Information Presentation in Autonomous Shuttle Busses: –What and How?

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Abstract. This paper addresses what kind of information users need when driving in an autonomously shuttle and how this information is communicated. This was investigated in two studies with participants in the age-range of 23–25 years using online focus groups. Results showed that both groups rely on the "safety driver" because it supports the feeling of security. Concerning the possibilities of transmission via different human-machine-interfaces, the participants agreed in both studies that the type of information and its transmission should be similar to that used in today's public transport. Differences between the two studies arose in the discussion about the presentation of technical information. One group preferred that technical information, including the explanation of how the shuttle works and real-time sensor data of what the autonomous shuttle is detecting, be shown by default. On the contrary, the other group only preferred this information on request by the passengers. Furthermore, participants explained that such information could increase insecurity as it could be too detailed and might overwhelm passengers. Both groups agreed that providing some extra information for reducing concerns is helpful. One aspect for overcoming negative feelings in the shuttle was the idea that more infotainment options, such as showing Points of Interest, can elicit positive feelings during the ride and this in turn can decrease potential fear or trust issues with autonomous shuttles.

Keywords: Autonomous shuttle · Human-machine-interfaces · Passenger information · Trust

1 Introduction

Research on information presentation in automotive user-interfaces of highly-automated, privately used vehicles has a long history [1]. Influential factors for the acceptance of automated vehicles, such as trust in technology that lead to acceptance of the systems [2], have already been identified. Currently, autonomously driving shuttle buses are introduced in public transportation. While the technological implementation already allows testing in specific regions [3], the conditions of operation require that a "safety-driver" is always present for intervening in specific situations and that vehicles drive very slowly. Field tests showed slightly positive feelings of safety towards autonomously

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driving shuttles when a safety driver is present [4–6]. Only one study showed a decreased level of acceptance [7] compared to a human-operated bus.

The safety driver was perceived as a positive factor in various studies [6–9]. However, since the specific conditions (safety-driver, slow vehicle speed) will change in the future, trust in the technology and autonomous shuttles might be lower and lead to decreases in acceptance. Possible countermeasures may include presenting passengers with more information about the operations of the shuttle or other relevant aspects with the help of different human-machine-interfaces (HMI) [10]. Users must feel comfortable in the shuttle and be able to trust the technology of the shuttle to feel safe [8]. Therefore, expectations and requirements of potential passengers concerning information presentation in future autonomous shuttles were investigated in two studies and the results are reported in this research paper.

2 Study Design

2.1 Research Questions

For the conducted studies a fully autonomous driving shuttle without safety-driver was assumed and verbally introduced to the participants. To investigate expectations and requirements from potential passengers, two studies were conducted in May 2021. These two studies occurred independently from one another. Based on addressing similar topics, their results are combined in this paper. Since the studies apply slightly different approaches, as described below, the two studies are hereinafter referred to as Study A or Study B. Research questions that are addressed by both studies and can be evaluated similarly are the following:

1. Do potential users of autonomous shuttles need specific information from an internal human-machine-interface (HMI)?
2. What information do the passengers need during an autonomous shuttle ride?
3. How should this information be displayed via HMIs?
4. Which information should be given in case of a problem with the shuttle?

In this context, it is interesting to determine what information can improve the users' feeling of safety within the shuttle during the ride and how this information can be transmitted via HMIs. The following additional research questions are specifically related to Study A:

– What are the reasons for concerns using autonomous shuttles?
– Can information reduce concerns about autonomous shuttles?

Study B also poses an additional research question:

– Which information should be continuously displayed, and which information only on request?

2.2 Materials and Methods

These questions are investigated in two online focus groups. One advantage of doing focus groups is that new creative ideas can be generated collaboratively, which might have remained hidden in individual interviews [11]. Through the group dynamics, ideas can be further discussed, extended, and directly evaluated by several potential users. Since the goal of the two studies is to get an impression of the users' requirements for the information in future autonomous shuttles, this was selected as the preferred research method. While it is true that focus group studies are not representative, they generate new ideas and findings for topics that are under-researched so that they can be further investigated in future research using quantitative methods. Of course, the implications of this study are therefore limited to the investigated sample. Overall, this research focuses on idea-generation aiming for new ideas, wishes and requirements of individual potential users.

