Towards Flexible Ridesharing Experiences: Human-Centered Design of Segmented Shared Spaces

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Abstract. The increasing usage of ride-sharing and autonomous vehicles has presented a need for personalized mobility experiences. This research defines these needs through an investigation from passengers who have used or will use these services. User-behaviors and user pain-points were categorized through in-depth interviews and observations. The most pressing categories were defined to be safety, privacy, and comfort. The variety of responses and user pain points defined a need for a flexible solution that employ a safe, private, and comfortable experience during a shared ride. We present a human-centered design solution that segments the shared space and provides a sense of security through personal physical space, privacy through asymmetrical viewing of neighboring passengers, and comfort through increasing the field of view of the passenger.

Keywords: User behavior, ride-sharing, privacy, semi-autonomous

1 Introduction

Overcrowded cities and unpreventable traffic are the results of 1) considerable demographic growth of the last few decades [1] and 2) an increasing number of registered vehicles on the road [2]. People in the US spend on average 200 hours per year commuting [2] and 6.9 billion driver hours are wasted due to traffic. According to Texas A&M Transportation Institute (TTI) and Irinx, inc., this issue yields in a total cost of $160 billion from time lost and fuel consumption implied [3]. Avoiding wasted time on unnecessary activities is a main public concern and there is a great opportunity to try and improve this problem.

The development of autonomous vehicle (AV) technology had opened new possibilities for future mobility solutions. It had created new ways of solving the increasing traffic issue and the existing commuting inefficiency [4]. Current

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automotive companies, ride-sharing companies, and academia are spending a considerable amount of time and resources in developing research and market testing on AV's role to address ground transportation challenges. However, AVs are facing many challenges regarding safety, reliability, and technological unemployment; the transition to this technology will need to consider many different aspects to achieve a high market penetration.

During the last five years, the ride-sharing industry has increased its market participation in transportation exponentially [5] and has revolutionized urban mobility and helped address the increasing problems in congestion and commuting time [4]. This trend is projected to continue, especially with advances in AV leading to an expected switch from car ownership to ride-sharing services [6]. As the autonomous vehicle and ride-sharing platform converge within the next decade, with the growth of Waymo and Uber's Advanced Technologies Group (ATG), the ride-sharing passenger dynamics and experience within the vehicle become an increasing concern. For example, simple passenger matching is an exponentially difficult problem to tackle [7], which is dependent on not only matching route compatibility, but also personal features such as gender, social status, and social interaction types.

Current methods already satisfy the most important features that end-users seek: getting from point A to B. Hence, why high occupancy public transportation is still in business. Consumers do not mind standing in a sea of other commuters, as long as the bus/subway/train brings them to their destination. Additionally, micromobility has dented short-range transportation solutions, and their growth has overshadowed even Uber and Lyfts rapid growth back when they were still starting [8]. Moreover, there is still a preference for using personal vehicles because users also mobilize their personal items and require the comfort/accessibility of storage. Despite these alternatives, there is a gap in the market for flexible-customize and premium services.

The scope of this project is to address problems and user's needs under a scenario where the vast majority of the people will commute through autonomous ride-sharing vehicles, using Human Centered Design (HCD). By aiming to satisfy ride-sharing users, whose needs are currently not being completely met, the focus is on generating an easily implementable solution, with a target timeline of 5-10 years. By possibly working with ride-hailing organizations in the future, such as Uber/Lyft, who are providing real-time solutions to address current needs in mobility [9], we hope our approach will actively contribute on the future mobility problem.

2 Methods and Approach

To explore new opportunities for the future of autonomous-rideshare vehicles, a human-centered design approach was utilized. Human-centered design is a creative approach to problem solving where a product is designed through strong empathy with the end user [10]. With the increasing usage of new vehicle types, autonomous vehicles, new users, and ride-share users, a human-centered approach will be utilized to find new opportunities to address newly discovered user needs.

