

Social Robots for Health Psychology: A New Frontier for Improving Human Health and Well-Being

Guy Laban

*University of Cambridge,
UK & University of
Glasgow, UK*

Val Morrison

Bangor University, UK

Emily S. Cross

*ETH Zürich, Switzerland;
University of Glasgow, UK
& Western Sydney
University, Australia*

The idea of social robots, autonomous machines that interact and communicate with humans or other agents by following social behaviours and rules relevant to their role (Breazeal, 2003), has been prominent in post-modern science fiction literature, art, and cinema for decades. In industrial contexts, we are already familiar with robots that are not particularly social but are instead designed for industrial work like moving and assembling materials. However, the depictions of social robots in science fiction, communicating with us, acting as our companions, and assisting with our daily lives, have fuelled people's imagination about the capabilities these machines might have in the future. Accordingly, social robots are gradually but steadily moving from our books and screens and into different social settings such as commerce and services, health care, education, and even people's households. These robotic agents can take on various forms and shapes and are increasingly being deployed across various health and well-being settings, as their abilities to function autonomously or semi-autonomously in physical and social spaces alongside humans are continually improving (Henschel et al., 2021).

Due to social robots' social features (i.e., communicating verbally and nonverbally with and around humans; Cross & Ramsey, 2021; Hortensius & Cross, 2018), and animate qualities (i.e.,

embodying animated visual features such as human-like or animal-like design or movements; Cross et al., 2016), these artificial agents hold potential to simulate social behaviour and trigger emotions and feelings from human users (Laban et al., 2021; Laban, Kappas, et al., 2022a; Laban, Morrison, et al., 2022, 2023). Moreover, social robots are being equipped with technologies such as sensors, cameras, microphones, and processors that facilitate the high-fidelity collection of human data, like position, gaze, speech, emotions, and feelings, as well as support real-time analysis of human interaction behaviour (see Spitale & Gunes, 2022). Therefore, as the field of health psychology aims to understand the interplay of psychological, social, behavioural, biological and cultural factors on human health and well-being (Morrison & Bennett, 2022), *human—robot interaction* (HRI) research provides unique opportunities for studying how social robots may positively impact human well-being in different areas (Laban, Ben-Zion, et al., 2022; Robinson et al., 2019). In this piece, we address several avenues for the introduction of social robots in health psychology settings, such as emotion regulation and support, as tools for health monitoring and clinical management, to encourage people to adopt healthy habits and to assist with physical therapy and rehabilitation.

Supporting Emotional Health via Interpersonal Communication

Interpersonal communication behaviours like self-disclosure and social sharing can support

emotional health by providing and receiving support, improving mood, creating an environment for expressing feelings and regulating emotions (Coan, 2012; Rimé, 2009; Zaki & Williams, 2013). However, people tend to react to their communication partner's expression and might suppress their communication with others when those seem uninterested or unapproachable, or when perceiving them as judgmental, negative, or threatening (Rosenfeld, 1979). This is especially noticeable when sharing sensitive information (Lee & Renzetti, 1990), as people are often worried about shame and stigma (Smart & Wegner, 2000). Accordingly, people engage in self-disclosure with social robots as they induce a higher sense of anonymity (Pickard et al., 2016) while maintaining rapport in their interactions (Gratch & Lucas, 2021; Laban et al., 2021) and offering the positive effects of engaging in these behaviours with reduced social tensions. Therefore, we see promising performance of robots in socio-emotional settings such as care and education (Henschel et al., 2021), supporting people via companionship (e.g., Chen et al., 2020), coaching (e.g., Bodala et al., 2021), counselling (e.g., Utami et al., 2017), and as platforms for people to share about their lives and worries (e.g., Akiyoshi et al., 2021; Laban et al., 2023; Laban, Kappas, et al., 2022a).

In a long-term experiment performed by our research team, 39 participants from the general population based in the UK conversed with the social robot Pepper (SoftBank Robotics, see figure 1A) twice a week for 5 weeks (10 sessions in total), disclosing to the robot about general everyday experiences. We found that participants self-disclosed more to the robot (in terms of disclosure duration in seconds, and number of words) as the sessions progressed, perceiving the robot to be more socially competent and comforting over time. The repeated interactions also led to improved mood (after each session, and over time) and decreased feelings of loneliness (Laban, Kappas, et al., 2022a, 2022b). We replicated this study with a

sample of informal caregivers (Laban, Morrison, et al., 2022, 2023), who often experience high levels of emotional distress (Revenson et al., 2016). Our findings replicated the previous results (Laban, Kappas, et al., 2022a, 2022b) and showed that caregiver participants felt less lonely and stressed, were more accepting of their caregiving situation, positively reappraised their caregiving situation and experienced reduced feelings of blame towards others (Laban, Morrison, et al., 2023). In addition, we found that experiencing higher rates of negative emotions (e.g., lower mood, feelings of loneliness and stress) as well as reporting higher levels of introversion is associated with higher rates of self-disclosure towards the robot (Laban, Kappas, et al., 2023). These results demonstrate that people can establish meaningful relationships with social robots and highlight the value of social robot-led interventions with individuals living with considerably difficult life situations. Social robots could potentially elicit rich interactions with individuals in need (due to stress, experiencing negative emotions, or going through difficult life situations) over time, acquire relevant information from their disclosures, and support their emotional well-being.

