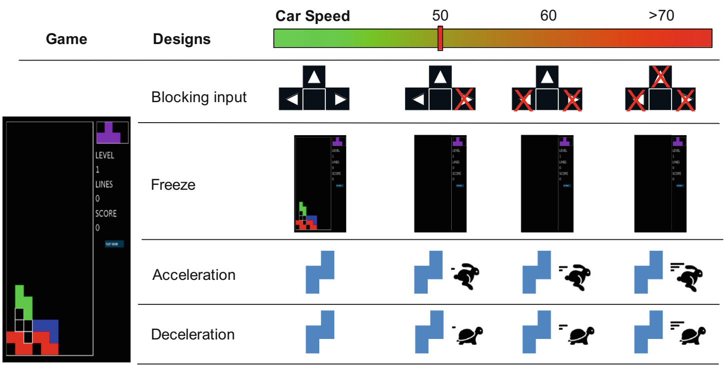

Fig. 1. Schematic of the four different game designs (blocking input, freeze, acceleration, deceleration): Starting with a speed limit of 50 km/h, different changes in the game mechanics and behavior are induced depending on how much the driver exceeds the speed limit.

4 Exploratory User Study

In order to investigate the general potential of our approach to act as a trigger for communication as means of social persuasion, as well as to explore the individual designs, we conducted a user study in the driving simulator (see Fig. 2). We focused on the passenger's role of being a successful persuader by means of the game in order to keep the driver off the gas pedal. Thus, the role of the driver was executed by one of our colleagues.

We conducted our study with 16 participants (9f, 7 m), aged between 22 and 35 years, with a mean age of 30 years, who all took on the role of the passenger in the study. All participants were rather experienced drivers, who held their driving licenses for an average of 11.5 years. The annual mileage travelled by car of all participants averaged out at 7.170 km. Eleven participants declared themselves to be actively playing digital games, whereas five participants don't play digital games at all. The gamers were rather moderate ones regarding the frequency and duration of playing, as the mean gaming frequency was once a week, with one gaming session lasting about 65.5 min on average. All participants were familiar with the game Tetris, and 15 out of 16 participants had already played the game at least once before.

4.1 Study Procedure

At the beginning of the study each participant was asked to sign an informed consent. Then participants were seated next to the driver and introduced to the game and its controls, as well as, the study procedure. To allow for consistent study conditions, we briefed one of our colleagues to take on the role of the driver. He was told to generally stick to the speed limit (50 km/h) but to exceed this limit at certain spots on the track in order to provoke the desired in-game changes. He was allowed to communicate with the passenger, but only if the communication (i.e., asking the driver to stop speeding) was first initiated by the passenger.

The study was realized as within-design, with each participant testing all four designs. To prevent aftereffects, the sequence in which the game designs were tested was permutated. The participants were informed beforehand that the driving style of the driver would somehow influence the game, but without going into details on the exact in-game changes or the influencing car-parameters. Furthermore, participants were encouraged to think aloud of their experiences and impressions during the ride, as well as, to make assumptions about the underlying linkage of the real-car data and the in-game changes. After testing a design, participants were asked to outline their assumptions about how the driver behavior and the game design were linked with each other, how much the game design encouraged communication with the driver and how much fun it was to play. One researcher was present on the backseat of the car to lead through the study and to ask questions after every condition. Another researcher took notes on observations during the ride, as well as on user comments and feedback after the ride. After testing all conditions, participants were asked in a final interview on their opinion on the general approach, as well as, how they would rank the different designs regarding their ability to foster driver-passenger communication as a means of social persuasion.

Fig. 2. Picture of the study setup within the car simulator. Passenger is playing Tetris on a laptop while the briefed driver is varying the speed of the car to trigger in-game changes.

4.2 Technical Setup

Our prototype setup used VDrift (vdrift.net) as a simulation software and combined it with Spacebrew (docs.spacebrew.cc) for communication matters between the game (running on a network connected laptop) and the car simulation. Spacebrew, is a websocket-based prototyping framework that was used to connect the game running on a laptop with the car simulation software. The simulation software sent the current speed of the car to the game, which in turn translated the speed into the different in-game changes (based on the aforementioned designs).

