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AutoJammin' – Designing Progression in Traffic and Music

Sven Krome
RMIT University
Melbourne, VIC, Australia
sven.krome@rmit.edu.au

Stefan Greuter
RMIT University
Melbourne, VIC, Australia
stefan.greuter@rmit.edu.au

Jonathan Liono
RMIT University
Melbourne, VIC, Australia
jonathan.liono@rmit.edu.au

Fabius Steinberger
Queensland University of Technology
Brisbane, QLD, Australia
fabius.steinberger@qut.edu.au

Flora D. Salim
RMIT University
Melbourne, VIC, Australia
flora.salim@rmit.edu.au

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Abstract
Since the early days of automotive entertainment, music has played a crucial role in establishing pleasurable driving experiences. Future autonomous driving technologies will relieve the driver from the responsibility of driving and will allow for more interactive types of non-driving activities. However, there is a lack of research on how the liberation from the driving task will impact in-car music experiences. In this paper we present AutoJam, an interactive music application designed to explore the potential of (semi-) autonomous driving. We describe how the AutoJam prototype capitalizes on the context of the driving situation as structural features of the interactive music system. We report on a simulator pilot study and discuss participants' driving experience with AutoJam in traffic. By proposing design implications that help to re-connect music entertainment with the driving experience of the future, we contribute to the design space for autonomous driving experiences.

Author Keywords
Autonomous driving; music; in-car entertainment, design.

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H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction

Autonomous driving technologies promise a gradual relief from the responsibility of driving. For the driver the introduction of automation technology comes with a new inactive, supervisory role. However, as experience research on advanced driving assistance systems (ADAS) pointed out, this new role is associated with a feeling of decreased competency and control [6, 1]. One promising way to compensate for the loss of competency and control in autonomous driving, is to substitute the driving task with fun non-driving activities while maintaining the driver's situational awareness.

Music is arguably one of the most important form of driver entertainment. The pleasure of driving a car but also the defined seating position makes the car a perfect place for enjoying music. Moreover, the aesthetic relationship between the physical driving movement and the emotional movement through music literally transforms the car into a "sonic envelope" [2] that transforms the driving task into a personalized experience. To explore how interactive music experiences can facilitate the "sonic envelope" of autonomous driving, we applied a *research through design* approach. Specifically, we designed and evaluated AutoJam, an interactive music application for autonomous driving situations. The *research aim* was to design a non-driving activity that potentially serves as a substitute for the driving task and subsequently helps to re-establish a feeling of competency and control. Therefore, the key design challenge was to connect a music experience with the car's movement in an interactive and pleasurable way.

Related Work

Car-based music listening has been investigated intensively as a social phenomenon and regarding safety and ergonomics. For example, it has been investigated in relation to mood and appearance management as well as music and playlist selection processes among car drivers and passengers [5,12]. From a human factors perspective, researchers studied the influence of music and sound on driver vigilance and in the context of autonomous driving where contextual warning sounds may help to facilitate a feeling of control [8, 1].

Despite the importance of in-car music, there are surprisingly little design-related research projects on *interactive* music experiences. The SoundPryer prototype is a social music sharing application that enables drivers to tune into the music listened to in cars in the near proximity in order to connect road users in a musical way [7]. Investigating collaborative experiences among car passengers, Eckholdt and Schulz implemented a drum kit into a car's interior [5]. The implementation provided passengers with instruments of the drum kit aiming to facilitate a collaborative music experience in the car. Both projects are similar in their use of music as a catalyst to establish social experiences between road users.

Most prior research has focused on the *social* aspect of music or the use of music as a tool for in-car collaboration. In contrast, we aimed to substitute the driving task *itself* by turning the driving context into an *interactive* music experience.

Figure 1. Car-Storming Session: Ideation in the context. The steering wheel is statically mounted on the passenger's side. The sessions were recorded and evaluated together with the participants'' notes and mockups.

Figure 2. Simulator study setup. Each of the three touch pads was mapped to a drum sound and instructed by an LED. On the screen, the video footage of the source traffic clip was played in sync with its tracked speed-data.

AutoJam Prototype

Applying a *research through design* approach, we created AutoJam as an artefact for our inquiry into this unique design context.

Design Process

The process of designing AutoJam builds upon findings from earlier prototypes (such as [8]). Central to our approach was to facilitate *contextual ideation* in the early stages of the design process. For example, Figure 1 shows a steering wheel mockup that we mounted on the passenger side of a car in order to conduct several "car-storming" [8] sessions. These sessions enabled us to ideate in the context and "play" through our ideas while being exposed to the targeted traffic situation. We identified the steering wheel as a potential artifact for non-driving activities such as tapping a rhythm or stroking the wheel. We concluded that the prominent positioning of the steering wheel would receive particular attention in the case of semi-autonomous driving, i.e., when it is turning "magically" by itself. Starting from this we investigated the design possibilities of the steering wheel when it was not required for driving and free for secondary interactions.

