AutoGym: An Exertion Game for Autonomous Driving

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ABSTRACT
In-car exercises are a promising way to keep the inactive driver of future autonomous cars in good shape and alert of the situation around them. To explore how to implement exercises into the car context, we designed AutoGym, an in-car fitness program that translates frustrating traffic into a fun exertion game. To progress in the game, the players must anticipate changes to the traffic situation they are exposed to in the car and work-out against their prediction. In this paper, we present the conceptual design of AutoGym and report what we have learnt from an explorative user study with 28 participants. Furthermore, from the design process and the evaluation, we derived three strategies for implementing exertion games. We found that these strategies helped to conceptualize exertion games as a playful embodiment of the dynamics of driving and as such, can positively influence the experience of control, orientation and situational awareness i.e. experiential factors that can be crucial for facilitating future autonomous driving in a pleasurable and safe way.

Author Keywords
Exertion Games; Autonomous Driving; Games.

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

INTRODUCTION
Driving a car is arguably not the healthiest form of transportation. The suboptimal sitting posture, combined with a very restricted space for movement, often results in physical fatigue and an uncomfortable transportation experience. Especially professional drivers and long-distance commuters, spending several hours in vehicles, are at risk of physical and mental suffering [15]. Autonomous driving technology relieves the driver from the driving task, enabling a much wider range of interactions and movements within the driving context. In order to explore the possibilities of in-car exercise games, we designed AutoGym, an in-car exertion game that motivates exercise through an integration of the driving context as a game element. Physical exercise as health, wellness and stress management method is widely accepted [4]. Exertion games are one gameful strategy to motivate physical exercise [9]. The general concept of exertion games is to package physical exercise into a gameful experience and thereby facilitate and motivate exercise in a more pleasurable and fun way.

Even though autonomous driving is expected to allow the inactive driver a bigger range of movements, the spatial dimensions of a standard passenger car will naturally restrain the player's movements and their body position. But even in this restricted space, a large variety of physical exercises are possible. For example, several self-help books provide a repertoire of instructions for in-car exercise and promise to increase wellbeing during transportation [1,11,18]. However, a gameful, fun and motivating approach to in-car exercise, which seamlessly integrates exertion within the car context, has not been available. To explore a new way of motivating in-car exertion we studied a proof-of-concept implementation of AutoGym with 28 participants in a lab-based simulator.

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RELATED WORK
The car as a space for activities and entertainment beyond the driving task is almost as old as the automobile itself. However, for a long time, music and other forms of auditory content were the only feasible entertainment alternatives for the active driver. For passengers, however, researchers have explored a wide range of entertainment opportunities, from immersive media consumption to a large variety of games and even physical interactions.

Car Passenger Games
Substantial research on interactive passenger entertainment has been conducted by Oscar Juhlin. Investigating the road as a medium for social encounters, Juhlin suggested several in-car prototypes to establish a social connection between the player/user, co-passengers, road users and the transportation environment. For instance, the *Backseat Gaming Project* [6] investigated how an interactive story can unfold through defined points-of-interest along the travel route. Like most research on passenger games, the aim was to entertain children to avoid boredom. However, besides simply entertaining the kids in the rear of the car, the researchers have also suggested games for various other purposes.

Sundström et al. [14] suggested three games that aim to encourage children to sit safely in the car. The authors used driving features, such as g-force and the alternation of light/shadow, as basis for designing core-experiences into their games. All of the three games aim to have the kids sit in a safe position as a side effect of the game play. For example, in the game *emo-car* the player has to mimic the "feeling" of the car with facial expressions. Since the facial expressions of the player are only properly registered if the player sits in an upright position in front of the camera, the player only performs well when sitting safely. In other words, to progress in the game, the child must perform the desired behavior i.e. sit upright.

Wilfinger et al. [17] conceptualized *RiddleRide* an educational in-car multiplayer quiz game that was aimed to connect adults and children with points-of-interest while on a car trip. Each player plays the game on their individual mobile device. To make the quiz suitable for all age groups, the answer modality provided adapted difficulty levels suited for adults and children. Similarly, Broy et al. [3] suggested *nICE* an in-car multiplayer game that facilitates collaborative and communicative experiences among passengers and the driver based on an image puzzle that needs to be uncovered by playing several mini-games. Additionally, Zuckerman et al. [19] developed *Mileys* a digital in-car game with the purpose to connect children with their families and their environment.

Research on in-car games indicate that the integration of contextual data such as location, e.g. [3,19], or the dynamics of driving, e.g. [14], is a promising approach for an engaging gameplay while driving. Even though all the above mentioned games are targeted at children, we believe that an appropriate implementation of the driving context would also motivate adult drivers to engage in games and even in exercises.

