On the Road with an Autonomous Passenger Shuttle: Integration in Public Spaces

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Abstract
The integration of autonomous vehicles (AVs) onto public roads presents both technical and social challenges. Public understanding and acceptance of AVs requires engagement with people who live in, work at or visit cities where they are deployed on public road networks. We investigate the impact of one of the first placements of AV passenger transport on public roadways: the Sion <<SmartShuttle>>. This late-breaking research presents preliminary results from interviews with local shopkeepers, residents, pedestrians and drivers to understand their attitudes and opinions of the shuttle. We also discuss video-based fieldwork that demonstrates how drivers negotiate next moves with one another through their windscreens using embodied signals such as gestures, lip-reading, and head nods to coordinate and manage a traffic situation. Finally, we consider the implications for how fully autonomous vehicles might be designed to take into account the subtle negotiations that road users engage in to coordinate with one another.

Author Keywords
Autonomous vehicles; public transportation; ethnography; embodied interaction.

ACM Classification Keywords
H.1.2 User/Machine Systems (Human factors); I.2.9 Robotics (Autonomous vehicles).

Introduction

Self-driving cars are now a reality with many companies and universities testing them on public roadways. For instance, in the commercial sector Google, Tesla, and Uber, are bringing AVs on to roads. Also, academic projects such the LUTZ Pathfinder [16] in the UK, and the European Union CityMobil2 [4] examine technical and infrastructure concerns. These projects collect data about vehicle performance such as the robustness of mapping technologies and obstacle detection in addition to measuring public perceptions of safety and comfort. More specifically within HCI, researchers have examined issues around driver-vehicle interaction [8, 14, 18], dashboard design [7], and in-car interaction [19]. To date, most research has been conducted in laboratory settings using prototypes, future scenarios, and in some cases onsite at test facilities [20]. However, as AVs move from test facilities to public roadways, researchers now have an opportunity to investigate Human-AV interaction in real world traffic situations [1, 11, 23, 24].

Recent studies in AV Human-Machine Interaction (HMI) provide insights into how algorithms may need to be calibrated to take into account the norms of conduct between pedestrians and vehicles [24], the types of information drivers might need prior to an AV action [7], and implications for transforming the role and skills of drivers [17]. With so much valuable research underway, it is worth noting that enquiries into Human-AV interaction are nascent, with in-car research focusing primarily on driver-vehicle, and passenger-vehicle interaction in ordinary cars with AV technology added to them. The same nascent state is true for HCI ethnographic research; where studies have only recently appeared that discuss how ordinary cars (kitted out with AV technologies) interact with other road users. However, in the social sciences Mobilities research has been a vibrant field of study for decades and includes a rich and growing corpus of material that describe interactions in ordinary cars between drivers, passengers and pedestrians and their implications for movement and traffic flows [9, 13, 15].

For this paper we draw upon similar video-based methods and analysis used in Mobilities research to investigate an entirely new type of vehicle – a bespoke passenger shuttle service designed specifically to transport people on roadways and public areas. In contrast to ordinary cars, these vehicles operate on a specified route where anyone from the general public can board the shuttle, embarking and disembarking at designated stops. The shuttle’s deployment on to city streets is not only a technical feasibility study but also a public engagement exercise that provides us with an opportunity to investigate Human-AV interaction in real-time traffic situations.

We describe the elements of a broad and ongoing ethnographically-informed research study where we are in the process of collecting and analyzing data across four key areas: driver-vehicle interaction (support for handovers and control), how people make sense of AV behaviors in public areas (its intelligibility), reactions of passengers when riding on the shuttle (perceptions of safety and comfort), and acceptance amongst the local community (perceived advantages and disadvantages). The goal of this research is to advance our understanding of how AVs impact the broader ecosystem and to reveal the interdependencies between how people make sense of AV behaviors and public acceptance.