Both group discussions took place online and in German using the platform Zoom [12]. All participants joined the online conference with audio and video. A PowerPoint presentation with prepared questions, images, and video materials from an autonomous shuttle was used to guide the group through several topics. Mural [13] was used as a digital bulletin board in which all participants interacted simultaneously to brainstorm ideas during the group discussion phase. For analyzing the results (i.e., coding the transcripts), the software MAXQDA [14] was used.

2.3 Participants

Focus Group A. The five participants in the focus group of Study A are aged between 23 and 25 and all live either in Stuttgart, Germany or in Karlsruhe, Germany. Four of them are female, one male. They mainly use public transportation, cycling or walking as a primary mode of transportation. In addition, all of them have completed a bachelor's degree in the various fields of mathematics, transportation management or public administration. Three of them are currently master's students and two participants have a full-time job. Two of the five participants have already used an autonomous shuttle in the past.

Focus Group B. The focus group in Study B also consists of five participants aged between 23 and 25. All five participants are male and live in Stuttgart, Germany or in Karlsruhe, Germany. They mainly use bicycle, public transportation, and cars as their primary modes of transportation. In addition, all of them are students of the study program transportation management. Four of the five participants have already ridden an autonomous shuttle and all five participants had some experience with autonomous vehicles.

2.4 Procedure

The online focus groups, lasting approximately two hours, were conducted in May 2021. In the two groups, the participants discussed the following aspects:

1. Introduction: This phase was the same for both groups. The participants introduced themselves to each other and were familiarized with the topic with the help of pictures and videos. In the videos, a shuttle from Monheim, Germany drives through a roundabout and through a residential street. The pictures show the interior of the shuttle without the displays, so that the participants are not already focused on the displays.
2. Experiences: During the next phase of both studies, everyone could share their experience with autonomous shuttles. Additionally, group A participants were confronted with the statement that some people have concerns about autonomous shuttles and were asked about their opinion about the underlying reasons.
3. Required Information: Study A participants were asked about what information they would need from an autonomous shuttle if there would be no safety driver on board which they could ask. They were presented with a scenario in which they are in a foreign city and want to get to a tourist attraction, and they know that an autonomous shuttle services the route. After this short introduction to the scenario, they had to use the Mural tool to cluster the different aspects which they identified into categories relating to the time at which the information should be provided. The participants of Study B also sorted relevant information into clusters but were introduced to another potential scenario of going from home to a supermarket. Another topic of Study B was how frequent information should be presented.
4. Information in problematic situations: In both groups, a different situation was introduced in which the shuttle behaves unusually for reasons that are not obvious to the passengers. Participants of Study A were confronted with the problem that the shuttle drives very slowly. An example video was shown how the autonomous shuttle in Monheim, Germany drives very slowly for no apparent reason and cars overtake the shuttle. Additionally, the scenario of a shuttle which brakes suddenly for reasons unknown to the passengers was introduced verbally and the participants had to discuss which information they expected to receive in such situations. The scenario with the sudden braking was also introduced to the participants of Study B.
5. Technical transmission: In addition to the discussion about the content of the information, participants of both studies were also asked about their ideas for transmitting the information.
6. Ending: At the end of the group discussion, Study A participants had to discuss if they think autonomous shuttles would be available in the future and whether they think the discussed information can help to reduce possible concerns against driving in an autonomous shuttle. Study B participants were encouraged to summarize the discussed topics in a short questionnaire. As an example, one of these questions was: Which of the discussed information would you like to receive continuously?

Proceedings from both focus groups were separately recorded and transcribed. Finally, through coding, the individual statements were categorized into different topics. The results of the coding and categorization into the topics are described in the following section.

3 Results

Since the described studies are qualitative in nature, they do not allow for inferential statistical analyses and therefore the results are also qualitative.