2.1 In-depth Interviews

In-depth user interviews were first conducted to understand what were the main pain points of users while riding a vehicle and their perceptions on ride-share and autonomous vehicle technologies. Twenty interviews were conducted, interacting with users from different backgrounds and diverse commuting preferences to identify the main mobility problems that each of them had experienced. The interview protocol was based on 19 questions within six different categories: Pre-survey (4), Background (5), Ride-share (3), Sensing (1), Autonomous Vehicles (3) and Conclusion (3). The outcomes of the interviews were classified by identifying core users needs through quotes. Each of the quotes represented a specific user need and was then clustered into labeled groups, allowing for analysis of each interpretation collectively. They were assigned to seven categories: Safety, Privacy, Entertainment, Comfort, Convenience, Hygiene and User's Control.

Quotes and user's needs corresponding to these classes were grouped and analyzed through 2 x 2 matrix analysis. The main objective of this technique was to identify gaps in a two-dimensional graph which labels all users interviewed under specific criteria.

The first analysis compared people's willingness to talk in a ride and their preference between using a personal vehicle and having shared rides. The main conclusions were: 1) people that are more likely to prefer a quiet ride prefer using a personal vehicle rather than a ride-sharing service, 2) people that mainly use ride-sharing services for commuting tend to be more talkative. Therefore, considering that an increase in ride-sharing commuting is expected with the development of AVs [6], there is a gap that current ride-sharing services are not addressing; giving more quiet people more privacy in their ride while pooling with another passenger. This is one of the main opportunities obtained from the insights of this research and was considered in the development of the proposed final solution.

The second 2 x 2 matrix analysis constructed compared user's trust in AV technology with the amount of time they spend weekly inside of a car for commuting. The analysis found that people that spend more time inside of a car tend to be more confident about AVs. One possible explanation may be that people who stay longer on the road experience more pain points related to their commuting experience. Taking this into account, the solution will try to fit the needs of short distance commuters with different demographics and help improve their perception of autonomous vehicle safety.

The final analysis was conducted to understand what passengers of different ages would like to do while commuting in an AV. It was found that people older than 25 years old preferred to rest while commuting, while those below 25 preferred to engage in other activities. Thus, the possible solution will need to give the users the flexibility to decide between a quiet and restful ride or a social experience with people looking for the same commuting experience.

2.2 Concept Generation

User interviews and previous research with academic and industry experts provided the foundation for our concept generation activities. These experts covered the fields of mechanical and product design, interaction design, and user experience (UX) design.

With the main user needs and current gaps in ride-sharing solutions identified, 72 concepts were developed and then clustered and filtered based on feasibility, ease of implementation, and ability to address the core user needs. The final three concepts obtained were the following:

1. Customized Vehicles: The idea of this concept was to create a flexible mobility service according to user's preferences. By delivering a vehicle with a different configuration representing a particular concept, users would be able to enjoy a variety of commuting experiences according to their mood and preference. Possible configurations designed were the coffee shop vehicle, social bar vehicle, hotel room vehicle, and office vehicle.
2. Segmented Space-Based Ride-Share Solution: This provides both a private and personal space through segmented spaces. Passengers who want to spend their commuting experience are matched with people who requested the same; this solution aims to solve the unsatisfied need of quiet users for ride-sharing services. This solution also provides a modular option, allowing the passenger to interact with other riders who also requested a social experience. Through the construction of automatic configurable partitions, the same physical car will allow different types of people to experience a vehicle that is adjusted to their preferences.
3. Personal/Ride-share Automatic Configuration: A completely automated vehicle that will allow passengers to perform several activities while having a ride. The main idea is to enable people with the ability to configure their vehicle at will (collapsible tables, rotating chairs, personalized entertainment systems) and then return to the default mode when the vehicle is parked.

Our expert feedback provided valuable insights in our concept selection process. Even though changing the expectation of regular rides was considered a valuable and innovative option, the variable expectation vehicle solution was discounted because of its difficulty to implement into the current automobile industry. For the personal/ride-share automatic configuration solution, industry experts warned us that this idea would be challenging as the targeted user base was too broad for a feasible solution. The solution was trying to tackle multiple problems at the same time and may result in a solution that is undesirable to any one user-base. The partition-based ride-share solution was recommended by the experts for further development. It was interpreted as a practical and short-term implementable solution that could be useful in the near future of ride-sharing services.

