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Empowering the mobility of older adults via autonomous cars: A usability study of the high-fidelity prototype autoELF.

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The demographic shift towards an aging society is an ongoing phenomenon in industrialized countries. For the growing number of older adults, access to mobility is an important factor for the quality of life. Mobility enables older adults to maintain their participation in social life and prevents them from becoming dependent on others. Due to age-related changes, common means of transportation like bicycling or car driving can become more difficult for older adults. For example, a severe decline in visual acuity can be a reason for older adults to cease driving. Public transportation might be a suitable alternative, but it entails other drawbacks for older adults like problems during access and egress or reaching the station. Therefore, promoting tailored means of transportation for older adults becomes imperative.

A possible solution to tackle mobility-related disadvantages of older adults could be to use autonomous vehicles (AVs). AVs do not require a human driver and, therefore, do not require certain driving skills or physical fitness. However, users of an AV must be able to fulfill tasks, such as entering the route, storing luggage, and starting the AV.

If AVs aim to improve older adults' mobility, the car's operation must be easy and pleasant for them. Otherwise, older adults may not use AVs or may even be harmed while using an AV, such as when entering a car with a ramp. Interface design tailored to the cognitive and physical abilities of older adults and their hedonic needs is essential. Usability studies can be used to gain a better understanding of the user group, their user requirements, and potential problems when interacting with the interfaces of privately owned AVs. Moreover, usability studies support the exploration of further research questions.

Since, to our current knowledge, there is no usability study regarding the operation of a real high-fidelity AV prototype by older adults, we conducted a first explorative usability study. We used the high-fidelity AV prototype autoELF built as part of the UNICARagil project. AutoELF was developed as a family vehicle for mobility-disadvantaged people who are unable, unwilling, or unauthorized to drive themselves, such as older adults with a certain degree of cognitive or physical decline, people with disabilities, and children below the legal age of driving.

a)  b) 
Figure 1. The high-fidelity prototype autoELF from a) the outside and b) the inside.

In total, 14 participants took part in the study (M_{age} = 73.8 years, SD = 6.2 years). The study started with an interview containing questions regarding demographic data, mobility behavior, and technology use. Afterwards, the participants experienced a fictitious trip to the local theatre where they tested 14 important functions to operate autoELF. For example, participants used a tablet to enter the route and closed the door using a green button. Effectiveness, efficiency, and satisfaction were measured through observation and interviews. Afterward, participants evaluated autoELF in a semi-structured interview. For insurance reasons, autoELF never drove with passengers.

High satisfaction ratings indicate that participants generally enjoyed the tasks. An in-depth mixed-method analysis of each task revealed various important insights. In one task, the participants had to close the door from the inside by pressing a green button (Figure 1b). The older adults mainly searched for a solution on the left-hand side, where the door handle is installed in conventional cars. There was little further explorative behavior so most participants could not find the button. This is one of many examples indicating that the older adults transferred knowledge from different driving-related situations to the context of privately owned AVs and had problems when the interface deviated from the transferred schemata.

Operation via the tablet worked well for highly trained tasks like playing a song. Nevertheless, participants had problems when the interaction design deviated from the usual interfaces, especially when entering a route. Many participants tended to get stuck on irrelevant information and confused it with the solution. For example, instead of entering a new route, they clicked on an old, pre-registered route. They did not identify the mistake but instead thought they had solved the task correctly.

The interview revealed that although participants had problems finding the close button, they enjoyed using buttons because they did not have to use their muscle power. Nevertheless, they would like to enhance the visibility of buttons. In line with the problems entering the route, the older adults mentioned better system guidance as a possible improvement. Regarding the intention to use, most participants stated that they would use autoELF under some conditions, including affordability or no longer being able to drive themselves.

The generally high intention to use highlights the potential of privately owned AVs to enhance older adults' mobility. Nevertheless, usability problems during the core operation like closing the door or entering the route stress the importance of a user group oriented interaction and interface design. Our study lays the foundation for evidence-based study designs for necessary further research. For example, the problems with entering the route can be further investigated when comparing a conventional navigation system with the new one from autoELF.