

Human-Centered Socially Assistive Robotics for Rehabilitation: is it Time for a Robot Coach?

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I. RESEARCH OVERVIEW

HUMAN-Robot Interaction (HRI) for *socially assistive* Applications is a growing research area at the intersection of robotics, health science, psychology, social and cognitive science. Assistive robotics has the potential to enhance quality of life for large user populations. Individuals in rehabilitation therapy are potential beneficiaries of socially assistive technology, both for improved mobility and for improved outcomes in recovery. *Socially Assistive Robotics* (SAR) focuses on assisting through social, not physical, interaction [1]. SAR can offer cost-effective methods for aiding recovery by maximizing the patient motivation both during and after structured rehabilitation. We are developing a general and affordable technology that can provide supplemental therapy, supervision, and encouragement of functional practice for individuals with impaired movement capability in an effort to significantly augment in- and out-of clinic care. This creates a critical niche for SAR, wherein human-robot interaction can be used not to replace physical or occupational therapists, but to augment human care as a readily available individualized rehabilitation aid.

We have performed several published studies that tested human user interaction with SAR systems we developed. First, we investigated stroke patients' response to a talking mobile robot with various interaction modes using speech, sound, and movement [1,2]. The pilot results were positive; the robot was well-received by the patients, who expressed consistent preferences in terms of robot voices and interface technologies. Some participants continued to perform the activity beyond the end of the experiment, providing further evidence of improved compliance in the robot condition beyond any novelty effect. The design of the study emphasized the user's response to the robot's behavior, not its appearance. There were significant personality differences among the users; some were highly compliant but less un-engaged, while others were highly engaged and even entertained, but got involved with playing with the robot rather than performing the prescribed exercises. This lead to interesting questions of how to define adaptive robot-assisted rehabilitation protocols that will serve the variety of

patients as well as the time-extended and evolving needs of a single patient, which shaped our next experiments. We endowed robots with extrovert and introvert personalities, expressed through amount and type of movement, and pitch, volume and content of speech. System evaluation was performed based on user introspection (questionnaires). The data obtained conclusively showed that the robot's personality was fundamental in the interaction and two statistically significant results were found: (1) participants consistently performed better on the task (more pages turned, more sticks moved, etc.) when interacting with the personality-matched robot; (2) both extroverted and introverted participants reported preferring the personality-matched robot [3,4]. Finally, most recently we endowed a robot with the ability to change its personality and interaction style based on the user's performance on the task. The experimental results provided first evidence for the effectiveness of robot behavior adaptation to user personality and performance: users tended to perform more or longer trials under the personality matched and therapy style matched conditions. The latter refers to nurturing styles being correlated with the introversion side of the personality spectrum, and challenging styles correlated with the extroversion side of the spectrum [5]. Our ongoing work is aimed at evaluating the described approach in time-extended user studies with a large group of stroke patients in order to develop technology-assisted therapy methods that can augment the current standard of rehabilitation care.

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