Interactive driver entertainment and gamification

Although researchers have suggested an integration of the driver and interactive in-car entertainment, such as [3], driver-focused approaches have been insufficient due to safety considerations. Solitary driver applications have to be secondary activities that are *augmenting* the driving tasks such as safe-driving and/or eco-driving gamification approaches [5]. In contrast to passenger entertainment most of these approaches focused on the design of visual feedback such as points, leaderboards and virtual rewards based on a target activity such as fuel efficient driving.

With autonomously driven cars, the driving task becomes a secondary activity, and the implementation of gamification needs to be adapted accordingly. Depending on the level of automation, gamification of supervisory tasks and situational awareness become a central focus but also wellbeing and dynamic sitting will likely become gamification challenges of the future. For example, Terken et al. [16] suggested an interactive in-car environment for stress reduction in commuting scenarios. The system projects immersive virtual environments into the interior of the car that can be explored by a tangible interface. This system is intended for higher-level driving automation that does not require an ongoing supervisory control. This enables the system to be independent from the driving situation and does not require situational-awareness of the driver. Investigating creative activities in stop-and-go traffic, Krome et al. [7] suggested AutoJam, an in-car music game that is played on a stationary steering wheel within an autonomously driven car. In AutoJam we concluded, that an integration of traffic into the music game can facilitate a consistent feeling of progression even when the car was not moving and as such positively influence the traffic experience.

In-car exertion tools and occupational health

Besides the aforementioned self-help books for in-car exercises that mostly focus on stretching and strengthening exercises [1,11,18], a large variety of mobile foot-rockers and mini-exercise bikes are available for travel and office use. Figure 1 shows an example of a commercially available foot stepper of the company *Gamercize*. These devices aim to integrate exercise and video game activities.

Figure 1: Commercially available Power Stepper *(c) Richard Coshott, BY-SA 2.0*

Similarly, some airlines suggest that passengers on long distance flights engage in onboard exercise programs and the car tuner *Becker Automotive Design* [12] offers to build a full body exercise machine into a Cadillac Escalade to enable exercise on-the-go. Research has confirmed that exercise is beneficial to the wellbeing of office workers [10]. Despite the benefits of exercises and the advancements of autonomously driven cars, neither motivational aspects of in-car exercises nor the importance of maintaining a situational awareness being driven by an autonomous car have been investigated by research or industry. In approaching this research context, we aim to explore how a gameful interaction system can motivate in-car exercises by using the driving context as a playable input in the system.

PROTOTYPE CONCEPT

AutoGym is an exertion game for future driving experiences in autonomous cars. Based on a commuter pilot study [8], we selected a rush hour driving scenario within Melbourne's city traffic. Within the context of an autonomously driven car, we envisaged that the inactive driver could engage in other non-driving activities while maintaining awareness of the traffic situation.

The AutoGym prototype consisted of a mini-exercise bike positioned on the driver's lap that was manually operated by hand. The resistance of the mini-exercise bike was linked to the car's speed, i.e. the faster the car drives, the higher the resistance of the exercise bike. When the car stopped completely, the resistance was at its minimum, allowing the player to turn the wheel without much effort. The resistance increased to the maximum at a speed of 60 km/h. Maximum resistance made it almost impossible to spin the wheel. A touchscreen tablet pc, displayed the game interface and the interactions via the exercise bike. Figure 2 shows the implementation of AutoGym on the passenger side of a test vehicle that was driven by another driver to simulate the experience of being in an autonomously driven vehicle.

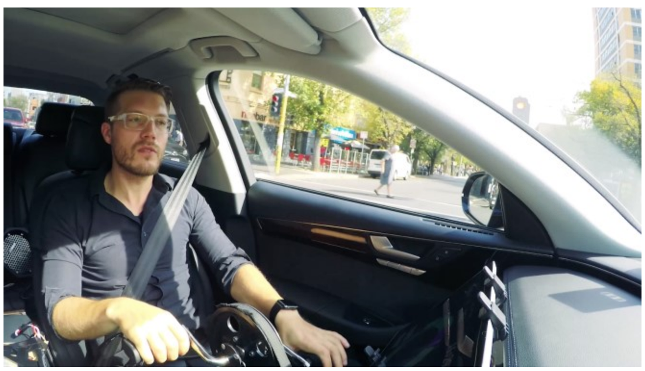

Figure 2: In-car setup of AutoGym with manually operated exercise bike. The resistance of the bike was linked to the car's speed. The game was displayed on a touch screen PC in front of the driver on the dashboard.