3.1 Reasons for Concerns and Insecure Feeling

In general, the participants of Study A have a positive attitude towards autonomous shuttles, even if they have some concerns. They think that the technology is not yet fully developed and that it would feel strange to sit in such a vehicle without a driver. They also note that they cannot imagine riding in an autonomous shuttle, especially in a busy city center with a lot of traffic, because they would not feel safe. Similarly, the participants of Study B say that the safety driver had to intervene in many situations during their trips with the autonomous shuttle. When asked why they think others have concerns about autonomous shuttles, participants of Study A mention the loss of control and that the passengers should have total trust in the technology. In their opinion, this aspect can be counteracted by driving with the safety driver present at the beginning or by weekly test drives. Even if they like the presence of the safety driver at the beginning, they think that when the safety driver is no longer on board, they do not want too much specific information about the technology of the shuttle.

3.2 Required Information

Concerning the question of which information the users need during the ride with an autonomous shuttle, three different types can be distinguished: basic, technical, and supplementary information. In the following, the results are clustered into these three categories.

Basic Information. For both groups, the main focus concerning basic information is on route information. They expect to see the planned route with the next stops of the shuttle. Discrepancies between the displayed route and the actual route in a situation where, for example, the planned route is unexpectedly closed, and the shuttle therefore detours, should be avoided because this could create insecurity. In this case, the participants of Study A request real-time information and display of the modified route. Other requested basic information of both groups is related to the arrival and travel times, including possible delays, the ticket prices, the rules of conduct inside the shuttle, transfer options to other modes of transport, and the current time and date. Information on changing trains should also be available during the ride based on the participants responses. Additionally, the participants request this basic information continuously during the ride. The participants of Study A specifically state that the basic information should be similar to the information currently given by public transportation systems. They explain further that they do not want to feel as if they are in a special vehicle. Instead, they prefer the feeling as if they are travelling on a normal public bus. For example, one participant of Study A said: “I think it helps people to feel a bit safer, to feel normal, when you see something like that [Information] there, because you already know it from other modes of transport” (translated from German).

Technical Information. Technical details about the autonomous shuttle should be explained, according to the participants of Study A, to non-experts in such a way that they can be easily understood by everyone and thus can also increase trust in the technology. For example, it should be shown what the sensors can detect, how fast the shuttle is travelling, etc. Accident statistics should also be shown, so that people can see that the shuttles are much safer than other modes of transport. All information should be easily available for all passenger groups including older passengers, who may not have a smartphone or be able to use a touchscreen. According to the participants of study B, the technical information should help to better understand why the shuttle slows down or even stops. Participants also request some kind of feedback for the user in the form of symbols. They would like to know which events and situations the shuttle is reacting to, including the information that the shuttle detected a person on the street and therefore slows down.

Participants from Study A state that advanced information during the ride should only be presented in such a way that interested users can inform themselves about autonomous shuttle technology. However, the other passengers who do not want this information should not be confronted with it, because this may increase concerns rather than reduce them. One participant said: "For those who want more information, more information should be made available, but not all of them should be flooded with this information. Because I think that this can also result in insecurity, if you get in and first think: 'Okay, wow I don't know what to do.' Then maybe I'd better get out again" (translated from German). On the contrary, participants of Study B say that they would like to have the information always shown, and therefore they can always get the information if they need it. This can be seen in one statement of a participant in Study B: "It does not hurt to always display it and if you need the information, you can pick it up. If not, then you just do not have to look at it (…)" (translated from German).

However, in the opinion of participants from Study A, real-time data, such as a visualization of what the sensors are currently detecting, should never be available, as this would make passengers focus too much on this information. In this case, the passengers might look for errors in the system behavior, or immediately detect the smallest mistakes of the system, which would increase the potential for fear and reduce the trust in the shuttle. This result is completely different to the opinions of Study B participants who wish for real-time data of sensors and additional information such as the speed of the shuttle.

Supplementary Information. In addition to the technical data of the shuttle, the participants of both studies would like to have tourist information or information about the ride and the route. This would also help to bring the passengers' attention to a positive topic and make autonomous driving as normal as possible. Tourist information, such as Points of Interest, should be shown. Here, the participants of Study B also add the occupancy of the Points of Interest, shown for example on a display in the shuttle, as interesting information that could be transmitted to know off-peak times to visit the supermarket or gym.

In general, according to Study A participants, the ride should be a positive event and therefore information that elicits positive feelings and possibly distracts from potential

insecurities should be presented. The reasoning is that the passengers have positive feelings concerning infotainment options and this in turn can decrease negative thoughts about autonomous shuttles. The participants of Study B mention that the comparison with the infotainment display from light rail vehicles sums up well what kind of entertainment information the participants would also like to see in this case.

