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**Short paper for position paper**

# Persuasive social robots for promoting ecological sustainability

**Keywords**: persuasive social robots, sustainability, HRI, emotional feedback, ethics

## 1 Introduction

The climate emergency of our times has raised environmental, social and economic concerns about the health of our planet. A growing awareness of sustainability and climate change issues has led researchers to focus on how to solve problems related to environmental misbehaviour, which, despite the current crisis, continues today. Recent years have brought an increase in technology solutions in order to accelerate progress toward the 17 Sustainable Development Goals (SDGs) defined by the United Nations General Assembly in 2015. We live in an era in which digital technology, AI and robotics are developing and spreading faster and faster, gradually becoming part of our daily lives, homes and societies. My contribution, although still at an early stage of the study, aims to understand what are the possible advantages of using these new technologies for sustainability? Can they be a valid tool for solving our environmental problems? The paper partly intends to answer this question, focusing on the use of new technologies such as persuasive social robots (Siegel et al., 2009) that are able, through specific persuasion strategies, to encourage specific behaviours and attitudes in users. The emphasis is on persuasive social robots and sustainability, the main purpose is to explore the potential of persuasive social robots to persuade people to behave sustainably. To do so, I will begin my paper with an initial section devoted to the concept of sustainability, what it means to act sustainably and what robotic technologies are nowadays at the service of environmental protection. In the following section, I will focus on persuasive social robots, analysing persuasion factors and strategies. In the third section, I will focus on a particular behavioural influence strategy, the emotion strategy, to understand whether persuasive social robots can be more effective if we equip them with mechanisms that expose the user to emotional feedback on their behaviour. Finally, the paper concludes with a section concerned with the ethical implications of the use of these persuasive technologies, proposing a discussion on issues such as manipulation, the choice of objectives and the results that the robot must achieve, and the design of these technologies, highlighting how an ethical reflection is the starting point from which to begin if we want to live with this new kind of robots.

Today, lots of research and literature are now available about many technologies that help humans to preserve the environment and reduce energy waste. Although, the literature still lacks an overall discourse on the use of social robots as tools for sustainability. It is in this context that the paper is set to provide an overview of this important field of research

## 2 What does mean sustainability? A linkage between robotics and sustainable

The concept of sustainability is very vague and open-ended, with a myriad of interpretations. This began to emerge in the 1970s when the Green Party (UK Green Party) used the term for one of its manifestos (Manifesto for a Sustainable Society) in 1975 (Purvis *et al*, 2019). Today the term sustainability and the related concept of sustainable development are used in many ways and in different areas. I refer to environmental, social and economic sustainability, defined as "the three pillars of sustainability" (Hansmann *et al*., 2012). Technological evolution today sees sustainability, in its broadest sense represented by the *17 Sustainable Development Goals*, as an essential element. These goals, set by the United Nations, have the task of driving nations towards the realisation of sustainable development. The term sustainable development is understood as ''development that meets the needs of the present without compromising the ability of future generations to meet their own needs'' (WCED, 1987). To pursue this goal, technology will be one of the most important and valuable tools. Iravani, Akbari and Zohoori talk about *green technologies*, which "seek to reduce the emission of greenhouse gases, the use of natural resources and energy in addition to promoting recycling and the use of recyclable materials" (Iravani et al., 2017). In the last decade, robots have been used increasingly to collect floating waste material and monitor water quality (Turesinin, *et al*., 2020; Pan *et al*., 2017), to pick up and sort trash (Chinnathurai *et al*., 2016; Ms Shivaanivarsha *et al*., 2020), to reduce pollution and waste of energy and materials during the manufacturing phases (Galati, 2021), or to increase production and reduce environmental impact in the field of agriculture (Ball. *et al*. 2015). Also, the urgent concern about global temperature rise has led a group of researchers in HCI to design devices that detect energy consumption and offer corresponding feedback to users. This project is part of a research field called *sustainable HCI* (Mankoff *et al*., 2008; Disalvo *et al*., 2010; Dillahunt *et al*., 2010) to persuade peopleto change their behaviors in order to reduce their carbon footprint. As illustrated by the examples above, many robotic technologies and applications today aim to protect the environment, establishing the usefulness of non-interactive autonomous robots as tools for sustainability. Less established in literature is how social robots can be useful for the environment. Thus, I question, what is the role of social robots in one of the greatest social and ethical challenges that the world is calling us to face: sustainability?

