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Exploring influencing variables for the acceptance of social robots

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HIGHLIGHTS

- An extensive literature review was performed on social robot acceptance variables.
- In a user study, users evaluated both the social robot and the interaction experience.
- Social robot acceptance research should include both utilitarian and hedonic factors.
- Important utilitarian factors are usefulness and adaptability.
- Important hedonic factors are enjoyment, sociability and companionship.

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ABSTRACT

In order to introduce social robots successfully, we must first understand the underlying reasons whereupon potential users accept these robots to reside within their own homes. An extensive literature review has been conducted and provides an overview of variables influencing the acceptance of social robots categorized by utilitarian variables, hedonic variables, user characteristics, social normative beliefs and control beliefs. In a user study, in which 60 participants interacted with a social robot, both the robot itself and the interaction experience the users had with the robot were evaluated. The results indicate that especially the variables of usefulness, adaptability, enjoyment, sociability, companionship and perceived behavioral control are important evaluating the user acceptance of social robots. Hence, the present study contributes to human–robot interaction research by designating the variables that lead to social robot acceptance. Subsequently, this study may serve as a onset in developing an integral model which takes into consideration the relevant determinants of social robot acceptance.

1. Introduction

Social robots are expected to increasingly penetrate our everyday lives. They are designed to interact socially with humans to simplify communication and, therefore, increase their acceptance by users [1]. However, if social robots are to be successfully introduced into people's homes, we must understand the underlying reasons whereupon potential users decide to accept these robots and invite them into their domestic environments. To be able to explain social robot acceptance and use, it is essential to understand the determinants of the key acceptance variables [2]. Cumulatively, the fields of information systems, human–computer interaction, psychology and communication science realms a long history in technology acceptance research. Prominent models such as the Technology Acceptance Model (TAM) [3] or the Unified Theory of Acceptance and Use of Technology (UTAUT) [4] provide the utilitarian variables such as usefulness and ease of use. However, these basic technology acceptance models do not take into consideration the hedonic variables such as enjoyment and attractiveness.

Over the past decades, the field of human–computer interaction experienced a transformation from pragmatics and functionality to encompassing emotional responses and positive experiences associated with the use of that technology [5]. Indeed, the experience people have with interactive systems is two-fold. Currently, both the utilitarian and the hedonic views are considered equally important when studying technology acceptance. Moreover, several studies in the human–robot interaction also point to the relevance of including the hedonic view in evaluating robots [6–9]. Utilitarian variables are attributes connected to the practicality and usability of a product, whereas, in contrast, the hedonic variables are attributes related to the user experience while using a product. Although a few studies on social robots have included hedonic aspects, only a few have focused on the user acceptance of these robots (for example [7]). This study examines both utilitarian and hedonic variables as they present a broader view on robots as social actors in interaction scenarios and enable the evaluation of the affective factors of the interaction which distinguishes social robots as a unique technological genre [6,10]. This paper will focus on providing insight into the influence of the various variables for the user

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acceptance of social robots. Subsequently, our results may serve as a protocol for the development of an integral model which takes into consideration the relevant variables of social robot acceptance.

2. Theoretical background

Because intentions are found to be good predictors of specific behavior, they have become a critical part of many contemporary theories of human behavior [11]. And although the details of these theories differ, they all show conjunction on a small number of variables that account for much of the variance in behavioral intentions. These variables can be considered as three major kinds of considerations that influence the decision to perform a particular behavior: (1) the likely positive or negative consequences of the behavior, (2) the approval or disapproval of the behavior by respected individuals or groups, and (3) the factors that may facilitate or impede performance of the behavior. When these three categories are applied to the acceptance of social robots, the first category can be viewed as the user's evaluation of (using) a robot, the second category as the social normative beliefs the user holds about using a robot, and the third category as the contextual factors that play a role while using a robot.

The next sections address these three categories and present the corresponding variables of social robots relating to their acceptance. Additionally, we also present relevant user characteristics, which are more trait like, thus stable, variable that are found to be influential in the acceptance of technology in general or social robots specifically. Before presenting an overview of hypotheses derived from findings of previous studies, this theoretical outline will describe the outcome variables of social robots acceptance.