GAME AND INTERFACE DESIGN

The objective of AutoGym is to complete a whole exercise program (represented as the ring seen in Figure 3) consisting of segments that the player needed to complete though workout on the exercise bike. The length of a segment represented the amount of time in which the player had to finish the segment through a work-out via the exercise bike. The longer the segment, the longer the player has to turn the spinning wheel on the exercise bike to complete it.

As soon as a segment was selected, a countdown is initiated visualized by an increasing status bar on the inside of the segment. Each turn on the exercise bike was rewarded with audio feedback and a progress visualization. Figure 4 illustrates the game loop.

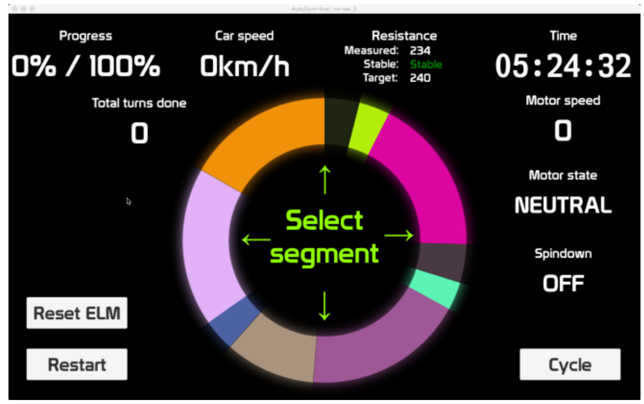

Figure 3: AutoGym Graphical User Interface.

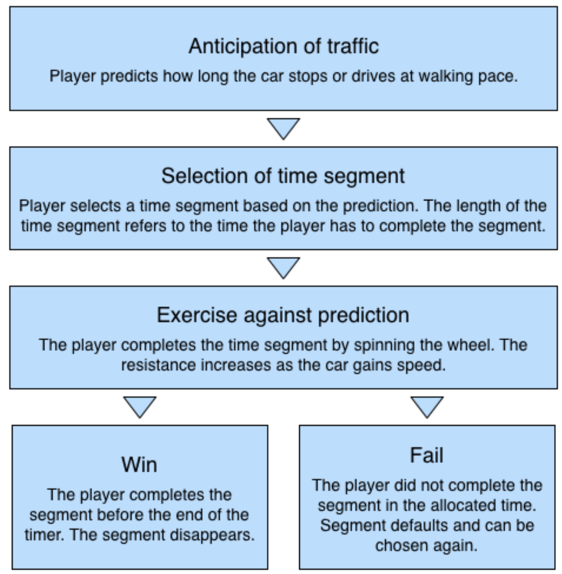

Figure 4: *AutoGym* Interaction Loop.

The decisions required from the player to successfully complete the game consist of three complementary steps: (1) The anticipation and prediction of the traffic situation, (2) The translation of the prediction into a time segment and (3) the completion of the time segment by turning the exercise bike often and fast enough before the countdown of the time segment expires.

The game is finished as soon as the player successfully completed all segments of the ring. Upon completion, the player is presented with performance statistics showing the overall turns, the time and the failed attempts.

TECHNICAL IMPLEMENTATION

For the AutoGym prototype we modified an off-the-shelf mini-exercise bike with adjustable resistance. We exchanged the manual adjustment system with a high-torque electrical motor that was controlled by an Arduino microcontroller with H-Bridge Shield to enable the motor to turn in both directions. We attached two additional sensors to the exercise wheel: a magnetic sensor to register the turns and a slider sensor to measure and adjust the resistance by the motor.

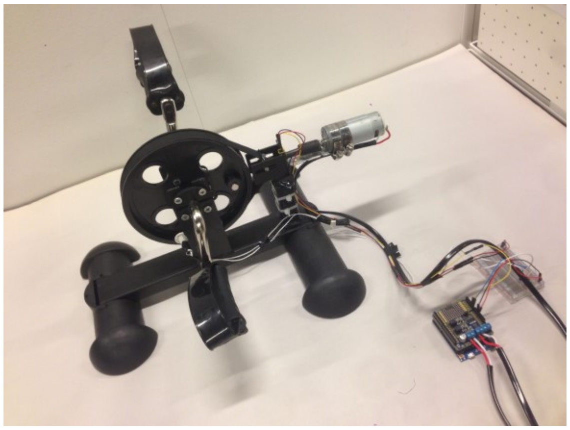

Figure 5: AutoGym Technical Setup.