5 Results and Findings

5.1 Analysis and Results of Quantitative Data

The quantitative data consisted of participants' answers on which designs were the most intutitive ones regarding the linkage between car speed and in-game changes (multiple answers possible) as well as, the final rankings on which designs were the most fun to play and also which design fostered communication with the driver the most. For a first comparative analysis every rank was associated with a predefined number of points. A first rank was worth 20 points, a second rank 15 points, a third rank 10 points, and a fourth rank 5 points. Every game design received points from 16 participants, which were totaled for the final *fun* and *communication* score. Furthermore, the number of mentions (i.e., how often the specific designs were mentioned to be the most intuitive ones) was counted for each design, and multiplied by 20 for the final linkage score. Finally, each design was assigned an overall score in points, which totaled the scores for fun, communication, and linkage (see Table 1).

Table 1. Rankings of the designs, rated in terms of fun, communication, and best linkage. The overall score combines all three rankings, with a higher score meaning a higher rating.

Condition	Fun	Communication (=based on points)	Best linkage (=nr of mentions)	Overall score
Acceleration	**285**	205	**160**	**650**
Blocking input	150	**235**	120	505
Freeze	155	230	60	445
Deceleration	215	160	40	415

In terms of fun, condition *acceleration* was ranked as being the most fun design by participants, followed by condition *deceleration*. We think that this is due to the fact that the design of condition *acceleration* was based on increasing the challenge for the players, and for many players in-game challenge is directly related to the fun-level of a game. Further, we assume that condition *deceleration* was ranked second highest, because it represented the least severe interventions in terms of playability of the game (i.e., the game only got slower). The conditions *blocking input* and *freeze* were clearly ranked last in terms of fun. A reason for this could be, that both of them strongly interfere with the playability of the game. Additionally, the *blocking input* design, which was ranked last, was experienced to be the most frustrating one.

In turn, the conditions *blocking input* and *freeze* triggered driver-passenger communication the most, whereas condition *acceleration* and *deceleration* were ranked as being the last in terms of communication. We conclude that the more severe the interference in the playability and the higher the experienced frustration level were the more the driver and passenger communicated with each other.

Regarding the linkage of the car speed and the in-game changes, design *acceleration* was rated best, which was presumably a result of the direct mapping between the in-game speed and car speed and corresponded to the general expectations of Tetris tiles falling faster as the game progresses. That is also, why we reason, that the reverse design implementation *deceleration* was experienced to be the least intuitive one. We assume, that *blocking input* was ranked second, due to the stepwise removal of input controls which was linked to a stepwise rise in car speed. Condition *freeze* on the other hand was designed to be binary (i.e., the game was either on or off), which could have made it slightly more difficult for participants to establish a reasonable connection between the speeding and the in-game changes.

Condition *accelerate* and *blocking input* received the best overall scores with all three rankings combined. Based on this result, we argue that a potential real world implementation of our approach should follow a hybrid strategy between designing around increasing the challenge for the player (to foster engagement based on fun) and intervening drastically in the players' game experience e.g., by stepwise removing the player's input capabilities (to foster driver-passenger communication). Such a hybrid design could dynamically adapt the in-game changes based on the severity of real world driving misbehavior and change in-game embodiments accordingly (i.e., the more the driver is speeding the more drastic the in-game interventions could get).

5.2 Analysis and Results of Qualitative Data

The qualitative data consisted of data and notes based on the observations during the study and questions asked at the end of the game sessions. The data was analyzed according to the basics of qualitative content analysis [6].

In general, participants thought our approach was fun and that it was feasible in terms of providing them with a means to stop the driver from speeding. One participant stated: "The game is an indirect way of keeping more eyes on the road, and it encouraged me to tell the driver to slow down". A point of critique was that the mappings of car data and in-game changes were not dynamic, meaning that the game did not adapt to differently skilled players, or players that became better at the game over time. Thus, the balance between creating enough challenge for the player to have an engaging gaming experience but at the same time creating in-game situations that to some extent force the player to give verbal feedback to the driver, is a design challenge for future work. Participants liked the designs that increased the challenge better than those that punished the player. Participants also suggested to create game designs around rewarding the passenger-driver couple for positive driving behavior, rather than punishing the passenger for the driver's neagtive behavior.