2.1. Attitudinal beliefs

The attitudinal belief structure involves the user's favorable or unfavorable evaluation of a particular behavior [11], or in this case the evaluation of behavioral beliefs resulting from the use of a social robot. The experience people have with interactive technologies are two-fold. According to researchers in the human–computer interaction [12,13], there are both utilitarian and hedonic product aspects. To allow a broader view on the acceptance of social robots, both utilitarian and hedonic factors of human–robot interaction have been chosen to evaluate the interaction between humans and robots. Utilitarian factors relate to the practicality and usability of a product. Hedonic factors, on the other hand, refer to the user experience while using a product and have no obvious relation to task-related goals. The dichotomy of utilitarian and hedonic factors as determinants of technology acceptance also arises from motivation theory which suggests a main classification of motivators based on the different reasons or goals people have that encourages the performance of an activity [14,15]. This dichotomy is between extrinsic and intrinsic motivation. Extrinsic motivation refers to doing something because it leads to a separate outcome and intrinsic motivation relates to the performance of an activity for no apparent reinforcement other than the process of performing that activity itself. This holistic dichotomous view, including both utilitarian and hedonic factors of social robot acceptance, acknowledges the unique elements that distinguishes social robots as a new technological genre and demonstrates the need to include these factors with respect to traditional evaluation factors in the human–computer interaction.

2.1.1. Utilitarian factors

Utilitarian factors are tied to utility and emphasizes the extrinsic motivations to accept or use a technology. Widely acknowledged utilitarian variables originating from the TAM are usefulness and ease of use [3] and are solid predictors of intention to use in the context of human–computer interaction [16]. In the context of robotics, usefulness is defined as the user's belief that using the robot would enhance their daily activities and ease of use is defined as the user's belief that using the robot would be free from effort [7]. Both robotics and information systems research indicates that perceived usefulness influences usefulness, use attitude, use intention and actual use [7,16–18]. Together, research in the human–robot interaction and human–computer interaction found that perceived ease of use has a direct influence on perceived usefulness, use attitude and use intention [7,17,18]. The human–computer interaction research also found an influence of ease of use on use attitude [19,20]. Besides being useful and easy to use, a technology must be a counterpart to its intended function. People expect a robot to look and act appropriately given the task in context [21]. If a robot is designed for the social interaction with humans, the robot must project some amount of humanness so that the user feels comfortable enough to socially engage with the robot [22]. The adaptability of the robot is defined as the perceived ability of the system to be adaptive to the changing needs of the user [7]. Perceived adaptability influences perceived usefulness, enjoyment, attitude towards use and use intention [7,17,18,23,24]. Robotics research thus suggests that a robot's ability to adapt its behavior to the user's preferences and personality can improve acceptability [23]. Therefore, it is important to include this variable in our exploration of variables influencing social robot acceptance. In addition to these general technological variables, robots face the significant challenge of attempting to appear intelligent to provoke users to perceive them as genuine. The intelligence of the robot is defined as the user's evaluation of the robot's level of intelligence [25]. A robot that is evaluated as more intelligent is liked more and viewed as more realistic [26]. As the authenticity of the robot depends on its intelligence, it is important to include this variable when studying the user acceptance of social robots.

2.1.2. Hedonic factors

Both consumer behavior research and information systems research have indicated various constructs related to hedonic factors or intrinsic motivations in technology acceptance of the consumer context [13,27]. Well-known hedonic variables in technology acceptance research are enjoyment and attractiveness. Enjoyment is defined as feelings of joy or pleasure associated by the user with the use of the robot [7]. When people evaluate a social robot their pleasures experience may certainly influence user acceptance. Enjoyment appears to be a crucial variable for social robot acceptance as it directly influences ease of use, use attitude and use intention of robots [7,18]. In addition to enjoyment, visual attractiveness is also a very powerful concept for technological objects [28] as it effects the attribution of positive traits [29]. The influence of attractiveness is explained by the 'what is beautiful is good' paradigm [30]. The attractiveness of the robot is defined as the positive evaluation of the robot's physical appearance [16]. Perceived attractiveness has been ascertained as the most important attribute in the preference for hedonic systems [31] as well as being the mediator for other qualities of technological systems [13]. To our knowledge, perceived attractiveness as a predictor of other aspects in the human–robot interaction has not been studied before. However, research in the human–computer interaction indicates that perceived attractiveness has an influence on usefulness, ease of use, and enjoyment [28]. Both the variables of enjoyment and attractiveness will, therefore, be included in our set of variables that influence the acceptance of social robots.

Together with these general variables of technology acceptance, for social robots specifically the variables of anthropomorphism, realism, sociability and companionship also influence the user experience with these robots. Bodies are salient indicators of social identity: entities that are embodied, either physically or virtually, are expected to function in the human social context [32]. When