Background

In an effort to contribute to the development and shaping of innovations in sustainable mobility, PostBus launched the Sion Smart Shuttle pilot project. As Switzerland's primary public bus transportation provider, PostBus operates and manages a network that extends to the most remote areas of the country. The aim of the pilot is to test the viability of AVs as a potential addition to the public transit network. Approval was granted for AV operations in a dual use vehicle/pedestrian area (Fig. 1) in June 2016 where it will operate until October 2017.

The Sion Smart Shuttle operates on a route of 1.5 kilometers in the Old Town district of the city (Fig. 2). They travel at a maximum speed of 20km and hold up to eleven people inside. On the outside, they are equipped with four sensors at heights of 20cm and 80cm, two at the front and two at the back that measure its distance from obstacles. In addition, there are two LIDAR sensors on top (front and back) that create a 360-degree map of the vehicle's surroundings in real-time. The AV software operates at levels of between 3 and 4 (conditional and high automation) [21] dependent upon traffic conditions. The vehicles do not have a steering wheel, accelerator or brake pedal. Rather, these are controlled using a reconfigured Xbox controller where the driving task can be transitioned from the software to the human (Fig. 3), and back again to the software, using its controls.

Figure 1: The Sion Smart Shuttle driving in a pedestrian area.

The shuttle provides residents and visitors of the city an opportunity to use and learn about AV public transit. Whilst the technical partners focus on operational feasibility, our team concentrates on collecting both observational and interview data related to behavior and acceptance factors. Outcomes from our research will inform requirements for improved HMI across its multiple facets.

Method and Approach

Our goal is to understand Human-AV interaction holistically across four key areas: driver-vehicle interaction, passenger reactions to riding on the shuttle, responses of other road users to AV behavior, and acceptance amongst the local population. Extending our unit of analysis across the larger ecosystem where AVs are embedded will provide us with an understanding of the interplay and interdependencies between how people make sense of and interact with AVs in public spaces.

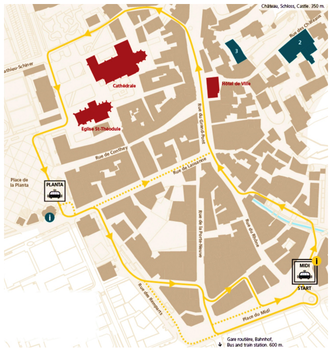

Figure 2: The route in the Sion Old Town includes eight designated stops.

Figure 3: An onboard attendant monitors and manages AV operations at all times. If necessary they can control its steering, acceleration and braking using a reconfigured Xbox controller in real-time traffic situations.

We are in the process of gathering data using a four-fold approach. First, we conduct semi-structured interviews with local shopkeepers, residents, pedestrians and other vehicle drivers to understand their attitudes and opinions of the Smart Shuttle. This includes questions about the intelligibility of AV trajectories and movements, as well as their overall likes and dislikes. Second, we interview and observe the PostBus AV attendants to understand how and when they interact with the Smart Shuttle and other road users. Third, we recruit participants to be passengers on the Smart Shuttle. These sessions are video-recorded using two mounted action cameras: one with an interior view of passengers and the other with an exterior view of the road ahead. Fourth, we engage in participant-observation riding on the shuttle as a passenger, and walking through the area as a pedestrian taking field notes and photographs.

Although our research is broad in scope, for this paper we present late-breaking results. First, from interviews underway on the streets and in shops in close proximity to where the shuttle operates. Second, we discuss in detail an example of how rich video data gathered in real-time traffic situations provides access to insights about Human-AV interaction that may otherwise be impossible to recover from interviews and lab-based studies alone. For this we draw upon Ethnomethodology [6] and Interaction Analysis [12] to analyze a video fragment and discuss the implications that driver-to-driver communication practices may have on future designs of AVs that operate in public spaces.