In the following, the "common themes" and similarities among the different designs that emerged during the study are described:

Challenge (condition *accelerate* and *decelerate*)**:** At a certain point, the game became boring or unplayable for the participants in these conditions. Thus, the initiated communication with the driver was based on the game getting too easy or too difficult. Some players also felt the need to get better at the game. However, perceived challenge of the game was a matter of individual player skills. This shows, that for a real world implementation of our approach, the mappings between real world misbehavior and in-game changes would need to be dynamic to the current driving scenario and the player's skills and/or game progression in order to enable more long term engagement in the game, hence awareness for the driving style.

Frustration/Punishment/Loss of control (*condition blocking input* and *freeze*)**:** The communication between driver and player was often a direct result of the player being interrupted in the flow of gameplay. The discrepancy between seeing the visuals of the game, but not having adequate control (*condition blocking tiles*) over the game, felt punishing and frustrating for the players. This frustration and loss of control was reported to lead to an increased amount of communication and feedback from player to driver. Attempts to slow down the driver like "Your speeding is breaking my game!" or "I can't play this way, drive slower!" illustrate that the interventions of *condition blocking input* and *condition freeze* were not perceived as being fun for the player, although on the other hand fostered immediate intervention of the passenger.

Commands/Agreements/Common Goal: The commands and feedback from the players were very precise and clearly targeted at slowing down the driver in order to make the game playable and fun to play again. This, in turn, also led to a negotiation process between the driver and passenger regarding the "ideal speed" as a common goal in order to have the best gaming experience but also stick to the speed limit. One participant stated "I achieve more within the game if the driver is sticking to the speedlimit" which illustrates the interconnectedness and common goal between the two of them.

Changing Visual Attention: Some participants were very aware of the speedometer in the central dashboard of the car simulator. They constantly switched their visual attention between the game and the speedometer to compare the car speed and the in-game changes, whereas others were completely focused on the game itself without actually looking at the surroundings. Nevertheless, all types of passengers – the active and the rather passive ones – were aware of the driver's behavior and interfered, when the driver was speeding, which proves our approach to be a viable means of involving even an inattentive passenger in the driving situation.

Social connection: Regardless of the game design, the better the passengers understood how and why the in-game changes were related to the driving behavior, the more interaction between them and the driver emerged. Some participants stated that they felt like "playing together co-operatively" and said that the more dependent they were towards the driver, the more they communicated and wanted to persuade him to stick to the speed limit. One participant concluded: "I like the idea, of influencing someone's behavior, like the driving style, by communicating with each other, which in turn influences the game, and hence, my gaming experience, and so on." This mutual influence loop described by the participant exemplarily illustrates the potential of our approach to deploy gaming technologies in the car, which unfold their persuasive effects based on social influence.

6 Discussion

Our approach proved to be feasible in presenting a game that acts as a mediatory artifact to trigger social persuasion. The different game designs involved the front-seat passenger into the driving experience even when focused on playing the game. This resulted in increased amounts of communication between the front-seat passenger and the driver. Hence, our approach allows to involve co-located passengers in the driving task based on creating a social coupling between them and fostering embodied communication through a shared resource and task (i.e., the game).

Dynamic Mappings: In a real world implementation of our prototype, the mappings between in-game changes and driving behavior would have to be dynamic in terms of presenting the right challenge to the player at the right time to be applicable in a real car setting. As perceived challenge is a matter of individual player skills and preferences, a future iteration of our game prototype could start at a level that suits these factors (i.e., being aware of the player's skill level and game progression).