## 3 Persuasive social robots for sustainability

In an increasingly exponential way, social robots are spreading in our society, entering our homes, schools, hospitals, nursing homes for the elderly, and museums. According to Korn «Social robots are robots which cannot only do services for us but also communicate - thus, they could come very close, into our homes, into our private lives» (Korn, 2019) becoming real "social partners" (Dumouchel and Damiano, 2017) to interact with. Having an influence on humans is crucial for social robots. There are social robots that encourage exercise and preventative gymnastics in the elderly (Tanioka et al., 2019); robots that motivate users to lose weight (Kidd and Breazeal, 2007) or that stimulate humans to engage in praiseworthy activities (Cappuccio, 2021). Can we also use social robots to influence and promote

ecologically sustainable behaviour in humans? Since most of the work on sustainability today is about changing the habits of humans, experts in Human-Robot Interaction have thought about exploiting the potential of persuasive social robots to encourage more sustainable behavior in people. There is a shift from strictly considering only the functional aspects of the robot to considering its social and persuasive capabilities first. A persuasive social robot is a robot that can interact socially with humans and significantly influence or change their behavior or cognitive processes (Siegel *et al*., 2009). Understanding how to make a social robot that is also persuasive is the first step in designing robots that are able to help users. In order to design robots that are highly persuasive, it is important to consider factors and strategies that, as in human-human interaction, increase the robots' persuasive potential. These can be: appearance, style and content of communication, non-verbal behaviour (Gass and Seiter, 2003). The appearance of a persuasive social robot is very important. Research has shown that robots (i.e. physically embodied agents) with a more human like body are more persuasive in HRI than virtual agents or other systems (Saunderson et.al, 2020), (Shih-Yu Lol et al., 2022), (Shinozawa et al., 2005). Being physically embodied can give the user a stronger semblance of sociality and this increases the persuasive influence of the robot (Li, 2013). If having a body is important for the persuasive robot, this is also due to the use of social cues such as gaze and gestures (Jam et al., 2011), touch and close distances (Siegel, 2009) that influence persuasiveness more. In addition to all these factors, persuasion can be achieved by implementing different strategies in the robot. According to a study conducted by Winkle, a persuasive robot should show an interest in the user it interacts with, it has to respond with appropriate behaviour to the emotional stimuli of the user (Winkle et al., 2019). Significantly, robots should use social influence strategies such as providing social feedback whether positive or negative - that can persuade the user to have one behaviour instead of another (Midden et al., 2009) - or gratification. Studies have shown how praising users and offering them rewards instead of sanctions makes the robot more persuasive. On the contrary, a robot that is too authoritarian and uses punishments causes a dislike of the user (Saunderson and Nejat 2021).

## 3.1 The emotion strategy: three cases study

Studies have shown that one of the factors that can influence the robot's persuasiveness is the use of expressiveinterfaces that through the expression of believable emotions are able to influence and change the users'behavior. We know to what extend our emotions influence other peoples' behaviors and moods. Saunderson and Nejat (Saunderson, 2020) showed that the emotion strategy has a significantly higherpersuasive influence compared to other kinds of strategies. On these grounds, I will analyze three types of social robots that use emotions to demonstrate that they can be considered an effective tool for persuading the users with whom they interact. The first is the *ICat* robot, whose face can change to express emotions. This robot has been used to provide users with positive or negative feedback regarding their energy consumption (Ham and Midden, 2014). In Ham and Madden's study, the user was invited to choose washing programs in a simulated washing machine. Depending on his choices, the robot reacted differently: through facial expressions it showed sadness or happiness; by lighting its ears green or red; by using verbal comments such as "terrible" or "fantastic". If the user, for example, set a low washing temperature, the robot showed happiness. The study demonstrates how giving positive or negative feedback through emotional and social expressions has a strong persuasive effect on reducing energy consumption. The second case is *Pepper*, a humanoid robot capable of sensing and expressing emotions via body posture. Castellano used Pepper to propose a recycling game to children in order to change the attitude the kids have about recycling (Castellano *et al*., 2021). The game consists of a challenge between