Figure 5 shows the technical implementation of the AutoGym exertion interface consisting of the mini-exercise bike, the sensors, a high torque electric motor and an *Arduino* with H-Bridge Shield to change the motor's direction of rotation. The hardware was connected to the output device via the serial port. The game interface was developed with Unity3D running on a laptop in the simulator and a tablet pc in the car.

EVALUATION

To investigate the impact of AutoGym, we conducted a lab-based simulator study with 28 participants. The study assessed (1) the impact of AutoGym on the users' feeling and satisfaction of playing, (2) the users' motivation of traffic-based contextual exercises and (3) the users' perception of the car and traffic situation. For the assessment, we chose a mixed qualitative and quantitative study design with the goal to explore the user experiences and compare them with the results from the standardized questionnaires.

STUDY PROCEDURE

After receiving formal consent, the participants were briefed on the purpose and scenario of the study: A regular rush-hour commute in a fully autonomous car. The study consisted of four components as shown in Figure 6.

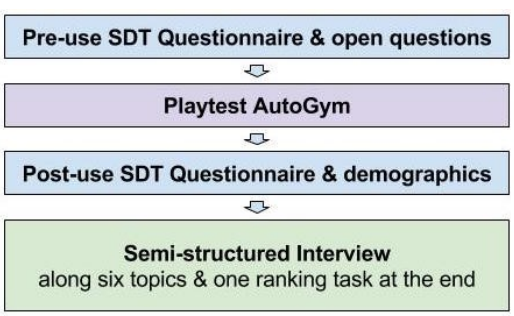

Figure 6: AutoGym Study Procedure. Before and after the playtest, the participants completed a questionnaire and a semi-structured interview at the end.

The pre- and post-questionnaire consisted of five scales from Sheldon's self-determination questionnaire [13]: autonomy-scale, competency-scale, stimulation-scale (two items from physical thriving and one item from the pleasure-scale), security-scale, and self-esteem scale. The test procedure was concluded by a semi-structured interview of 10-30 minutes. The interview was guided by 10 topics regarding the user experience, the difficulties, the experience of traffic and the game as well as a final ranking task on the most prominent feelings.

SIMULATOR SETUP

We tested AutoGym in an improved simulator setup based on a traffic clip recorded on an evening commute during rush-hour traffic in Melbourne. The video footage of the commute was played on a 46" TV screen to maximize immersion. When the video was recorded, we also recorded the car speed based on an OBD-II application. The simulator was playing the video in sync with the speed data that was controlling the exercise bikes resistance. Figure 7 shows the simulator setup.

Figure 7: AutoGym Simulator Setup.

PARTICIPANTS

For the user study, 28 volunteers were recruited through snowball sampling via word-of-mouth and social media channels. Participation was completely voluntary and not rewarded. Table 1 shows an overview of the participants grouped by occupation.

Table 1: Overview of participants grouped by occupation.

Occupation	Sex (f/m)	Avg. age
Post graduate students	5 / 6	26.00
Researchers / academic staff	4 / 5	33.33
Creative industry	0 / 4	29.50
Technician / IT	1 / 2	33.00
Maternity leave	1 / 0	30.00