CONCEPT

In accordance with the scenario, AutoJam was designed for severe stop-and-go traffic during rush-hour. AutoJam teaches a variety of drum rhythms extracted from a selected song. It consists of three modes that depend on the driving speed as described in Table 1: Training, Practice, and Freeplay. In the Training and Practice modes, the player's is challenged to repeat a one-bar drum pattern. The pattern increases in difficulty as soon as the player reaches a defined level of accuracy and timing. If the car exceeds 30km/h, AutoJam will enter freeplay-mode. In this mode, the song progresses and the player can listen to upcoming challenges while being able to improvise freely to the song based on what was learned.

Mode	Km/h	Description	Scoring
Training	0	Listen and repeat a one bar drum loop	Yes
Practice	1-30	Training-mode + fade in of background tracks	Yes
Freeplay	30-60	Song progresses; player can "jam-in"	No

Table 1: Game modes depending on driving speed.

Prototype Implementation

We implemented three drum patterns with varied difficulties. The user starts with the simplest drum pattern. If the player masters the first drum pattern, the application progresses to the next drum pattern. The Freeplay mode can be seen as a bonus level in which the player enjoys the progress of the song with no scoring of the game performance.

We designed AutoJam without the use of additional visuals besides the three LEDs as seen in Figure 2. All instructions are given through voice commands. The driver listens and repeats drum patterns that are extracted from Herby Hancock's "Chameleon" [11]. Future iterations will allow users to choose from their own selection of music. The AutoJam prototype was realized as an interactive steering wheel cover that contains three touch sensors as drum pads. As seen in Figure 2, each drum pad belongs to one LED that guides the player through the drum patterns. Both are connected to a Bare-Conductive Touchboard that

#	Sex	Age	Occupation
P1	M	31	Lecturer
P2	F	29	MA Student
P3	M	28	PhD Student
P4	M	36	Architect
P5	M	26	Software dev.

Table 2: Participants were recruited by convenience sampling in and around the research facility.

contains the game logic and manages the MIDI connection to the external sound processor (Ableton Live).

Design Evaluation

To evaluate the key design elements of this AutoJam iteration, we conducted a user study in a simulator-based setup. Interested in evaluating the impact of the gameplay as well as reflecting on design assumptions, we invited five participants (one female; age *M*=30, *SD*=3.81; cf. Table 2) for testing and discussing the prototype. In this study the research objectives were twofold: (1) Identify the impact of the musical interactions on the perception of traffic. (2) Identify design challenges and possible ways to address them. Both objectives were envisaged to inform future iterations of AutoJam.

Simulation Setup and Study Procedure

Each participant had the chance to play AutoJam within a simulator setup as illustrated in Figure 2. The simulation script was based on video footage and speed information captured from one of the author's morning commute. All participants were able to complete at least one level (5-10 minutes of playtime). The playtest was followed by a group discussion. The goal of the group discussion was exploratory and guided by three topics related to the research objectives: the experience of traffic, the contextual awareness and the effect of gameplay and interaction logic.

Analysis and Findings

The audio recordings of the group discussion were transcribed and analyzed using a free coding approach. The findings were clustered into three categories (C1-C3) with several associated themes as follows.

C1: Traffic and contextual awareness

One design goal of AutoJam was to create a contextual experience facilitated by the music interaction. However, participants reported that they did not pay much attention on the traffic because the difficulty and novelty of the game forced them to focus on the interactions. Too much situational awareness would distract you from enjoying the music as a media to *"build your own private world"* (P2). On the other hand, AutoJam would violate the traditional driving patterns in stop-and-go traffic: "*when I'm driving I only pay attention to the car in front and when I've stopped I look around and explore the surrounding [environment]*" (P1). Playfully increased situational awareness in traffic would require either "*clear instructions to make me share my vision between the steering wheel and the road*" (P2) or an obvious feedback that "*you are playing the road*" (P1). In other words, it seems that music must appear as it is coming from the context in question and not from a defined track.

C2: Feeling of situational awareness and control

The participants believe that the transfer of the driving task has a very strong impact on situational awareness and a feeling of control over the situation. The idea that the driver is able to unconditionally enjoy the new situation is questioned: *"Alone in an autonomous car you will never be like a passenger [in a train], you will always have some type of responsibility"* (P4). Subsequently the participant saw the biggest potential of AutoJam as a compensation for surrendering to the new technology. In the current iteration the music interactions are not experienced as an enhancement of trusting in driving automation or increased situational control. "*It was fun but I couldn't pay attention to the*

road and that gave me some insecurity" (P2). A suggested solution would be a musical metaphor that communicates the player that the system is working. The music interaction needs to mirror the car's processes or be associated with the situation.

