Sharing an Autonomous Taxi Without a Driver Through Guided Imaginary Projection to Identify Sources of (Dis)comfort

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Abstract. Future shared robot taxis should reduce traffic congestion in cities, and in order to design services adapted to the needs of users, the sources of comfort and discomfort must be specified. In order to project people into the use of this future mobility, the technique of Guided Imaginary Projection was used with 40 men and women between 22 and 66 years of age. It made it possible to specify the effect produced by the absence of a driver, a driver who usually takes on the role of mediator who reassures, organizes and manages the unexpected events. Recommendations for the design of such services were drafted.

Keywords: Autonomous taxi · Comfort and discomfort · Guided imaginary projection · Interactions · Security · Feeling of control

1 Problem Statement

This study is looking at future autonomous shared cars (full autonomy of level 5), also known as shared autonomous taxis or robotic taxis. These vehicles would be capable of travelling on different types of road, in built-up areas as well as on expressways, without a driver or attendant.

These shared autonomous taxis offer great promise. As electric vehicles, they should be more environmentally friendly, relieve road congestion and limit road accidents (ERTRAC Working Group 2017b, 2017a). But for significant effects to be observed, it is important that these robotic taxis be shared. Indeed, the electrification of autonomous vehicles alone will not prevent the harmful effects of the private car on the environment. Sharing vehicles should be more beneficial: it should limit the number of vehicles produced and make the trips produced by each vehicle profitable (Pélata et al., 2019; Saujot et al., 2018). Although several models of vehicle sharing exist, the idea here is to share the same vehicle with strangers during a journey, such as short distance carpooling, as opposed to car-sharing which consists of making a vehicle available to various users, without them having to live together for the duration of a journey. The shared robotic taxi therefore represents a paradigm shift from the personal owner-vehicle to a shared autonomous vehicle service, involving cohabitation in the passenger compartment with strangers and without a driver.

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For the user, the shared robotic taxi seems to be closer to two types of services that currently exist: car-pooling and Chauffeur-Driven-Car (CDC) in pool mode, thus shared with strangers. Studies concerning these modes of transport show the predominant role of the driver both in car-pooling (Adelé and Dionisio 2020; Cahour et al. 2018; Créno 2016) and for CDCs in solo mode (Kim et al. 2019) or in pool mode (Morris et al. 2020; Pratt et al. 2019). In carpooling or in CDC, drivers have both an organisational role, for example for helping the identification of the vehicle and choosing routes, and a role as facilitator of on-board interactions. Its absence in the context of shared robotic taxis therefore raises the issue: does the absence of the driver in a shared robotic taxi have an effect on tyhe appropriation of the service and in which way?

Although many prospective studies exist on level 5 autonomous vehicles and partly on shared robotic taxis (Becker and Axhausen 2017; Narayanan et al. 2020), they most often take place in the form of a priori acceptability questionnaires, i.e. without taking into account the participants' travel activity or, under the paradigm of declared choice, which does not question the motives of the choices made by the participants.

There are also experiments which are more ecological, but generally with routes with predefined stops (such as a bus) and not door-to-door, or with support persons in a level 2 or 3 shuttle to ensure that everything runs as smoothly as possible. Of particular interest is the study by Kim et al (2019) using the Wizard of Oz paradigm. This paradigm makes it possible, by hiding the driver behind an occulting system, to make participants believe that the vehicle is autonomous. This study specifically documents the interactions between the driver and the users of an autonomous CDC service in order to design a prototype that compensates for the absence of a driver. However, in this study, the vehicles are not shared and the routes are imposed, which does not quite answer our question.

2 Methodology

We wanted the participants to mobilize the robot taxi in a usual mobility activity. The futuristic service that was imagined with a working group including car manufacturers[1] is similar to a shared CDC service (such as Uber pool), but with an autonomous car without driver. The paradigm of the Wizard of Oz and the other classic projective methods, by imposing a scenario and a route, were not adequate for this objective. We then chose a mode of imaginary projection in a trip with the shared robotic taxi service that we presented to the participants.

2.1 Population

The 40 participants in the study (20 men and 20 women, aged 22 to 66, m. = 43.4, standard deviation = 15.12) were recruited by mailing list and word of mouth. Four age

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groups were balanced: 10 participants aged 22 to 30, 10 aged 30 to 45, 10 aged 45 to 60, 10 over 60. Their professions are varied, some are also students or retired.

So that participants could easily project themselves in the use of this type of service, the criteria for inclusion in the study were to have already used either a CDC in pool mode, or a CDC in solo mode and carpooling. The important point was that participants could easily imagine sharing a vehicle with strangers from a smartphone application that geolocates them[2].