Pepper and the children. The latter have to guess where to place the rubbish for recycling. When they get it wrong Pepper acts as a motivator with phrases such as "Try again, you'll get it next time!" In case of a correct answer, he expresses his joy using gestures such as clapping. This stimulates the child to beat the robot and thus to learn the correct way to recycle. The positive emotions expressed by Pepper contributed to the improvement of waste sorting by children. Lastly, *Floffy*, an interactive robot for children equipped with a proximity sensor, a solar panel, and water sensor. It has different behaviours: it jumps quickly and becomes happy when fed with water, when placed indoors it shows negative signs (its eyes turn orange as if he were angry or if the user approaches it, it moves away). When placed outdoors, instead, he gets closer to the user and its eyes turn green as a sign of happiness. “For example in a state of anger, Floffy would flash its eyes red, while joy or happiness showed the flashing of green eyes and desperation with orange” (Mubin et al., 2013). The study shows that Floffy responds to children positively if they implement environmentally beneficial behaviors and negatively if the behavior is bad.

## 4 Ethical reflections on persuasive social robots: persuasion or manipulation?

In this last part of my paper, I will focus on an ethical analysis of the use of these new technologies. Thepersuasive power of social robots raises important ethical issues that should not be underestimated, especially because these persuasive technologies will become increasingly integrated into our social ecologies. We should not underestimate the persuasive power of these technologies, a power that is always asymmetrical since they can influence us but we cannot influence them. What are the difficulties when we use persuasion techniques in human-robot interaction? These persuasive social robots are no longer neutral objects of technology but truly powerful tools in the hands of man. It is the man who decides what kind of behaviour the robot should try to stimulate in the user, it is the man who decides what goals and strategies the robot should achieve. The question we should ask ourselves is: does the user always agree with what the robot proposes to him? And in this case, is the technology being used for a better purpose, or can be present a conflict between the user's will and autonomy and the goals of the persuasive robot? Is it ethically correct to push the user toward one behavior instead of another even if it may interfere with autonomy, dignity, or freedom of choice? “As autonomy and freedom are fundamental values in western societies, users of PT have a prima facie basic right not to be influenced in ways that violate voluntariness, even not in cases where the intentions behind the PT and its aims are praiseworthy” (Smids, 2012). What is the line between a robot persuading me to eat healthily and exercise and my decision to not follow its advice? What is the limit between influence and manipulation? To what extend should a robot influence human behaviour, even if it is for a noble purpose such as ecological sustainability? Is a robot that encourages us to behave sustainably more moral than a robot that through the same persuasion strategies urges us, for example, to buy something we would not want to buy? Thus, a fundamental ethical question concerns the goal of persuasion but also the values and behaviour promoted through it. We must not only ask whether the goal is morally acceptable, but also whether the strategies the robot uses are. One strategy used by persuasive robots is the so-called nudge, which Thaler and Sunstein define as "any aspect of the choice architecture that alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic incentives" (Thaler, Sunstein, 2008 p.6). An example of a nudge is placing fruit on the highest shelves of the supermarket, at the eye level of the customer, and junk food on lower shelves. Today, social robotics employs robotic nudges to suggest a desired behaviour to the user by the system. Is a robot using nudges considered morally acceptable? The point of the question is that nudging must never turn into manipulation. The nudge must be gentle and not an order, and it must always act in

the best interest of the user. But how can we know what the best interest of the user is? More importantly, is the user always aware of the nudge? Can s/he still exercise control over it? Which goals should be promoted via nudging? And which ones should be avoided? Who has the right to make such a decision? We should pay close attention and reflect on who proposes the methods and goals that robots should achieve. The influence a robot has on us is mainly due to the design choices made by the designer. But is it ethically acceptable for a single group of experts and designers to build robots that push the user towards a certain behaviour rather than another? If we also consider that there are designers who design military robots to kill. Unfortunately, there are still no ethical guidelines governing the construction of these technologies. Leaving everything in the hands of those involved in the design makes it hardly inclusive and this means that these issues are only decided by a select elite. This is why, in my view, we should not leave the design phases exclusively to a design team. I propose, instead, to use an approach called participatory design (Spinuzzi, 2005), (Forlizzi, 2007) that includes the users in the design phases, before reserved for designers and development teams only. Today, more and more people are actively engaged in sustainability issues, so why not also make them involved in the design of tools, such as robots, that can help us achieve sustainable development goals? In this way, users will be actively involved in changing their habits towards a green and sustainable direction using persuasive social robots.