C3: Feeling of progress by connecting music and speed
The AutoJam prototype uses the car's speed as a constructing element to gradually enhance the music experience (Practice mode) and finally enabling a moment of progress (Freeplay mode). However, the experience of progress as a function of speed and music has been described as too subtle. The participants agreed that the car's speed, and in particular the stop phases in traffic, are the most fundamental experience in traffic. However, they disagreed on the best way to map speed and music interactions in order to generate desirable user experiences. A feeling of progression could be achieved by mapping the interactions with the idle-time of the car. *"[W]hen the car is driving it is playing the music but when it has stopped it doesn't have to do nothing so I need to interact in order to listen to the music" (P1).* A feeling of progress, however, may be better as a linear mapping of music tempo and car speed. The player would experience a musical acceleration that require a rhythmic interaction as input

Implications and Discussion

Playtest and group discussion showed that interactive music applications bear a great potential to compensate for the inactivity in autonomous cars. We synthesized three design implications (D1-D3) that will guide our next iteration of AutoJam.

D1: Conceptualize the source of music
Depending on the desired effect of AutoJam it is central to investigate the conceptual source of the music. This can be the car, the traffic or other situational entities and of course the users. For example, to optimize for a feeling of situational awareness the source of music can alternate between the car and the player. In that way the player is forced to align the interactions to a selected process of the car. In this iteration of AutoJam, the conceptual source of music is mixed between the user, the undefined playback of the track, and the car's speed. In this configuration, it seems that the players do not benefit from directing their attention to the driving situation as the musical input. Articulating a conceptual understanding of the source of music allows us to tailor the interaction for the desired outcome; making traffic progress faster.

D2: Use contextual elements as core-interactions
To create a contextual experience, it is not enough to align the application with the contextual features of the car. As the evaluation of AutoJam indicates, the central interaction of the game is such an engaging activity so that the player neglects the contextual features as a contributing input. Possible solutions are a deterioration of the central interaction while improving the aesthetical quality of the contextual elements (such as the background tracks). Another promising solution is reframing the context as a playable or play defining input such as aligning the playback tempo with speed.

D3: Balancing the experience of progress
In stop-and-go traffic, the experience of progress is very limited. Introducing some form of entertainment that facilitates a feeling of progress could dramatically improve the traffic experience. In the AutoJam

prototype, the freeplay-mode facilitates this feeling by progressing the song. This is largely experienced as an enhancement of traffic progress. Furthermore, the stop-phase can be designed as a progress-phase. This, however, comes with a disconnection from the driving context. Managing a feeling of progress requires striking a balance between real, traffic-based progress and virtual, game-based progress.

Conclusion

Our study data suggest that the context of autonomous driving entails great potential for developing interactive music experiences. It provides inactive drivers a new way to engage with music and it shows promise to substitute driving in an enjoyable way. From design and evaluation, we drew three implications for developing interactive music experiences that help dealing with crucial challenges of autonomous driving such as situational awareness and progress. Looking into the future, an understanding of these implications will not only frame the next iteration of the AutoJam prototype. It will also make a contribution towards developing design guidelines for interactions within the context of autonomous driving.

References

1. David Beattie, Lynne Baillie, Martin Halvey, and Roderick McCall. 2014. What's Around the Corner? Enhancing Driver Awareness in Autonomous Vehicles via In-Vehicle Spatial Auditory Displays. *NordiCHI'14*, ACM, 10.
2. Michael Bull. 2004. Automobility and the power of sound. *Theory, Culture & Society* 21, 243–259. http://doi.org/10.1177/0263276404046069
3. Sally Jo Cunningham, David M Nichols, David Bainbridge, and Hasan Ali. 2014. Social music in cars. ISMIR, 457–462.
4. Kai Eckoldt, Martin Knobel, Marc Hassenzahl, and Josef Schumann. 2012. An Experiential Perspective on Advanced Driver Assistance Systems. *it - Information Technology* 54, 4, 165–171. http://doi.org/10.1524/itit.2012.0678
5. Kai Eckoldt and Benjamin N.N. Schulz. 2009. Das Auto als Musikinsturment: gemeinsames Trommeln als positives Erlebnis. *i-com* 1/2009, 1, 83–85.
6. Chisa Hasegawa, Koji Oguri, and A Drowsiness. 2006. The Effects of Specific Musical Stimuli on Driver ' s Drowsiness. 817–822.
7. Oskar Juhlin. 2010. *Social media on the road: The future of car based computing*. Springer London, London. http://doi.org/10.1007/978-1-84996-332-9
8. Sven Krome, William Goddard, Stefan Greuter, Steffen P Walz, and Ansgar Gerlicher. 2015. A Context-based Design Process for Future Use Cases of Autonomous Driving: Prototyping AutoGym. *AutomotiveUI 2015*.
9. Tesla. Your Autopilot has arrived | Tesla Motors. Retrieved January 13, 2016 from https://www.teslamotors.com/blog/your-autopilot-has-arrived
10. Michael J. Walsh. 2010. *Driving to the beat of one's own hum: automobility and musical listening*. Elsevier. http://doi.org/10.1108/S0163-2396(2010)0000035015
11. Herbie Hancock - Chameleon (FULL VERSION). Retrieved January 13, 2016 from https://www.youtube.com/watch?v=UbkqE4fpvdI