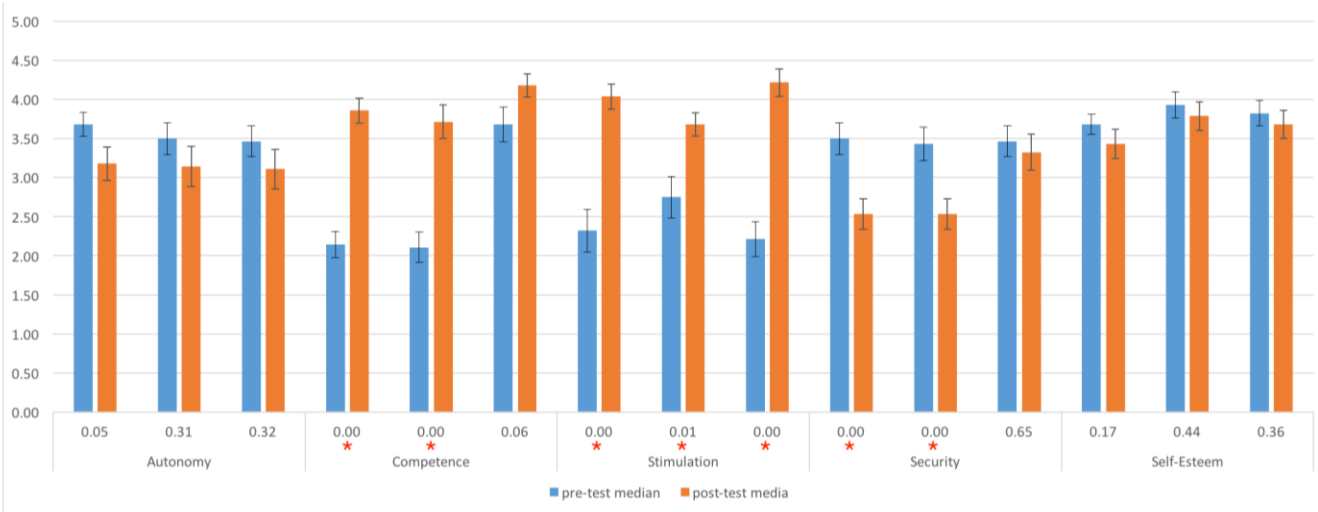

Figure 8: Questionnaire results. Means of each item of the five scales with p-Value for each pair of items below. Pre (blue) and post (orange) questionnaire.

FINDINGS

Pre / Post Questionnaires

The data of the pre- and post-questionnaires was imported into SPSS for analysis. Figure 8 shows the results of each item of the pre-and post-questionnaires. To analyze the data, we performed a paired t-test for each pair of pre-and post-questionnaire items. The comparison of pre-and post-values shows that the items from the autonomy and self-esteem scale do not have any significant differences, even though a slight tendency can be recognized.

The most significant difference can be found on the stimulation scale ($p<.001$ for all three items). After playing *AutoGym*, the users valued the *AutoGym* experience as significantly more stimulating than the experience during their usual commute. Similarly, the first two items of the competency scale show a significant difference ($p<.001$) much more than the third item. These items inquired about the "successful completion of a difficult task" and "mastering a hard challenge". From these results, we imply that *AutoGym* was experienced by the players as a gameful and challenging activity that lead to a significant feeling of competence and mastery, at least in comparison to the participants' last commute.

Interestingly, the two first security items show a very significant decrease between pre- and post- questionnaire. Of interest is the first security item because it inquires if the user felt "structured and predictable" while using *AutoGym*. In comparison to a usual commute, participants valued the *AutoGym* experience as less predictable and structured. This can be an indication for a novelty effect. However, it can also be interpreted that the exposure to traffic i.e. making the traffic the topic of the game had an impact on the players' perception of the situation.

Besides the SDT scales, the pre-test questionnaire also contained several questions about the participants' demographic as well as their driving history, such as car ownership.

The pre-test questionnaire also contained two open questions that asked about previous commuting experiences. For example, one of the questions was "Describe your last commuting trip in one word". As expected, the last commute was described as a negative experience, most common words used being stress, boredom, or frustration.

On one hand, we can conclude from the questionnaires that the participants have a negative evaluation of their last commute. On the other hand, the results from the SDT items were mostly as expected, except for the decreasing security items that requires further investigations.

Semi-Structured Interviews

The interviews were between 10 to 30 minutes long and pre-structured by ten topics. All interviews were audio recorded and conducted immediately after the post-test questionnaire. The recordings were transcribed and analyzed with NVivo software using a thematic analysis approach [2]. After an initial open coding session in which the participants' transcripts were coded based on the contextual meaning, we compared the identified nodes and clustered them into 13 categories with several sub-categories. In the following we report on the six categories that, we assume, are particularly descriptive for designing exertion games in the context of autonomous driving.

A. General evaluation and difficulties

All 28 participants were able to finish the *AutoGym* game: five participants completed without failure, 17 participants repeated one segment, five participants two and only one participant repeated three segments before completing the game. In the interviews, most participants described the *AutoGym* as easy and not very physically challenging. All participants reported they would like to play it again, particularly in different traffic conditions.

The general attitude was very positive, participants described the AutoGym experience as fun, interesting and satisfying. However, the participants were unsure about the nature of *AutoGym* experience, undecided if they should consider AutoGym a game, an exercise tool or a substitute for driving. For example, one participant proposes:

> *Games like this would definitely be a substitute for driving. It translates the driving to another high-level task* (male, 26).

The build-up of expectation also influenced the interpretation:

> *I was expecting more an arcade game. Right now it's more an exercise. I could see that after a few times the novelty wears off* (female, 31).

Contrary to this, the idea of embedding exertion into games was questioned because it blurred the exercise part.

> *If that'd be in an autonomous car, it's a good way to kill down time. However, I don't know what the purpose of gamifying the exercise [was]. If it's for the exercise, I'd work out effectively* (male, 28).

Interestingly, the differences in determining the character of AutoGym, was expressed in most of the participants' answers. The perception was changing depending on topic or question. We believe that this interpretive openness resulted from linear mapping of the speed and the bike's resistance, which would allow participants' to evaluate the game depending on their effort and physical strength.