Using Interactions with Robots for Monitoring Symptoms

Our results (Laban, 2022) provide important evidence concerning the potential of social robots to collect health-related data in care recipients' environments, monitor and report symptoms, and offer early intervention. The use of social robots with enhanced mobility and verbal capabilities can further support the collection of health data (e.g., via analysing users' facial expressions, voice, content, and variety of physiological information; see review Spitale & Gunes, 2022) in public healthcare environments such as hospitals and nursing homes. Human resources in healthcare

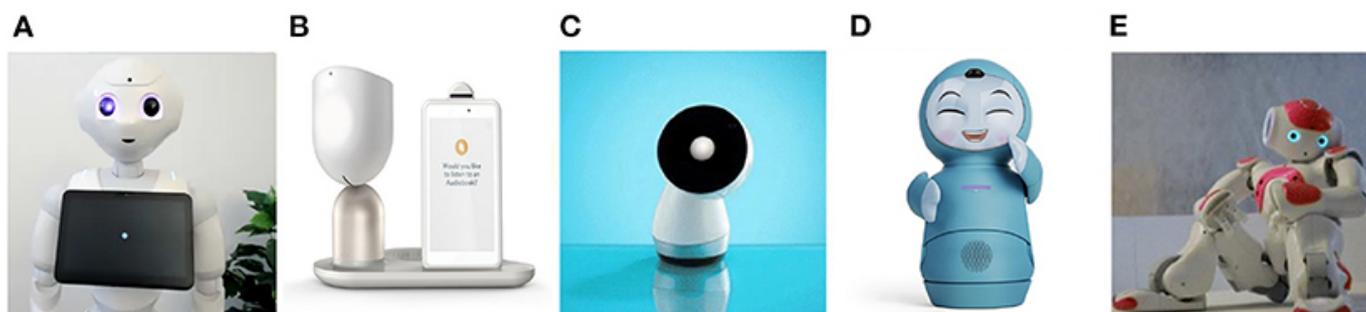


Figure 1. Figure from (Laban, Ben-Zion, et al., 2022) includes examples of several social robotics platforms that are heavily used in research and/or have enjoyed commercial success and are discussed in this paper. (A) Pepper, a humanoid by SoftBank Robotics. (B) ElliQ, a household robot by Intuition Robotics. (C) Jibo, a personal home assistant robot by NTT Disruption. (D) Moxi, an animated household robot by Embodied. (E) Nao, a humanoid robot and Pepper's little sibling by SoftBank Robotics.

environments are limited and people working in these contexts experience high rates of burnout due to unsustainably high workloads (Moukarzel et al., 2019). We have previously argued that such workers would benefit from delegating simple tasks to robotic agents (see Laban, Ben-Zion, et al., 2022). Previous research and ecologically valid studies have provided evidence for the efficacy of social robots in autonomous health data acquisition among hospitalized patients in various settings, including hospitals, homes, schools, and nursing homes (e.g., Boumans et al., 2019). In more personal settings, small, stable home-based social robots like ElliQ (Intuition Robotics, See Figure 1B), Moxi (Embodied, See Figure 1D), and Jibo (NTT Disruption, See Figure 1C) can be placed in patients' homes to monitor their symptoms and health condition. These robots are easy to operate and can elicit meaningful responses from humans in relevant settings, identify symptoms and react accordingly. For example, the social robot Jibo was used as a positive psychology coach to enhance the mental health of students residing on campus, resulting in improved well-being, boosted mood and increased motivation to improve their own mental health (Jeong et al., 2022).

Social Robots Delivering Behavioural Change Interventions

Beyond providing emotional support and monitoring symptoms, social robots show potential for supporting humans in adopting health habits through behavioural change interventions. These interventions can be for building habits over time, but also for sustaining habitual behaviour. For example, a study by Robinson et al. (2020a) showed that the Nao robot (SoftBank Robotics, See Figure 1E) can effectively deliver a behavioural intervention to reduce high-calorie snack consumption, resulting in a 50% reduction in snack episodes and a 4.4 kg weight loss after two weeks. Participants also reported increased confidence and positive emotions. The qualitative data from this study indicated that participants valued the robot's interactivity and sociability (Robinson & Kavanagh, 2021). The authors also reported successful testing of a similar intervention with a small group of diabetes patients (Robinson et al., 2020a).