## Conclusions

In my contribution - still in the early stages of research that deserves more depth - I addressed the question of the possible use of persuasive social robots for sustainability. We have seen how today sustainability is an ethical and social challenge that we need to address. I explored how robots and persuasive social robots in particular can play an important role in promoting a lifestyle that is ecologically balanced. Analysed the persuasion factors and strategies, understanding how the robot can change user behaviour through emotional feedback. I showed, through three examples of social robots, that emotional strategy can have a high level of persuasiveness, also to promote sustainability issues. Finally, I dwelt extensively on the ethical implications of using these technologies and their highly persuasive power. My study identified several issues and questions that we must not ignore if we want to use these robots transparently and for noble purposes such as sustainability. I am aware that greater collaboration between the fields of robotics and ethics is necessary to face the challenge of a future in which humans and robots are destined to coexist in the same social ecologies.

Since, as we have seen before, in the literature there are still few cases of persuasive social robots that serve sustainability, therefore my study aims to highlight sustainability issues that could be better considered within HRI research programs.

**References**


Ball, D. *et al.* (2015). Robotics for Sustainable Broad-Acre Agriculture. In: Mejias, L., Corke, P., Roberts, J. (eds) Field and Service Robotics. Springer Tracts in Advanced Robotics, vol 105. Springer, Cham.

Cappuccio, M.L., Sandoval, E.B., Mubin, O. *et al.* (2021), Can Robots Make us Better Humans?, *International Journal of Social Robotics* 13, pp. 7–22.

Castellano G., De Carolis B., D'Errico F. et al., (2021), PeppeRecycle: Improving Children's Attitude Toward Recycling by Playing with a Social Robot, *International Journal of Social Robotics*, 13, pp. 97-111.

Chinnathurai B.M., Sivakumar R., Sadagopan S., Conrad J.M., (2016), *Design and implementation of a semi-autonomous waste segregation robot*, in *SoutheastCon 2016*, pp. 1-6.

Dillahunt T., Mankoff J., Forlizzi J., (2010), A proposed framework for assessing environmental sustainabilityin the HCI community, in: *CHI 2010*, 2010, Atlanta, pp. 1–3.

DiSalvo C., Sengers P., Brynjarsdottir H., (2010), Mapping the Landscape of Sustainable HCI, in *Proceedings of Chi 2010. ACM*, New York, NY, pp. 1975-1984.

Dumouchel, P., Damiano, L. (2017), *Living with Robots*, Cambridge, MA:Harvard University Press.

Forlizzi J., (2008), The Product Ecology: Understanding Social Product Use and Supporting Design Culture, *International Journal of design*, 2, 1, pp. 11-20.

Galati, R., Mantriota, G., Reina, G., (2022). Mobile Robotics for Sustainable Development: Two Case Studies. In: Quaglia, G., Gasparetto, A., Petuya, V., Carbone, G. (eds) Proceedings of I4SDG Workshop 2021. I4SDG 2021. Mechanisms and Machine Science, vol 108. Springer, Cham.

Gass R.H, Seiter, J.S. (2003), *Persuasion, social influence, and compliance gaining*, Routledge, Boston.

Ham J., Midden C., (2014), A Persuasive Robot to Stimulate Energy Conservation: The Influence of Positive and Negative Social Feedback and Task Similarity on Energy-Consumption Behavior, *International Journal of Social Robotics*, 6, pp. 163–171.

Hansmann, R., Mieg, H. A., Frischknecht, P. (2012), Principal sustainability components: empirical analysis of synergies between the three pillars of sustainability, *International Journal of Sustainable Development & World Ecology, 19,* 5, pp. 451-459.

Iravani A., Akbari M. H, Zohoori M., (2017), Advantages and disadvantages of green technology; goals, challenges and strengths, *International Journal of Science and Engineering Application*, 6, 9, p. 272-284.

Jamy L., (2013), The nature of the bots: how people respond to robots, virtual agents and humans as multimodal stimuli. In Proceedings of the 15th ACM on International conference on multimodal interaction (ICMI '13), Association for Computing Machinery, New York, NY, USA, 337–340.

Kidd C. D., Breazeal C., (2007), A Robotic Weight Loss Coach, in Proceedings of the Twenty-Second AAAI Conference on Artificial Intelligence, July 22-26, 2007, Vancouver, British Columbia, Canada.