A major challenge will be to find a balance between safety (i.e., preventing unsafe driving behavior) and a positive gaming experience. For instance, if the players are getting better, they can handle the speed of the falling tiles better but should nevertheless encourage the driver to stop speeding. Hence, the better the player gets, the more the driver could speed, which would be an undesired side effect. As real world settings are much more complex, a future implementation of a game in the real car would need more "intelligence" to react to the ever changing surroundings and traffic situations as well as the player's skill level and game progression, in order to present the right in-game consequence at the right time. If in a future iteration of our approach this level of intelligence in the game is reached, the game itself as well as the mappings between in-game changes and real world driving behavior could also be much more complex thus, being closer to real world scenarios. In that sense, new designs around multiple disadvantageous driving behavior (e.g., tailgating, insufficient lane keeping, etc.) could be incorporated in one game.

Balance of In-game Interventions (Frustration vs. Persuasion): Regarding the in-game interventions, the biggest design challenge would be to find the right level between presenting an appropriate challenge to the player, but also encouraging him/her to actually influence the driver. In our study, we found that intervening in the input and control capabilities of the player, as well as pulling the player out of the game by pausing and interrupting the experience (conditions *blocking input* and *freeze*), create frustration and punishment for the player. These designs provoked more and immediate communication between driver and passenger, though. On the other hand the designs that worked with continous effects (condition *accelerate* and *decelerate*) were ranked as being more fun. However, these designs were not ranked as high in terms of fostering driver-passenger communication, thus, proved to be harder to achieve the desired persuasive effect of keeping the driver from the gas pedal through social influence of the passenger. Finding the right balance between creating an understandable link between in-game and real world, while presenting the right level of challenge and at the same time also increasing communication based on in-game consequences, is an enourmous design challenge. Based on our study results, we argue for a *hybrid design strategy* based on creating a game that, depending on the severity of speeding, also adapts the severity of in-game interventions as needed. This would in turn be an ideal compromise between passenger-game engagement and increased communication between driver and passenger. Based on the results and observations, we conclude that intervening in a player's input capabilities or taking her/him out of the game itself (condition freeze), can result in immediate frustration, however also fostering communication rapidly. Thus, we argue that designs based on such input interventions are more likely to be applicable for short term settings where a player is only playing over a short period of time. On the other hand, designs around the mentioned challenge aspect have the potential to create long term engagement, but are a bigger design challenge.

Our approach presents an opportunity to let a person currently focused on gameplay, simultaneously take part in the driving situation. Creating a shared embodied resource, i.e., the game itself, in order to foster communication and social interdependence as a persuasive strategy, proofed to be feasible. This notion is supported by the theory of embodied simulation [1] which describes how humans create meaning by continuously constructing mental models of the currently perceived scene, which in our case is mirroring the experience of the driver based on the current game scene. Different in-game embodiments can facilitate this mirroring process and create a "window" for the player to mirror the behavior of the driver to interfere if necessary.

Limitations and Future Work. A persuasive approach in a safety critical environment like the car that focuses on verbal feedback and increased communication, also has some conflict potential for the passengers (e.g., increased distraction for the driver). In future iterations of our prototype this challenge of potentially increased driver distraction through increased verbal activities has to be mitigated (e.g., by alowing the driver to take over control and disable the connection of the real-car data and the in-game events at some point). In our future work we plan to iterate our designs based on the study findings and create a game that incorporates the mentioned *dynamic mappings* in order to investigate our approach in a real car scenario.

7 Conclusion

We presented an approach that utilizes a digital in-car game, which translates real-world misbehavior (i.e., speeding) into in-game interventions. We designed different levels of in-game interventions and investigated their potentials of acting as a communication trigger for social persuasion, as well as their impact on fun and engagement. Our approach fostered communication between driver and front-seat passenger by using different in-game embodiments of car data to create a connection between the real- and the game world. Thus, the approach proved to be effective in terms of positive short-term effects on the speeding behavior of car drivers.

Our study findings illustrate how using a game as a facilitator for social persuasion and mediatory artifact in a safety critical scenario can be implemented. The respective game should be dynamic to player skills and preferences as well as dynamic to the current driving situation and environment (i.e., a hybrid design strategy with dynamic mappings between in-game changes and driving behavior based on the severity of speeding). Based on our findings we argue, that there is great potential in using contextual data for creating new interactive persuasive systems that are designed around social couplings in the car.

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