The Smart Shuttle in Public Spaces

From the interviews completed thus far, there is an overall opinion that the shuttle is very good for the city's image characterizing it as an innovation destination. Many locals have ridden on the shuttle out of curiosity but have only used it once. This is because the current route is "not practical" (traversing through a small, walkable area). Rather, it is seen as something that tourist can use to acquaint themselves with the old town. Many people feel that the shuttle slows down traffic in the area. This is primarily because of its slow speed but also because other road users cannot interpret its intentions. For instance, more than half of those interviewed said that they either completely avoid or were extremely careful walking or driving near the shuttle because they are unable to interpret its movements or because "the technology might fail". Many suggested that some kind of communication device be installed to better inform other road users. Their suggestions include larger signaling indicators, sounds, or an electronic display mounted on to the AV. Their feedback suggests that other road users would like the shuttle to take into account the social norms of road etiquette and behavior [2, 3] by making its intentions and actions more transparent. This requirement for better communication between AVs and other road users is demonstrated in detail in the following video fragment.

Video-based ethnographic fieldwork is used in HCI research in a variety of settings to understand social organization and communication providing insights, observations and findings to inform the design of technologies [5, 10]. Video data provides us with the ability to examine action as it occurs in real-time across the shuttle's surroundings. In the following fragment we present an instance of interaction that demonstrates the complexities of co-managing traffic behaviors amongst drivers who share the same roadways. We

Figure 4a: The attendant gestures to the driver behind to wait. ‘Stop.’

Figure 4b: The other driver challenges his request. ‘Stop!!’

Figure 4c: Waving the vehicle forward when it is safe. ‘Go.’

discuss the potential implications for coordinating the management of traffic between drivers, if and when, fully autonomous vehicles are introduced.

Coordinating orderly traffic flows

How people make sense of AV actions can be complicated in high-density areas such as busy dual use vehicle/pedestrian roadways. Communicating the intentions of an AVs forthcoming actions has been identified as a priority for improving Human-AV interaction specifically in relation to driver-vehicle, passenger, and pedestrian interaction [8, 14, 24]. We examine another communication requirement that involves making a request to another road user to modify their behavior. Here we discuss an instance where a shuttle attendant manages the behavior of another driver on behalf of the AV as it operates in high-automation mode (SAE level 4) with no on-hand driving assistance from the attendant.

WHEN A REQUEST IS CHALLENGED – THE MISSING FIERCE GLARE

In the video fragment depicted in Figs. 4a-b-c, we examine strategies used by the shuttle attendant to make a request on behalf of the AV. Here, the AV is in the process of turning left onto another road. However, there is vehicle behind it that carelessly attempts to takeover and pass the AV as it makes its turn. There is a blind spot ahead when making the turn and the attendant correctly recognizes that the attempt to overtake could create a potentially dangerous situation for the AV, other vehicles and pedestrians. To manage the situation, the shuttle attendant must communicate a request to the other driver not to overtake. This is achieved through making eye contact with the driver in addition to signaling with his hand (Fig. 4a). Both his eye contact and hand gestures communicate the request to ‘Stop’.

Nevertheless, the other driver challenges the attendant’s request and so he must counter the challenge more forcefully (Fig. 4b). The attendant achieves this by exaggerating his hand gestures, speaking aloud, making more focused eye contact and tilting his head to the side displaying highly animated gestures that communicate to the other driver; ‘Listen to what I said’; ‘Stop!!’. This time, the other driver complies with the attendant’s request, waits, and does not overtake thus allowing the AV to make its left turn unencumbered. Once the shuttle has safely made the turn, it moves forward to its next bus stop less than a meter away. When the attendant is satisfied that the maneuver has been completed safely, he gestures to the other driver to move forward and to ‘Go’ (Fig. 4c) indicating that it is now safe to overtake the AV. In this instance, although the shuttle is in high-automation mode, the AV requires interactional assistance from the attendant to communicate requests on its behalf (Fig. 5).

Figure 5: Coordinating activity on behalf of the AV.

Here, the shuttle attendant serves as an agent for the AV intervening on its behalf using gestures, words, and eye contact. Making requests in traffic situations such as 'stop', 'go', 'slow down', 'turn', and so forth, through a kind of pantomime of gestures and facial expressions is an everyday communicative performance that road users rely upon to maintain the safe and orderly coordination of traffic. However, what is typically regarded as routine interaction between people becomes potentially problematic for a fully autonomous vehicle (with no human attendant).