2.2 Protocol[3]

The aim was to project the participants into a simulation of the use of the shared robotic taxi so that the participants could understand it "as if" they were using it; it allows them to describe sources of comfort/discomfort after having almost tested the service and not just on the basis of an abstract and global representation. This projection into future and non-existent use can be done through films (Cahour and Forzy 2009), but then it is not the participant who acts, or through virtual reality, but it is very complex to simulate a taxi robot with several people entering, exiting and interacting. The method of Guided Imaginary Projection, developed by Allinc et al. (2018) for the use of still inexistent modes of transport, seemed very appropriate. It proceeds with the following steps.

Phase 1: Presentation of the Service. Le service de robot-taxi a été expliqué aux participants à l'aide de plusieurs images représentant l'application sur smartphone et l'intérieur du véhicule. L'ensemble des étapes de l'usage du service étaient détaillées: comment réserver, identifier le véhicule, rentrer dans le véhicule, l'organisation du trajet, les informations, l'espace, moyen de contact avec un superviseur lointain, les bagages, les arrêts du véhicule, l'arrivée à destination, la notation après-coup, etc. (Fig. 1).

Phase 2: The Guided Imaginary Projection (GIP). Participants are invited to close their eyes and imagine a journey they could make on board such an autonomous shared taxi. They are guided by the interviewer so that the imaginary journey is as detailed as possible. As the choice of route is completely free, the participants can project themselves into the use they imagine they could make of this service without any limits whatsoever. They are regularly asked to verbalize what happens to them in their imaginary journey, what they do, perceive, think or feel during this journey. The objective is to help them have an embodied position of talk, not an abstract one, and to immerse them in this imaginary journey.

Phase 3: Sources of Comfort and Discomfort. Participants are then invited to answer questions about potential sources of comfort and discomfort they have encountered

[2] Nevertheless, we note that 8 participants did not meet these criteria: 7 participants over the age of 60 (it turned out that older persons make very little use of shared services) and 1 pre-test participant that we included in the study because he did not show any difficulties during the GIP phase.

[3] We first intended to have face to face interviews but it was difficult with the Covid situation; we then tested the videoconference interviews and it appeared to be very satisfying. All the interviews were therefore conducted by videoconference.

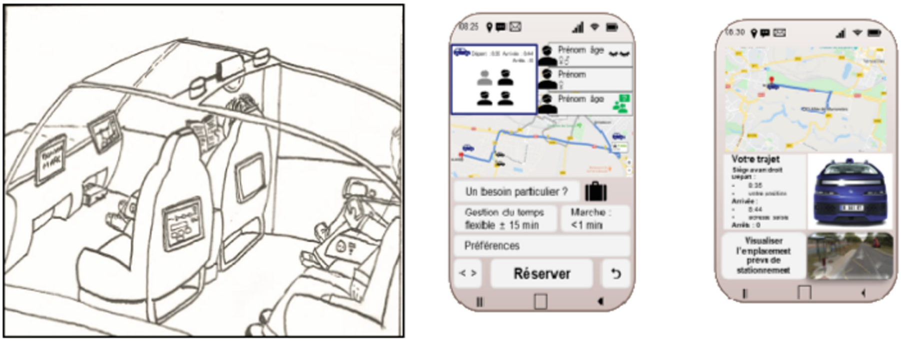

Fig. 1. Figures of the interior of the car and of the smartphone application

(some of which they verbalized during GIP) or might encounter while using this service in various situations.

Phase 4: General Questions. Finally, participants answer demographic questions (age, etc.) and questions about their car-sharing service usage habits.

2.3 Analysis of the Verbal Data

The parts of the protocol containing the Guided Imaginary Projection (phase 2) and the questions on the sources of comfort and discomfort (phase 3) were transcribed and then categorized according to 8 categories, already identified in the literature on car sharing (Allinc 2018, Allinc et al. 2015, Créno, 2018), and adapted to the shared taxi robot:

– interactions (with passengers and with the service),
– feeking of security (aggression or accident),
– feeling of control (time, route and automaton),
– availability of information,
– interior design,
– values,
– multi-activity,
– others.

Finally, a count was made of the sources of comfort/discomfort mentioned by the participants. Where relevant, i.e. where there appeared to be a difference between participants according to their gender or age, a Fisher's test was carried out to identify differences between populations on small numbers.

3 Results

We will develop here results concerning the three first sources of comfort/discomfort: interactions, security and control. Then we will focus on the effects of the driver's absence.

3.1 Main Sources of Comfort and Discomfort

We report here the most interesting elements, some categories, although mentioned by the participants, are not developed.

Interactions: They represent a source of comfort or discomfort for all participants, with great differences between and within individuals: 40% of participants find it comfortable to talk with other passengers, 37.5% prefer to respect the standards of politeness and then to make the journey in a calm manner. 60% of participants imagine that some passengers might behave badly, which could be a source of discomfort for them: these participants thus mention noisy or rude passengers.

