COLLABORATIVE ROBOTS IN REHABILITATION FOR SOCIAL SELF-MANAGEMENT OF HEALTH

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ABSTRACT

This paper reports the design plan of a social rehabilitation robot for optimizing social self-management of health. Managing health with physically and stigmatizing disabling conditions involves managing both physical and social daily functioning. The robot will use artificial moral emotions that trigger actions that mirror health care ethical behavior to preserve therapeutic relationships and empower social participation in people with Parkinson's disease.

BACKGROUND

A primary aim of rehabilitation is to optimize participation in one's preferred social roles and cultural milieu (WHO, 2001). Participation requires conforming to social norms about appropriate and friendly behavior. Deviation from norms leads to misunderstanding, stigmatization and social isolation (Tickle-Degnen, Zebrowitz, & Ma, 2011). Inadequate social activity is a risk factor for unfavorable health outcomes, including accelerated motor decline in older adults (Buchman et al., 2009). As people age in their homes, their health depends on the ability to self- and co-manage daily life with their informal social support system of family and friends and their formal system of health care providers. Despite solid evidence for the need to maintain one's social support systems, little has been done to address social self-management in rehabilitation. Technological advances in robots that work with humans collaboratively, called *co-robots*, promise to address this gap. These robots must meet the needs of rehabilitation clients and informal and formal care givers. Their actions must be guided by coherent models of social participation, and governed by ethical principles of human service.

PURPOSE

This paper defines social self-management and describes the five-year research plan for designing a social co-robot that contributes innovative technology to rehabilitation. The research, in its first year, is funded by the National Science Foundation's National Robotics Initiative. The new robot will provide moral functionality that promotes dignified therapeutic human relationships in the context of occupational therapy and Parkinson's disease.

SOCIAL SELF-MANAGEMENT

The concept of *self-management of health* comes from cognitive-behavioral models that link life outcomes to individuals' beliefs, attitudes, self-efficacy and self-regulated behavior (e.g., Ajzen, 2002). This concept has been applied primarily to physical health management as exemplified in the International Classification of Functioning, Disability & Health (ICF; WHO, 2001) self-care activity category of *looking after one's health*: "ensuring physical comfort, health and physical and mental well-being, such as by maintaining a balanced diet, and an appropriate level of physical activity..." (d570). In earlier work, we developed a definition of *social self-management of health* as self-care practices that ensure social comfort while supporting mental and physical well-being, such as by participating in valued social activities, maintaining rewarding interpersonal relationships, and seeking help from capable people (Tickle-Degnen et al., 2012). This definition unifies social constructs in the ICF and brings coherence to the development of rehabilitation approaches that address social life as central to looking after one's health.

This project focuses on Parkinson's disease (PD) because PD exemplifies how social management is critical to physical management of disability for social participation. PD is characterized by a progressive decline in speed, flexibility and coordination of movement throughout the body, including the face. At variable rates, a *facial mask* descends that curtails expression of feelings, thoughts and intentions, even while psychological dynamics of experience are preserved. Lay observers and expert and novice health care providers perceive highly masked individuals as having less desirable personalities and as being less competent socially and mentally (Tickle-Degnen et al., 2011). People unknowingly and confidently rely more on their automatic "gut" sense of facial expression than words that the person with masking is saying. This reliance makes stigmatizing impressions resistant to self-correction or training.

The aim of self-management rehabilitation is to promote a sense of control in valued life domains that realistically are within the person's capacity to influence (Tickle-Degnen, Ellis, Saint-Hilaire, Thomas, & Wagenaar, 2010). However, clients with facial masking have compromised capacity to express their sense of control. Rehabilitation providers may perceive masked clients as unreliable sources of information and be put off by apathetic or negative looking facial expressions. They may interact with clients differently based on biased impressions and elicit social withdrawal in the case of higher masking and social engagement in the case of lower masking. Because machines do not have automatic socio-cognitive biases, a social co-robot provides a logical solution to the problem of social self-empowerment while living with facial masking. A co-robot could help providers to test and correct their immediate impressions and clients to effectively convey their feelings through expressive robot signals.