Korn O., (2019), *Social Robots: Technological, Societal and Ethical Aspects of Human-Robot Interaction*, Springer, Offenburg.

Li J.,( 2013), The nature of the bots: how people respond to robots, virtual agents and humans as multimodal stimuli. In Proceedings of the 15th ACM on International conference on multimodal interaction (ICMI '13). Association for Computing Machinery, New York, NY, USA, 337–340.

Mankoff J., Kravets R., Blevis E., (2008), Some Computer Science Issues in Creating a Sustainable World, *Computer,* 41, 8, pp. 102-105.

Midden, C., Ham, J.(2009), Using negative and positive social feedback from a robotic agent to save energy. In: Conference Proceedings of Persuasive 2009, Claremont, USA, Springer.

Ms Shivaanivarsha N., (2020), Design Of Low Cost Autonomous Environment Cleaning Vehicle, *Elementary Education Online,* 19, 2, pp. 1975-1982.

Mubin, O., Vink, L., Oosterwijk, P., Mahmud, A.A., Shahid, S., (2013), Floffy: Designing an Outdoor Robot for Children, in: Kotzé, P., Marsden, G., Lindgaard, G., Wesson, J., Winckler, M. (eds) *Human- Computer Interaction – INTERACT 2013. INTERACT 2013. Lecture Notes in Computer Science*, vol 8120, 2013, Springer, Berlin, Heidelberg, pp. 563-570.

Pan N., Kan L., Sun, Y., Dai, J., (2017) Amphibious clean-Up robot, in: *Proceedings of the 2017 IEEE International Conference on Information and Automation (ICIA)*, Macao, China, 18-20 July 2017, pp.565-568.

Purvis, B., Mao, Y. & Robinson, D. (2019), Three pillars of sustainability: in search of conceptual origins, *Sustainability Science,* 14, 3, pp.681–695.

Saunderson S., Nejat G., (2022), Investigating Strategies for Robot Persuasion in Social Human–Robot Interaction, *IEEE Transactions on Cybernetics,* 52, 1, pp. 641-653.

Saunderson S., Nejat G., (2021), Persuasive robots should avoid authority: the effects of formal and real authority on persuasion in human-robot interaction, "*Science Robotics",* 6,58

Shinozawa K., Naya F., Yamato J., Kogure K, (2005), Differences in effect of robot and screen agent recommendations on human decision-making, *International Journal of Human Computer Studies*, 62, 2, pp. 267–279.

Siegel M., Breazeal C., Norton M., *Persuasive Robotics: The influence of robot gender on human behavior* in *IEEE/RSJ International Conference on Intelligent Robots and Systems*, 2009, pp. 2563- 2568.

Smids, J. (2012), The voluntariness of persuasive technology. In: Bang, M., Ragnemalm, E.L. (eds.) Persuasive Technology. Design for Health and Safety, Lecture Notes in Computer Science 7284, pp. 123–132. Springer, Berlin, Heidelberg.

Spinuzzi, C. (2005). The methodology of participatory design, *Technical communication*, 52, 2, pp.163-174.

Tanioka R., et al., (2019), Characteristics of Transactive Relationship Phenomena among Older adults, Care Workers as Intermediaries, and the Pepper Robot with Care Prevention Gymnastics Exercises, *The Journal of Medical Investigation*, 66, pp. 46-49.

Thaler R. H., Sunstein C.R., (2008), *Nudge: Improving Decisions About Health, Wealth, and Happiness*, Yale University Press, New Haven (CT).

Turesinin M., Kabir A.M.H., Mollah T., Sarwar S., Hosain, M.S, (2020), Aquatic Iguana: A Floating Waste Collecting Robot with IoT Based Water Monitoring System in *Proceedings of the 2020 7th International Conference on Electrical Engineering, Computer Sciences and Informatics (EECSI)*, Yogyakarta, Indonesia, 1–2 October 2020, pp. 21–25.

Winkle S. Lemaignan, P. Caleb-Solly, U. Leonards, A. Turton, and P. Bremner, (2019), Effective persuasion strategies for socially assistive robots, in 14th ACM/IEEE International Conference on Human-Robot Interaction (HRI). IEEE, pp. 277-285.