2.3 User Testing

To understand the strengths and flaws of the proposed concept, different user tests were generated using multiple Minimum Viable Products (MVP). The objective of this method was to replicate on a real-scale the concept through a low fidelity prototype. With the creation of the MVP, fast product testing was possible, helping to better understand users reactions and pain points. Through user testing, the configuration of the prototype was iterated several times according to the users' feedback, recommendations, and concerns, collected through interacting with a diverse group of users. The final product obtained in this process is the resulting version of the iterated prototypes.

The first round of user test was utilized to determine the reactions of users when they were on-board a partitioned vehicle, as shown in Fig. 1a. The goal of the test was to determine whether the partition helped improve the privacy, comfort, and safety of the user. The user test consisted of ten participants, all of whom experienced the partitioned vehicle on a fifteen-twenty minute ride to their destination within a five mile radius from their pick up point. Initial perceptions from the users were collected right after the ride was completed along with an in-depth survey.

3 Results

From the surveys, the partition was rated at an average of 3.7/5 for comfort, 4.2/5 for privacy, and 3.1/5 for safety. From the user feedback, some key insights on the design included:

- Positive
  - Quiet environment to get work done
  - Personal space without being disturbed by others
  - Prevents awkward situations where the user does not want to talk to others sharing the ride
- Negative
  - Safety concerns, due to not being able to see the driver or situate oneself on the road
  - Feeling of awkwardness caused by not knowing whether there is someone sitting next to you
  - Lack of windows created a claustrophobic feeling

The feedback received proved that the initial goals of creating a quiet and personal environment for the user during a commute was achieved. However, other negative features of the design were also discovered. To address the negative features of the design, a second round of user testing was conducted.

A/B testing was utilized to determine whether having a user looking at a screen that projects the front view of the vehicle is able to help improve the claustrophobic feeling and safety concerns addressed in the previous user test. The experiment was set by conducting five user tests on each of the two setups.

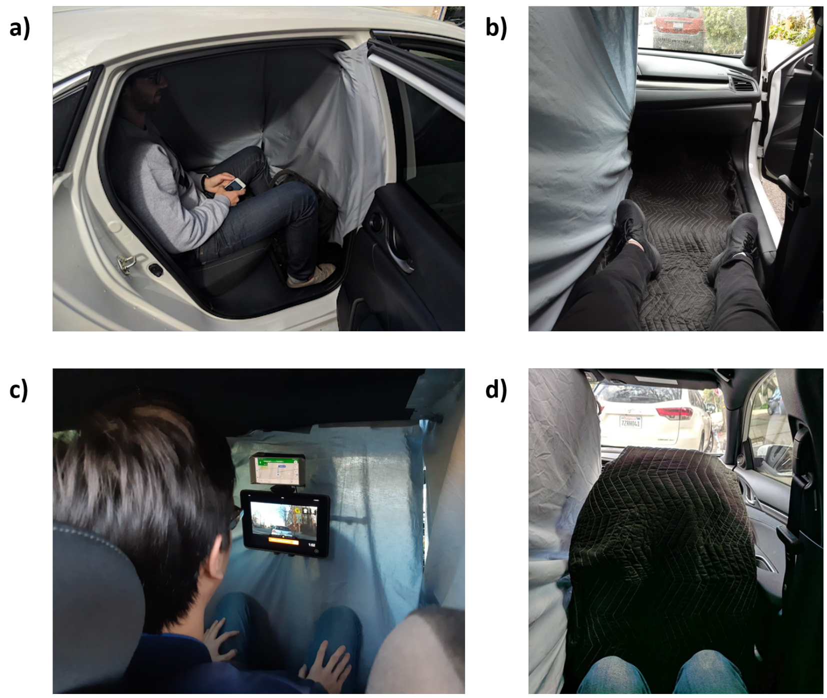

Fig. 1: Iterations and four different setups for experiential prototyping from the generated concepts. a) Demonstrates a completely enclosed private space with partitions. b) Demonstrates a premium user seating configuration with removed front seat and open leg room, more than doubling the physical space for the user. c) Configuration A demonstrates an enclosed space but provides the user with real-time information and tracking of the vehicle and surroundings. d) Configuration B demonstrates open field of view for live vehicle and surrounding status but physical space was restricted to the default size.