Even though this kind of interaction is commonplace in the coordination of traffic on public roadways, AVs do not possess the ability to communicate requests using gestures, speech, head nods or penetrating glares! Real-time decision-making in road traffic requires not only technical competence such as sensor and mapping systems. It also requires communicative competence to coordinate actions together in a way that maintains the order of traffic flows.

Discussion

Drivers commonly communicate their intentions, make requests, and negotiate next moves with one another through their windscreens using a kind of pantomime. Even so, the primary focus of AV design is on the development of situational awareness through technologies such as real-time obstacle detection and road mapping systems. Although these technologies are essential, it may be equally important to somehow compensate for more subtle approaches to traffic coordination. For instance, designing some sort of communication and negotiation mechanisms for AVs that takes into account the ongoing subtle interactions between road users could be considered in future designs.

Most HCI research to date has focused on interaction between the driver-vehicle and passenger-vehicle. However, there is an opportunity to expand HCI investigations more broadly especially now that AVs are being tested on public roadways. In particular, AV technologies apply algorithms that make decisions informed by sensors and formalized traffic rules. However, people manage traffic flows not only by complying with the rules of the road but also through interpreting the ongoing situated activity where human behavior and emotion, weather conditions, congestion and other factors play a part in the decisions people make when they are on the road [3, 13]. To maintain the orderly coordination of traffic flows, fully autonomous vehicles may require the ability to not only display intention, but also to make requests, and to negotiate between itself and other road users in a manner that is intelligible to humans.

In 'mobile encounters' people rely upon mutual gaze, gesture and movements to communicate with one another [9]. The findings from ethnographic research can compliment technical AV developments so that algorithms and sensors might be calibrated in a way that takes into account the norms of conduct between different types of people who share the road together at any given time. In particular, ethnomethodologically-informed research that reveals the moment-to-moment unfolding of shared understanding through distinctive communicative practices [22] in traffic settings is also needed if fully autonomous vehicles are to, one day, be successfully integrated on to public roadways. Such an approach would benefit future designs of all types of AV transport vehicles from merchandise (trucking), to personal (cars), and passenger (public transit).

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References

1. Tyler Brickle, Stephen Gonzalez, Logan McLaughlin, and Heather S. Roth. 2015. Ethnography and Engineering: How Qualitative Methods can Help Build the car of the Future. *Society for Applied Anthropology (SfAA) Annual Proceedings*: 1-12.
2. Barry Brown. 2017. The Social Life of Autonomous Cars. *Computer* 50, 2: 92-96. doi.org/10.1109/MC.2017.59
3. Barry Brown and Eric Laurier. 2017. The Trouble with Autopilots: Assisted and Autonomous Driving on the Social Road. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI'17)*.
4. CityMobil2. http://www.citymobil2.eu/en
5. Grace de la Flor, Paul Luff, Marina Jirotka, John Pybus, Ruth Kirkham, Annamaria Carusi. 2010. The Case of the Disappearing Ox: Seeing Through Digital Images to an Analysis of Ancient Texts. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI'10)*, 473-482. http://doi.acm.org/10.1145/1753326.1753397
6. Harold Garfinkel. 1967. *Studies in Ethnomethodology*. Englewood Cliffs, NJ: Prentice-Hall.
7. Nikhil Gowda, Wendy Ju, Kirstin Kohler. 2014. Dashboard Design for an Autonomous Car. In *6th Interfaces and Interactive Vehicular Applications*. http://dx.doi.org/10.1145/2667239.2667313
8. Nikhil Gowda, Wendy Ju, David Sirkin, Marcel Baltzer. 2016. Prototyping HMI for Autonomous Vehicles: A Human Centred Design Approach. Workshop, In *8th International Conference on Automotive User Interfaces and Interactive Vehicular Applications*. http://www.auto-ui.org/16/program/workshops-and-tutorials/#w1
9. Pentti Haddington and Mirka Rauniomaa. 2014. Interaction Between Road Users: Offering Space in Traffic. *Space and Culture* 17,2: 176–190.
10. Christian Heath, Jon Hindmarsh, and Paul Luff. 2010. *Video in Qualitative Research: Analysing social interaction in everyday life*. London: Sage.
11. Brigitte Jordan and Christina Wasson. 2015. Autonomous Vehicle Study Builds Bridges between Industry and Academia. In *Proceedings Ethnographic Praxis in Industry Conference (EPIC '15)*: 24–35. doi:10.1111/1559-8918.2015.01037
12. Brigitte Jordan and Austin Henderson. 1995. Interaction Analysis: Foundations and Practice. *The Journal of the Learning Sciences* 4, 1: 39-103.
13. Oskar Juhlin. 1999. Traffic behavior as social interaction – implications for the design of artificial drivers. In *Proceedings of the 6th World Congress on Intelligent Transportation Systems*.
14. Jeamin Koo, Jungsuk Kwac, Wendy Ju, Martin Steinert, Larry Leifer, Clifford Nas. 2015. Why did my car just do that? Explaining semi-autonomous driving actions to improve driver understanding, trust, and performance. *Int J Interact Des Manuf* 9: 269. doi:10.1007/s12008-014-0227-2
15. Eric Laurier. 2013. Before, in and after: cars making their way through roundabouts, In *Interaction and mobility: Language and the body in motion*, Pentti Haddington,Lorenza Mondada and Maurice Nevile (Eds.), Walter de Gruyter, Berlin, 212–242.
16. LUTZ Pathfinder project. http://mrg.robots.ox.ac.uk/projects/lutz-self-driving-pods