APPROACH

Most robots for adult neurorehabilitation in stroke, multiple sclerosis and PD assist in motor re-education (Buning, 2014). The co-robot for this project will be equipped with architecture that models moral emotions, abstract moral reasoning, and a theory of mind that guides ethical behavior aimed at preserving human dignity and enhancing autonomy (Arkin, Scheutz, & Tickle-Degnen, 2014). This architecture, and its challenges and solutions, is described elsewhere (Arkin, Ulam, & Wagner, 2012). It will be deeply integrated with cognitive tasks such as natural language understanding; reasoning; action planning and sequencing, including proxemics and kinesics; multi-modal perceptual processing; affect partner modeling; object, person and action detection and tracking; and overall behavior coordination (Brooks & Arkin, 2007; Moshkina, Park, Arkin, Lee, & Jung, 2011; Scheutz, 2012). This integration will provide functionality that promotes dignified and socially effective human interaction aimed at achieving social self-management goals. The robot will *not replace* direct human to human interaction; rather it will *augment* it.

RESEARCH PLAN

We will develop a sequence of increasingly complex co-robots. The simplest robot will be a “courier” of basic elements of interpersonal communication. The next robot will be an “observer” that accurately detects and prioritizes person, object and context attributes relevant to reasoned and ethical therapeutic interaction. The final robot will be a “mediator” that effectively engages positive and empowered interaction between clients and therapists.

The *courier robot* will be designed for simple, highly scripted one-on-one human interviews to recognize speech, understand natural language, compute personality traits and affective states, generate simple gestures and nonverbal expressions, and augment or suppress actions that could compromise the ethical interaction. Three ethical principles of occupational therapy will guide robot action: beneficence (attitude toward benefit), nonmaleficence (refrain from harm) and autonomy/confidentiality (respect client self-determination). For example, to respect autonomy, the robot should stop asking questions if the client’s mood changes from happy to irritation. Evaluation of this robot occurs through focus groups with experts: leading client advocates, neurologists and neurorehabilitation practitioners. It also occurs through simple experiments with college students to fine-tune the acceptability of the robots’ courier functions. Nao robots will be used due to their inexpensive, safe and non-threatening humanoid platforms (Moshkina et al., 2011).

The *observer robot* will be designed for more complex one-on-one daily life tasks to recognize purposeful human activity, detect action step errors, engage in complex dialogues, and to address clients’ social comfort when the robot detects action errors. The robot must be able to weight the benefits of its corrective actions against the potential costs to clients’ current affective states and desires for autonomy. The robot may guide the client through simple exercises or preparing a recipe. The robot will be evaluated by expert focus groups and simple experiments with non-expert college students and people with PD for fine-tuning its functionality as a reasoned observer that is sensitive to muted speech and action in PD and to ethical dimensions of interaction.

The final *mediator robot* will provide mediation of client and therapist interaction. The robot must maintain mental models of both client and therapist. It must represent the therapist’s predisposition to not believe the client when the client makes claims that typically are accompanied with facial expressiveness, such as when the client claims to be happy but has an affectless face. The robot will use more sophisticated nonverbal and verbal actions that enhance therapeutic rapport. Human-robot interaction will occur during routine stages of therapeutic encounters: *greetings*, client *reporting* during assessment, and therapist *recommendations* after assessment. For example, the client and robot interact with simple sensors/buttons to have the robot quickly express client affect during greetings. During reporting and recommendations, the client may activate the robot to provide cues of client attentiveness, understanding and collaboration.

We hypothesize that co-robot mediated encounters with facially masked clients would result in less stigmatization and more dignity than non-mediated encounters, and show little distinction when compared to non-mediated encounters with expressively normal clients with PD. To test this hypothesis, our fifth-year plan is to perform an experiment involving 40 occupational therapy students and 40 clients with early PD, normal mental status and no depression. At baseline, a researcher will complete a videotaped health quality of life and social participation assessment and introduce a one-week lab-based intervention involving simple tasks and the recording of client mood and social participation. Clients with facial masking will be randomly assigned to co-robot intervention versus no robot. Clients without masking will be assigned to the no-robot condition. At one-week post, client-student pairs will engage in a videotaped therapeutic encounter with co-robot or no-robot.

Outcome measures include coded social behavior during the encounter and client self-report of stigmatization. Data analysis will test the hypothesis that the greatest degree of stigmatization and compromised dignity will occur with no-robot masked clients, followed by co-robot masked clients, which will show minimal difference from no-robot expressive clients.

CONCLUSION

The project will develop adaptable robotic architecture that integrates mechanisms for ethical judgments, moral emotions, and theory of mind models in an effort to allow co-robots to facilitate ethically acceptable, non-stigmatizing interactions between humans. The research plan is delimited to evaluating the robot as an effective social self-management mediator for occupational therapy encounters. However the findings will provide implications for co-robot contexts involving a variety of formal and informal care givers for a broad range of disabling conditions that risk stigmatization and undermined dignity.

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