Technical Learning with Vulnerable Groups to Optimize Quality of Life in the Care Situation: the Example of Assistive Robotics for Neuromuscular Diseases (NMD)

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Background

Patients with severe motor impairments as a result of neuromuscular diseases (NMD) possess a high demand for support (Bach 2003). This special need could be partially met by robotic assistance systems (Maheu et al. 2011). In the research and development project *Assistive robotics for nursing care in patients with neuromuscular diseases (ArNe)*, research is being conducted to optimize the life situation for vulnerable patients with special consideration of the ethical, legal, and social implications (ELSI) (Tirschmann/Brukamp 2021).

The use of robotic assistance systems for the care situation should support the independence of care-dependent people for a longer period of time (Chang/Park 2003). In particular, activities of daily living (ADL) seem to be very suitable for support by assistive robotics (Chung et al. 2013). Therefore, patients with neuromuscular diseases (NMD), who exhibit a high level of need for support in these activities, should be able to use robot assistance more quickly and easily (Kim et al. 2009).

For a user-centred development of assistive robotics for the care provision, the learning process between the producers of robotic devices and the potential users becomes very important. It comprises interaction, communication, participation, co-creation, and training. In this learning process, the potential users integrate their expectations of assistive robotics into the development process. Manufacturers and developers, together with scientists, react to the requirements of the potential user group and take them into account for a simple and intuitive operability of robotic assistance systems.

Co-creation is a process which starts early within the framework of technology development to connect robotic capabilities with the specific requirements for healthcare interventions (Bardaro et al. 2021). Users in need of care should be empowered to make informed assumptions and judgments regarding further application areas for robotics. In this context, opportunities to become familiar with the systems promote the acceptance of assistive robotics in care (Flandorfer 2012).

In an extended perspective, a co-creation approach within the technology development process ensures not only the participation of vulnerable groups but also “responsible research” (Stahl 2013) in projects for the future of care.

Research Topic

In the ArNe project, the multi-level evaluation of a manufacturer-independent robotic platform is planned for the optimization of assistive robotics. The tests will be analysed regarding the dimensions of feasibility, usability, stress potential, technology acceptance, and ethical aspects. The results will be considered in the technology development process. The aim of the evaluation tests is to show whether shortening the learning phases and simplifying the operability in the group of neuromuscular patients could contribute to an increase in joy of use and quality of life in the care situation.

Methods

Technical learning of robotic assistance systems is tested with healthcare experts and patients with neuromuscular diseases (NMD). The object of evaluation consists of a graphical user interface, which is installed on a tablet, a robot arm for manipulating different objects within predefined tasks, and another computer. As an option, the graphical user interface can also be controlled with an eye-tracking control device.

The tests include a get-to-know phase, two to four application scenarios (e.g. to present a cup or to scoop food), and written surveys before, during, and after the test runs. In addition to self-generated questionnaires on usability as well as on the ethical, legal, and social implications (ELSI) of assistive robotics, the NASA TLX survey tool is used to measure task-related workloads (Hart/Staveland 1988).

Results

Research with vulnerable groups in healthcare regarding the potential of robotic assistance systems has shown that the technical learning of robot skills and the robot operation are very challenging. Therefore, it can be assumed that if it were doable to make both easier and more intuitive, it would be possible to achieve faster technical support in the care situation.

Optimizing technical learning of robotic assistance systems becomes particularly urgent in view of the progression of neuromuscular diseases (NMD) and the resulting reduction in life expectancy. The sooner the robotic system could be used intuitively by patients with incurable diseases, the sooner the quality of life at the end of life could be promoted and experienced in a self-determined manner.

Currently, two solutions are emerging to optimize technical learning and robot operation. Firstly, patients in need of care who receive an assistive robot could bridge the waiting time until they receive the device with individual training on a virtual model (Sanguino/Andújar 2012). In Germany, robotic assistance systems for neuromuscular diseases (NMD) are reimbursed by health insurance companies. Therefore, this virtual solution, for which no real robot device is used, builds on already existing care structures without having to be certified as a medical device.

Secondly, patients could teach their robotic device certain activities by themselves (as part of a "teach-in"). The robot could perform predefined tasks independently. Recurring tasks in the everyday life of the affected person, such as gripping a cup, would then no longer have to be carried out by the patient herself or himself. Once taught, the robot could take over these tasks on command automatically (Jahnavi/Sivraj 2017). Presumably, this task automation leads to a relief for the patient and the caregiving network.

Discussion

Two solutions were adapted in the ArNe project to increase simplicity and intuition in robot control. The first solution is meant for the time period before a robotic assistance system can be supplied. Patients with neuromuscular diseases (NMD) are to be prepared for the use of the robot with a virtual robot control. Vague expectations for the robotic system could be adapted to the actual technical functionalities in advance. At the same time, the learning phases would be shortened. Following technical learning with the virtual model, the real robot could be controlled more easily and intuitively right from the start. Individual experience, gained while dealing with the virtual model, could be built upon during real testing experience.

The second solution focuses on the actual handling of the device. Patients should be able to teach robot tasks independently (as part of a "teach-in"). This robot teaching would reduce the physical strain of controlling the robot manually and save time in the care situation. The use of the assistive robot could be personalized with the individual automation of robot tasks. As a result, the overall quality of life in the nursing situation could be increased.

Both solutions enable the simplification of technical learning. However, differences in user groups, regarding age, gender, or pre-existing conditions, should be taken into consideration in both individual training and personal programming of assistive robotics in order to make robot use safer and more appropriate for vulnerable groups in healthcare.

Conclusions

Robot skills and tasks can be tested with a virtual model. Several advantages are associated with simulations for evaluation. Firstly, robotic systems can be tried out without compromising the safety of users. Technical learning could be optimized before patients receive an assistive robot. With intuitive programming of robot tasks, users could have simple tasks performed automatically by their robot without having to ask anyone. Independent programming could facilitate the control of assistive robotics and unleash creative potentials in the care situation.

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