B. Perceived Control: self, car, traffic

One implicit design assumption of AutoGym was that the physical connection between the player and driving (facilitated by the exertion challenge) would increase the player's feeling of control over the situation. Participants reported that AutoGym would establish a feeling of control, however, the locus and impact differed depending on the interpretation. For example, one interpretation was that it is a physical challenge. By winning, despite the resistance, the player imposes control over the situation:

> *I felt good but I felt that I didn't predict the traffic very well. My instinct was saying let's do this despite the traffic. It was also that I was able to do it because it was quite easy. […] So like a trick to exert more control over the situation* (male, 32).

In accordance with our assumption, many participants reported that they gained control and orientation because it allowed them to feel the car behavior:

> *When the resistance was going harder I felt good because I was going again. Especially during [the] workout I was primarily looking at the application and the resistance signaled me to look up again* (female, 21).

Most interestingly, not only the physical experience of driving facilitated that feeling but also the prediction challenge i.e. the anticipation of traffic, seems to increase sovereignty by allowing the player to act on it.

> *If you are stuck in traffic, you feel out of control, but the game influenced that perception. With it [AutoGym] you can train yourself to read the traffic, and by reading and understanding traffic, it is less scary* (female, 34).

C. Sources of Pleasure: self-efficacy, relatedness to the car, mastery of traffic

We designed AutoGym to enable a faster progression in the exercise program, the slower the car drives. The most rewarding moment should be when the car comes to a halt with almost zero resistance on the spinning bike. Since the participants had different physical strength, they interpreted the reward structure differently. For example, some players felt more rewarded if they were able to complete a section despite higher resistance:

> *I understood the idea that you are rewarded by good predictions with less resistance but I'm quite the opposite. You could reward me with more resistance. For me, it's empty energy going away. […] In the end it was me who chose the prediction, so I have to fight my own prediction and seeing that the prediction was right or not was quite satisfying* (male, 26).

On the other hand, the physical experience of driving was not only reported as orientation but also as a pleasurable experience in itself:

> *I felt the resistance changes were very comfortable to experience. I'd like to play this with closed eyes and guess based on the resistance how fast the car is driving. It could even be more fun* (female, 34).

Mastery was not only related to physical exertion, predicting the traffic was reported as a skill that could be trained and improved:

> *I felt very good. Like winning. A feeling of mastery. I was able to predict the stops quite good. My predictions were improving over time* (female, 23).

D. Experiencing the car: competition, collaborator, companion

Even though the playtests took place in a lab-based simulator, the participants reported that they could imagine how they would perceive the car during playing AutoGym. On the one hand, the car was interpreted as the one to compete with: *I was busy beating the car* (male, 26). On the contrary, the interpretation was based on an exchange or sharing of work with the car, by taking over the work from the car. We interpreted this as a collaboration.

> *It's interesting to feel what the car feels. If the car works, you can rest and enjoy. […] You get communicated how the car feels and translate it in an activity […] when it stops, you take over the physical movement* (male, 25).

However, the alignment of car speed and resistance was also reported as counter-intuitive, especially when the players associated themselves with the car:

> *My mind assumes that when the car rests, I would be resting. I want to be more aligned with the car. It was a big effort to start being busy and physical when my car rests. I felt a little disconnected to the car* (female, 46).

E. Traffic Perception: Context, Opponent, Playground

As expected, time and traffic was experienced as much faster while playing AutoGym. All participants reported that they did not experience a feeling of waiting:

> *Usually I feel bored but with this game I wanted the traffic to stop so I can work out* (female, 22)

However, for the players able to turn the exercise bike even in higher speeds, the traffic situation transformed into a physical challenge for work out.

> *I was experiencing the traffic through the changes in resistance and the more resistance the faster the car and the more I was challenged* (male, 25)

Whereas a few participants reported that the traffic was impossible to predict, others reported that the prediction task connected them with the traffic. Traffic becomes a playground for informed decisions.

> *Yeah. I'm someone who likes to play with the traffic anyway. You will start to learn patterns. If I take a gamble and lose I'll be 2 minutes later so I take the risk* (male, 31).

F. Motivation of Exertion: abreaction, sympathy, progression

One central topic of the interview was the motivation to perform exercises while in traffic. The participants answered this question from several perspectives. Most prominently, participants reported how they would use AutoGym for integrating sport into their daily life. In particular, exercise seemed to be a good activity to deal with frustrating traffic situations.