Participants of Study A prefer similar information to that currently displayed in public transportation vehicles so that autonomous shuttles do not feel different from a normal bus. They favor a display with information about the planned route, the next stops, the time to the next stops, the transfer possibilities, and information about important Points of Interest. Participants from Study B additionally ask for information about the date and time and the current speed of the shuttle. However, both groups would like to see a map instead of the currently displayed line path with the expected route.

3.3 Display via Human-Machine-Interfaces (HMIs)

The participants of both groups prefer displays for presenting basic information to the passengers. In their opinion, these displays should show the current route, the planned stops, the current speed, time and date, and transfer options to other modes of transport. The participants of Study A compare this to the screens in the Stuttgart Underground or Karlsruhe Light Rail and state that the information shown in autonomous shuttles should be presented similarly so that the passengers do not feel like they are sitting in a special vehicle. Furthermore, the supplementary information like place and description of Points of Interests or news should be shown on a display. Participants of Study B prefer seeing the real-time sensor data on a head-up display integrated into the front windshield of the shuttle.

Information via loudspeakers is mainly requested by the participants of Study B. They imagine auditory information at the beginning of the ride, like a start signal tone or information about still missing passengers, and the transfer possibilities via loudspeakers. The participants of Study A on the contrary do not prefer audio information, except in the event of more severe technical problems.

As described in the previous chapter, the technical information requested by the participants of Study A should only be available on request from a passenger. They think this information could be displayed via a QR Code, which is placed in the shuttle and redirects to the information page from the shuttle operator. A built-in touchscreen is another idea so that the passengers can search for the technical and other basic information, which the passengers specifically request. For older passengers, the technical details should be available on paper flyers inside the vehicle.

Other HMIs that help to reduce concerns in the opinion of the participants of Study A are, for example, emergency stop buttons that can be used to get off at the next possible opportunity and an intercom station that connects you to the control center. If possible, a “real person” should be on the other end of the line. This would ensure easy communication in case of insecurity. Again, it is important for the participants that the way in which this information is displayed is not very different from normal buses.

Summarizing the findings obtained in both studies are displayed in Table 1. Each type of information is divided into the technical requirements and in which study it was mentioned.

Table 1. Required information and transmission

Type of information	Technical requirements	Study
Route	Display	A | B
Travel- and arrival time	Display	A | B
Ticket price	Sign/Display	A
Rule of conduction	Sign	A
Transfer possibilities	Display	B
Start information	Display + Auditory	B
Date and time	Display	B
Technical information	QR-Code, touchscreen, flyer	A
Real-time sensor data	Symbol, Display	B
Real-time speed	Display	B
Traffic situation	Display	B
Points of interest	Display	A | B
News	Display	A

3.4 Information in Case of a Problem

In the case of smaller problems such as driving with slow vehicle speed, the participants of Study A prefer a message on the display that communicates something positive such as "we are currently driving with increased attention". Moreover, this information should not be too obvious and should not give the impression that something is wrong. This aspect is similar to the ideas from the previous chapter in which the participants prefer discreet information presentation. Participants of Study B prefer real-time sensor data to know why the shuttle slows down.

In the case of larger problems such as suddenly heavy braking followed by a complete stop, the participants of both groups expect more detailed information about the reason and whether and when the journey will continue. They prefer in that case announcements via the loudspeakers with an explanation what has happened, a forecast if and how long the disturbance will exist and instructions on what to do, as it is common in many trains nowadays. This information also has to appear on the display. Participants of Study A mention specifically that the person speaking via the loudspeakers should be a real human to increase the feeling of safety as it might make passengers more insecure if announcements sound like a machine.

3.5 Reducing Concerns

Participants of Study A believe that flooding the passengers with information will not reduce the concerns about autonomous shuttles. They think in addition to the basic information, some positive information should be available on request, which shows that autonomous driving is safer than riding a normal public bus nowadays. Study B

participants in contrast think that too much specific information, like showing real-time sensor data on a display, is important for the passengers' feeling of safety. Therefore, it can be seen that the preference for the type of information which should be given to the passengers to reduce concerns is different in both studies even though both groups think that some selected extra information is helpful.