Security: 30% fear sharing the vehicle with an alcoholic passenger and 20% mention fearing the presence of an aggressive passenger.

Concerning accidents, 55% of the participants consider that they would feel safe in the robot taxi. Paradoxically, among these participants, 6 consider that they would still be afraid of the driving of the robot-taxi and 5 participants stipulate that they would monitor the driving of the vehicle during the PrIG. These participants consider this fear to be irrational or novelty related: they imagine that driving the robot taxi will be safer, but that they will need some time to feel reassured on board. In contrast to these participants, other participants (25%) consider that they will definitely have fears about the taxi robot's ability to drive safely, and in particular to adapt to unexpected situations such as a child crossing out of a pedestrian crossing.

Control of the Trip: This category is the one that most often questions the use of the service. 67.5% of participants would find it uncomfortable to lose time or make extra detours because of other passengers. If, at the time of booking, vehicles take too long to arrive, 40% of participants would look for another means of transport; this time varies greatly from one participant to another: between 10 and 30 min. 5 participants consider that it will be more comfortable for them to use the vehicle when there are no time constraints. One participant specifies that she would not use the vehicle to go to work.

Technical Bugs: Although the service presented to the participants is defined as reliable at all levels, some participants fear the occurrence of uncontrollable bugs of the automaton: when opening the vehicle door (30%), problem with seat allocation (30%), loading of the application too long when making a reservation (30%). It should be noted that this last technical problem would lead to the search for another mode of transport.

3.2 Effect of the Driver's Absence

As one of the participants pointed out, all the problematic situations mentioned are all the more so because there is no driver.

Interactions: For the management of interactions, the absence of a driver is perceived as uncomfortable by 6 participants because they consider that there is a risk of having no one to talk to. For 3 participants, the driver is a moderator who acts as a link between the participants, manages small incidents, or reassures about deadlines. For 2 participants, the absence of a driver is uncomfortable because he is the one who gives advice on tourism. For 2 participants, his absence makes the experience less convivial.

On the other hand, for other participants, the absence of a driver is a source of comfort: no imposed discussions (3 participants), no price changes (2 participants), no scams or mistakes (2 participants).

Aggression Risk: With regard to the risk of aggression, the absence of a driver is also a source of discomfort for 6 participants who consider that the call button or emergency stop does not replace the driver who can intervene immediately. However, one participant considers that the driver can be the one who aggresses.

Accident Risk: If, as we saw above, the autonomous vehicle can be perceived as safer in terms of accidents (55% of participants), this is directly attributed by 20% of participants to the absence of a driver who may be drunk, tired or driving badly. For 2 participants, the absence of a driver makes it possible to talk without distracting the driver.

On the other hand, accident management seems more complicated for 3 participants, especially for administrative questions of insurance.

Control of the Trip: The absence of a driver is a major source of discomfort for the control of the trip. Regarding technical breakdowns, 7 participants imagine that they are all the more uncomfortable as there is nobody to manage them. Regarding the journey, 10 participants find it uncomfortable not being able to negotiate detours, stops or shortcuts with a contact person as they can with the driver.

Information Availability: With regard to the availability of information, especially when identifying the vehicle, while 10 participants (i.e. 25%) consider that the autonomous vehicle should be easily identifiable, partly due to the absence of a driver, 9 participants (i.e. 22%) would like a distinctive sign or a light signal to ensure that the vehicle is theirs in a place heavily frequented by robot taxis. 4 participants specify that this is due to the absence of the driver: usually, the driver calls or signals to his passengers.

Car Design: Concerning the design of the interior, 10 participants feel a feeling of “strangeness” or “vertigo” due to the absence of the driver in the vehicle.

Values: Finally, in terms of values, 6 participants are concerned about the loss of jobs caused by the absence of a driver, and 3 feel that there is a form of dehumanization linked to the absence of a driver.

4 Discussion

This study allowed us to identify a large number of sources of comfort and discomfort when imagining the use of a shared robot-taxi. The Guided Imaginary Projection methodology, which aims to have future users “live” an experience of the service in an imaginary way, therefore seems to be effective for projecting in future uses that cannot yet be tested in the real world.

These elements will enable us to issue recommendations in order to limit the sources of discomfort of such a service. Some of these recommendations will relate to the design of the interactions with the vehicle and the service, which will aim to compensate for the absence of a driver: this may involve a charter for the use of the service for passengers, a protocol automatically triggered in the event of an accident or incident in conjunction with the remote operator, and the personalization of the interactions with the vehicle. However, certain sources of discomfort seem difficult to circumvent, such as user values, for example.

Our participants are users who already have experience of vehicle sharing so that they can more easily project themselves into the service, which is a sort of Uber-pool without a driver. It might be interesting to interview other populations, perhaps less familiar with shared systems or with special needs (disabled people, parents with young children, single teenagers), in order to identify whether they raise other sources of discomfort.

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