> *When I stuck in the traffic it makes sense to deal with frustration. It's a good abreaction. I'd play that in difficult traffic* (male, 28).

Moreover, the stimuli of the traffic situation had a natural effect to start interacting. As manual drivers, we are already conditioned to acting when in traffic. It seems a natural interaction that you start getting active when you see a change in traffic; in the sense of piggy-backing exertion onto traffic:

> *The traffic light, the cars in front of us. Especially the break light in front of me. If they turned on 20m in front, our impulse is to break and then you felt the decrease of resistance* (male, 23).

Lastly, a participant reported that sympathizing with the car can also result in exertion as a way of facilitating the driving task:

> *Somehow you can contribute [to driving]. I can show sympathy with the car. The car works hard; I work hard too* (male, 28).

DESIGNING EXERTION-GAMES FOR AUTONOMOUS DRIVING

The results clearly demonstrated that the connection between AutoGym and the driving context through the prediction and resistance mechanics of the game affected both the experience of the exertion task, as well as the driving situation. The exertion task, mediated by the experience of the car speed, had an impact on the perception of the car and the driving context. It appears as if the physical investment of exertion was facilitating the player's concept of who is in control of the situation, who sets the challenge and the motivation to continue. Table 2 summarizes the findings of the interviews by aligning them into three possible configurations. These three suggested configurations are an attempt to understand implementations of in-car exertion, based on the connection of the three core aspects of the experience: perception of traffic, perceived locus of control, and the motivation for exertion. The interviews indicated that the participants interpreted the AutoGym experience based on their physical

Table 2: Three Implementation Strategies with selected criteria from the findings.

Implementation of Exertion	Role of car as	Traffic perception	Exertion motivation	Perceived control	Sources of Pleasure
(1) Driving substitute	Competitor	Context	Fitness and abreaction	self / overcome the car	Self-efficacy / mastery
(2) Identification	Companion	Opponent	Sympathy with car	aligned with the car	Relatedness / feeling for car
(3) Contribution	Collaborator	Playground	Progression	over traffic	Mastery / understanding traffic

ability to control the game by exercising even when the car drove relatively fast. This motivation to exercise had a particularly strong effect on the interpretation of the perceived loci of control. Hence, each of the following implementation strategies can be seen as a possible configuration for designing traffic-based exertion games that are based on prediction and resistance mechanics.

Implementation Strategy 1: Exertion as a Driving Substitute

AutoGym substitutes the driving task by providing a new challenge for mastering the traffic: physical exertion. From a design perspective, exertion as a substitute was implemented by a linear and continuous mapping of car speed and resistance. This allows the players, depending on their physical strength, to dominate the car's driving behavior. Hence, the challenge was to beat the car. The car was perceived as a competitor that must be overcome to win the game. In other words, the rewarding moment was to impose their own power on top of the car's power. The higher the speed, the more challenging the game. In contrast to the original concept, the stop phases became time for recovery.

The traffic situation was relevant mostly as the source of the driving behavior but not as the focus of the activity. By overcoming the car as a competitor, the player experienced control as self-efficacy. The player was in control of the driving task by mastering the power and speed of the car through physical exercise. This implies that exercise and fitness motives were of similar importance to the pleasure of exertion in an unusual context.

The focus of implementing exertion as a driving substitute might be on making the car and driving dynamics a physical experience. The game component, such as the prediction mechanics of AutoGym, should be designed to support the experience of imposing their own power. Ultimately, this implementation leads to an in-car exercise program and would not necessarily be embedded in a game context. The traffic was a challenging moment of harder and easier intervals, similar to popular interval workouts. In future autonomous cars, it might be possible to represent the player's performance data through the driving style of the car which open new perspectives of external motivations.

Implementation Strategy 2: Exertion through Car Identification

This strategy was also based on a physical experience of the car's power. However, exertion was less strongly motivated by competition but by sympathy and progress. The car was perceived as a companion with whom the player shares the workload, in order to progress in traffic. Exertion was not the core-experience of the interaction system. Exertion was rather a medium to build a physical connection to the car thus making the traffic progression more tangible. The core experience was a consistent progression through an exercise program and traffic.

Traffic was not a motivation for exercising, such as in implementation strategy 1 nor the motivation for the gameplay as in strategy 3. The general assumption was that neither traffic nor physical exercise are fun. However, it was pleasurable to feel the progression through the power and the dynamics of the driving. Furthermore, the players gained orientation and control by feeling what the car was doing. The player was in a physically mediated dialogue with the car's driving dynamics having only one goal: progression, mediated by an understanding of the situation through the exertion tasks.