Research has demonstrated that children can also effectively benefit from behavioural change interventions utilizing robots. For instance, a study conducted in primary school settings found that the use of a social robot led to an 80% success rate

in achieving weekly personal health goals, such as increasing physical activity and keeping a healthy diet (Triantafyllidis et al., 2022). In fact, healthy habits formed in childhood can have a long-lasting impact on a person's health and well-being, making it crucial to promote them in children (Curtis et al., 2011). However, socioeconomic, and cultural barriers (e.g., limited access to care services and educational opportunities, in addition to encountering language barriers) can make it difficult to introduce different health practices in rural areas and among indigenous communities (Hernández et al., 2017). Social robots have the potential to establish a common way of communicating or interacting with people by employing universal signals such as expressions, repetitions, and sounds, even when there may be language barriers or differences in cultural understanding. These robotic agents serve as mediators, bridging gaps in understanding and promoting positive engagement with individuals in underprivileged or culturally diverse communities. They are designed to be accessible and tailored to each user, simplifying the introduction and encouragement of healthy habits and practices. The results of a study in rural India, which used a social robot to encourage hand washing among school children, showed a 40% increase in hand washing with soap and improved handwashing technique in real-world settings (Deshmukh et al., 2019). These findings demonstrate the effectiveness of social robots in promoting healthy habits among children from impoverished backgrounds by overcoming socio-economic and cultural barriers. In times of crisis, such as a global pandemic, social robots can play an important role in promoting healthy habits and reducing the spread of infectious diseases. A trial using the robot "WallBo" showed an 86.25% compliance rate for handwashing and a 35% improvement in knowledge about hand hygiene (Deshmukh et al., 2021). These findings suggest that social robots have the potential to deliver autonomous

behavioural change interventions and may overcome limitations in human-led interventions, such as social desirability biases.

Social Robots for Physical Therapy and Rehabilitation

Finally, social robots equipped with greater degrees of movement can demonstrate complex physical movements to aid in rehabilitation, increase physical fitness, and assist individuals with injury and illness (Langer & Levy-Tzedek, 2021). Feingold-Polak and Levi-Tzedek (2020) provided evidence in support of a long-term upper limb rehabilitation intervention facilitated by the humanoid social robot, Pepper (SoftBank Robotics), for post-stroke patients in a rehabilitation centre. Both clinicians and patients in the study found the intervention to be engaging, motivating, and most importantly, effective in meeting the needs of upper limb rehabilitation. Engaging with stakeholders, including patients, caregivers, clinicians, and families, is crucial when studying and testing social robots for rehabilitation and physical support, as each population requires specialized care. Recent focus groups with stroke patients and their caregivers (Dembovski et al., 2022) as well as clinicians treating Parkinson's disease (Bar-On et al., 2021) have yielded interesting insights, demonstrating the potential value and utility of embodied social robots for enhancing physical capacity in individuals across the lifespan.

Conclusions

Social robots have been found to be useful and engaging tools for monitoring people's health, and hold the potential to support human psychosocial, emotional, and physical functions. The public health crisis experienced in the last few years due

to the Coronavirus pandemic has highlighted the importance and urgency of embodied technological solutions that can alleviate emotional distress caused by factors such as loneliness, stress, and negative mood. These technologies could potentially serve as companions to individuals, but also facilitate social and emotional connections with others and help them to overcome their social and emotional barriers. Despite the potential benefits, more research is needed to ensure that social robots interact with humans ethically and responsibly (Lee et al., 2022). Furthermore, the potential benefits of social robotic interventions in various health and care-related settings warrant further validation and comparison to other home-based interventions such as telemedicine, community-based physiotherapy, self-monitoring tools, and social work. It is also essential to thoroughly evaluate the costs associated with utilizing social robots in this capacity. Therefore, we call on health psychology researchers to join in investigations exploring the roles and applications of social robots in supporting and maintaining human health and well-being.

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Guy Laban

(1) Department of Computer Science and Technology, University of Cambridge, Cambridge, UK.

(2) School of Psychology and Neuroscience, University of Glasgow, Glasgow, UK.

gl538@cam.ac.uk



Val Morrison

Department of Psychology, Bangor University, Bangor, UK

v.morrison@bangor.ac.uk



Emily Cross

(1) Professorship for Social Brain Sciences, ETH Zürich, Zürich, Switzerland

(2) School of Psychology and Neuroscience, University of Glasgow, Glasgow, UK

(3) MARCS Institute for Brain, Behaviour and Development, Western Sydney University, Sydney, NSW, Australia

emily.cross@gess.ethz.ch