17. Alexander Meschtscherjakov, Rod McCall, Nicolas Louveton, Thomas Engel, Manfred Tscheligi, Vincent Koenig. 2015. MaDSAV: Maintaining Driving Skills in Semi- Autonomous Vehicles. In *7th International Conference on Automotive User Interfaces and Interactive Vehicular Applications*. http://dx.doi.org/10.1145/2809730.2809732

18. Alexander Meschtscherjakov, Manfred Tscheligi, Dalila Szostak, Sven Krome, Rabindra Ratan, Bastian Pfleging, Ioannis Politis, Sonia Baltodan, Dave Miller, Wendy Ju. 2016. HCI and Autonomous Vehicles: Contextual Experience Informs Design. Workshop Summary, In *Proceedings CHI Conference Extended Abstracts on Human Factors in Computing Systems* (CHI '16), 3542-3549. http://doi.acm.org/10.1145/2851581.2856489

19. Alexander Meschtscherjakov, Alina Krischkowsky, Katja Neureiter, Alexander Mirnig, Axel Baumgartner, Verena Fuchsberger, Manfred Tscheligi. 2016. Active Corners: Collaborative In-Car Interaction Design. In Proceedings of the 2016 ACM Conference on Designing Interactive Systems (DIS ’16), 1136-1147. http://doi.acm.org/10.1145/2901790.2901872

20. Ingrid Pettersson and I.C. MariAnne Karlsson. 2014. Setting the stage for autonomous cars: a pilot study of future autonomous driving experiences. *IET Intell. Transp. Syst* 9, 7: 694-701.

21. Society of Automotive Engineers (SAE). 2016. Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles. http://standards.sae.org/j3016_201609

22. Lucy Suchman. 2007. *Human-machine reconfigurations: plans and situated actions* (2nd. ed.). Cambridge University Press.

23. Erik Vinkhuyzen and Mellissa Cefkin. 2016. On the Road with Autonomous Vehicles: Interactions of Driver, Passenger, and Other Road Users. In *CHI 2016 Workshop "HCI and Autonomous Vehicles: Contextual Experience Informs Design"*.

24. Erik Vinkhuyzen and Melissa Cefkin. 2016. Developing Socially Acceptable Autonomous Vehicles. In *Proceedings of Ethnographic Praxis in Industry Conference (EPIC ’16):* 522–534. doi:10.1111/1559-8918.2016.01108