The first setup, Configuration A (Fig. 1c), consisted of a partitioned space on a vehicle with monitor displays that show the frontal view from the vehicle along with the route information provided through Google Maps. The second setup, Configuration B (Fig. 1d), consisted of a partitioned space with a partial view of the front windshield.

Comparing the results from the two tests, it was found that Configuration A created a better feeling of privacy compared to Configuration B. Configuration A was rated at 4.2/5 for privacy while configuration B was rated at 3.6/5. Configuration B, however, was rated higher on comfort. Configuration B was rated at 3.8/5 for comfort, while configuration A was rated at 3.6/5. Analysis of the recorded videos of the user test and the comments addressed by the users showed that although Configuration A helped situated the users with the outside environment, the screen increased their sense of motion sickness. Furthermore, the location of the screen caused the user to constantly stare at the screen over the course of the ride.

Through the feedback from the A/B test, it was determined that the screen-based perception mechanism was not sufficient at addressing the claustrophobic feelings and safety concerns originally expressed by the users. The final solution, therefore, will utilize a different mechanism to allow the users to have a wider view of the outside environment.

Another feature that was tested was the prime seating arrangement (Fig. 1b). This was to see if users were willing to pay extra for the extended space and legroom. Five users were tested on short fifteen to twenty minute rides and their initial thoughts and ride experience were recorded through video capture and surveys.

Analysis of the user feedback found that four out of five users enjoyed the extra legroom and were willing to pay more for the extra legroom, especially on a long ride. One female passenger,however, felt that the extra legroom could not be effectively utilized by her. Although this looks like a promising solution, more testing will be required before implementation into the final solution.

4 Conclusion

The increasing trends in shared spaces has presented a need for safety, privacy, and comfort. After performing 20 in-depth interviews, the need was defined and categorized. Following, a thorough list of concepts was generated, clustered, and finally, a solution was selected after considering research and industry expert feedback. We implemented this solution to user tests with an MVP to obtain feedback directly from end-users. After multiple iterations of the design solution, we consolidated the feedback from the initial user interviews, experts, and user testing to propose a solution that addresses the three main concerns: safety, privacy, and comfort.

5 Future Work

From the feedback gathered, we have synthesized the final solution (Fig. 2), which will be an automatically-deployable partitioning that governs the field of view for all passengers to enhance comfort and safety, as well as provide a physical separation to increase privacy.

The separations are designed as pillars with a diamond cross section, which will be actuated to collapse (Fig. 2). A scaled vehicle prototype is in progress, which will demonstrate this.

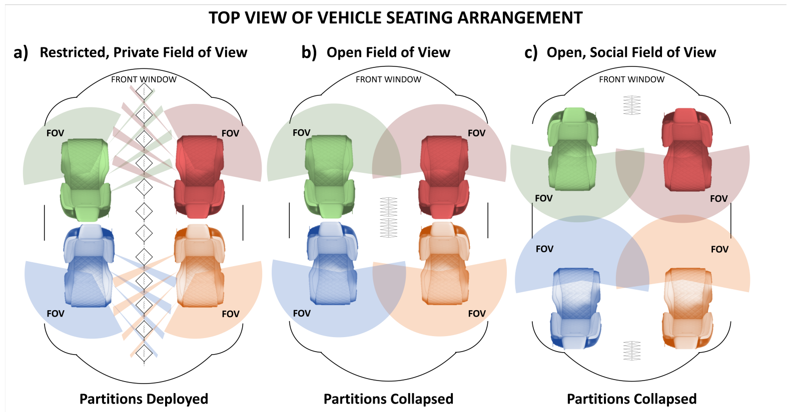

Fig. 2: Field of view (FOV) configurations for partitioned and social arrangements. a) Demonstrates deployed partitions, restricting the FOV of adjacent passengers. b) Partitions are collapsed but seats configuration discourages social interaction. c) Collapsed partitions and reconfigured seats for socialization.

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