3.6 Continuous Information

As described in Subsect. 2.1, Study B also explored what information participants expected to receive continuously during the ride with an autonomous shuttle. This category would include information about the speed of the shuttle, the arrival time, the route, and information about Points of Interest and transfer possibilities. Route information and arrival time information is expressly mentioned and discussed several times by different participants. The study by Mirnig et al. [10] shows that the display of stops and the planned route is an important issue for information transfer in autonomous shuttles and there are different ways to design this. The participants of Study B explain these requirements by saying that they have a plan after arriving at the desired target or use it for certain source-target connections and that it would therefore be particularly important to know when they would arrive at their target and to know with which route the shuttle would try to reach the target.

3.7 Summary

In summary, the participants of the focus groups prefer similar basic information. This information should be presented using a display inside the autonomous shuttle, similar to the implementations in today's public transport. Furthermore, the participants of both studies expect supplementary information like Points of Interest. Differences between the two focus groups arose in the discussion about the presentation of technical information. The participants of Study A prefer that the information is only presented at the request of passengers. The participants of Study B on the contrary, favor that the information is shown the whole time. They also wish to see real-time sensor data, which participants of Study A believe will increase the concerns about autonomous shuttles.

4 Discussion and Outlook

Some results of the focus group studies are in line with other research findings. First, most participants state that they like the "safety driver" as it supports the feeling of security. This is similar to other studies [4, 6–9]. Nevertheless, the results of Study A suggest, that users do not prefer to be flooded with a lot of extra information. They prefer to have basic information, like the planned route and some supplementary information that give a positive driving experience and increase trust towards the shuttle. A similar aspect is also described in another study which found that the information needs to be easily accessible, but shall not be disturbing [15]. This matches the findings of this study in which the participants believe that the technical details and specifics should be provided in an easily-accessible way for all age groups that does not overload the

passengers. For this reason, Study A participants believe this kind of information should only be given on request and ought not be provided continuously. On the contrary, the participants of Study B are interested in seeing real-time technical information about the shuttle (e.g., what the shuttle currently detects). Moreover, they think that such information would lower their concerns about autonomous shuttles. Participants from Study A do not wish that this information be displayed permanently. Study A participants only support providing this information to interested passengers on request (e.g., with an application on the smartphone). They explain that they prefer not to be reminded about the driverless shuttle as this would lead to lower trust. Instead, one can interpret that they pretend to be in a "normal" shuttle in order to feel more secure. This finding is partially in contrast to previous research such as [2], who conclude that all automated systems should be transparent about their system status in order to increase trust. We must acknowledge, however, that the reported studies A and B were focus groups with only five participants each and do not allow for generalizations. Any causal relationships would need to be tested in subsequent experiments.

An interesting aspect is the idea that providing entertainment features could lead to positive feelings. This was explained as possibly counteracting potential insecurities or trust issues. Another option could be using a social agent to interact with the passengers, compensating for the missing "safety driver". This could be especially helpful since the participants wished for a "human" in the shuttle (in the case of the helpline). A social agent has been found to be helpful in a study of automated vehicle driving because it increased trust in the automated driving system [16]. It would be interesting in further research to investigate whether increasing the anthropomorphic features is especially helpful in this context for mimicking an actual person.

Since the findings from the two focus groups are only an early starting point of researching which information presentation and new technological features can support trust and acceptance of autonomous shuttles, they surely cannot be generalized to the entire population. One problematic aspect of this and similar studies is that users who have not used the innovative new technologies under investigation, tend to stick to aspects which they already know. This became apparent specifically in Study A in which the participants prefer to "pretend" that they are using a normal bus and prefer the same information presentation as the one they are used to. If Study A had more participants with previous experiences riding in autonomous shuttles (such as in Study B) the results could have been very different. Furthermore, a greater variety of age groups shall be addressed in further studies since the groups in both studies were very homogeneous, that means all of them were young people who have graduated from university in the last few years. Other focus group participants may have different ideas about required information and transmission via HMIs, so conclusions drawn from this study are not generally valid for other focus groups of this topic. For this reason, future studies should incorporate specific social groups, such as the elderly, to get a better sense of the variety of preferences.

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