Interaction needs to be aligned with the dynamics of driving. An indirect implementation of speed could enforce that. Subsequently, this concept could also be implemented by an inverted mapping of speed and resistance as one participant suggested: *When the car works, I want to work as well.*

Implementation Strategy 3: Exertion for Driving Contribution

In contrast to the two former strategies, this configuration relied on the prediction mechanic as the core experience of the game. Exercise and the feeling for the car (the core-experiences of the other two implementations) were only an additional motivational affordance of a correct prediction. Avoiding or minimizing exertion by a precise prediction of traffic was the goal and challenge of the setup.

In this implementation, traffic was the playground and object of investigation i.e. it needed to be understood in order to progress in the game. The gameplay resembled a dialogue between the car and the inactive driver, which led to an interpretation of the car as a collaborator for progressing in the game (and the traffic respectively). Similar to strategy 2, the workload was shared between car and player. In other words, the player contributed to the driving activity by reading and communicating the traffic situation correctly.

This change the location of perceived control. Control was established through understanding the traffic and the driving situation. A correct prediction instilled a feeling of success and control over the traffic. It reframed traffic as something that can be understood and overcome. In that way, traffic lost its subjective characteristics of being uncontrollable, and potentially disastrous, and turned it into a playable environment.

This interpretation facilitated the exchange between the work of the car and the exertion activity. When the car stopped, the workload was transferred to the player. In particular, the exercise bike was associated with the concept of charging the car, such as a metaphor for an electric car. This could potentially add another layer of motivation for exertion. In any case, since this implementation relied on precise decisions, it would require a strict enforcement of the game rules. Wrong predictions should have severe consequences for the exercise routine. A linear connection between speed and resistance would not be required because the core experience was reading the traffic situation.

LIMITATION

The presented implementation strategies attempt to describe three possible configurations of aligning exertion games with the autonomous driving context. In this paper we posed this alignment as implications resulting mainly from the interviews, as well as from experiences and reflections of the design process. The 28 semi-structured interviews provided a comprehensive repository of user experiences, although only a subset of these experiences directly informed the three presented implications. In contrast to this, the questionnaires provided only few unexpected insights and the small number of cases does not allow a generalization of the results.

Furthermore, to increase the sample size, we tested AutoGym in a lab-based simulator setup. We assume that this setup had a major influence on the players' perception of the car, and of course, the experience of safety and a feeling of control. On the contrary, this setup allowed the participant to focus completely on the game without the distraction of a real driving situation. Because of these reasons, we believe that the implications provide an idealized concept of exertion implementation strategies.

In the design process and the lab-based study of AutoGym we explicitly excluded the safety constraints of current autonomous driving such as handover times and the physical dimensions of the interface. A legal implementation of AutoGym would require a level of automation technologies not yet available. Nevertheless, by designing and testing the concept AutoGym we investigated the traffic and driving situation as a playable input for a secondary activity. The impact on the situational awareness and as such an improved safety of autonomous driving has only been investigated indirectly and subjectively via the interviews. In future studies, it will be crucial to investigate the safety context of such an exertion-game, in terms of quantifiable situational awareness, emergency behavior and hand-over situations.

The AutoGym prototype has a limited scope of resistance. Over the length of the study, the strength of the resistance decreased which required us to readjust the resistance several times. Participants who followed right after the adjustment, had a slightly higher base-resistance then others. This might have influenced their experience. However, since everyone successfully completed the game, we believe that this effect can be marginalized.

Ultimately, the participants differed in their individual physical strength. Since we could not align the resistance with the personal strength, the physical effort required from the participant was not equal. We believe that these differences facilitated the individual interpretations which resulted in a rich variety of experiential aspects.

CONLUSION

This paper presented AutoGym, an in-car exertion game that integrates stop-and-go traffic as a playable input and thus forces the player to maintain situational awareness during autonomous driving. We reported the results from a lab-based simulator study with AutoGym that offer insight on the player experience and the impact on the motivation to engage in contextualized exertion.

We articulated three implementations that are based on generic configurations of the identified experience factors. The broader context of this work is the exploration of non-driving activities for autonomous driving that aims to compensate for this loss of operational control through a meaningful in-car integration.

AutoGym enabled a direct translation of driving dynamics into an interactive exertion experience. This made it suitable for exploring the fertile experiential tensions of the autonomous driving context. The suggested implementation strategies provide a blueprint for future explorations of in-car exertion games. Ultimately, AutoGym shows that even frustrating stop-and-go traffic can be a fun and healthy experience. In that way, we hope to inspire designers to continue exploring exertion as a healthy way to make up for the experiential caveats of autonomous driving.

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