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Research Report

Effects of lateral head tilt on user perceptions of humanoid and android robots

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ABSTRACT

Human responses to android and humanoid robots have become an important topic to social scientists due to the increasing prevalence of social and service robots in everyday life. The present research connects work on the effects of lateral (sideward) head tilts, an eminent feature of nonverbal human behavior, to the experience of android and humanoid robots. In two experiments ($N = 402$; $N = 253$) the influence of lateral head tilts on user perceptions of android and humanoid robots were examined. Photo portrayals of three different robots (*Asimo, Kojiro, Telenoid*) were manipulated. The stimuli included head tilts of −20°, −10° (left tilt), +10°, +20° (right tilt) and 0° (upright position). Compared to an upright head posture, we found higher scores for attributed human likeness, cuteness, and spine-tinglingness when the identical robots conveyed a head tilt. Results for perceived warmth, eeriness, attractiveness, and dominance varied with the robot or head tilts yielded no effects. Implications for the development and marketing of android and humanoid robots are discussed.

1. Introduction

1.1. Overview and issue relevance

Do you own a robot? Possibly you get your living room parquet vacuumed by an autonomous cleaner or your front lawn is cut by a mower robot, but otherwise you most likely answer "no" to this question. This could be quite different in 10 years. We are approaching an age in which robotic creatures will be turning up in more and more places in our life. "Rise of the robots" read recent cover stories in magazines (e.g. Fine, 2013). And Microsoft founder Bill Gates called robotics "the next hot field" after the PC revolution (Gates, 2007). This trend does not stop at industry-focused applications. Driven by ageing populations and ever more efficient, integrated and affordable technology, the field of social and service robots is growing as well (Japan External Trade Organization, 2006; Japan Robot Association, 2001; Kranenburg-de Lange, 2012). Especially on the Asian market, roboticists are already testing various types of robotic day-to-day assistants. They range from communication companions and autonomous housekeepers to care bots intended to dispense medicine to hospital patients.

Regarding their visual appearance, some of these service robots do not differ all that much from the C-3POs or WALL-Es we have become familiar with in movies and literature. Many contemporary robot designs mimic human beings to a greater or lesser extent. At the same time, robots with humanlike looks are reported to elicit particularly negative responses in human observers or interaction partners. They have even been associated with a feeling of eeriness—a psychological phenomenon referred to as the *uncanny valley* (Mori, 1970).

Despite the growing relevance of humanlike robots, comparatively little is known yet about the factors that influence the experience of them. Accordingly, this paper is focused on users' responses to humanoid and android robots. Beyond the realism of their external appearances, we postulate that features of nonverbal behavior of humanlike robots can increase the attributed anthropomorphism. More specifically, this paper argues that a head tilt conveyed by a robot, i.e. a shift of the head toward the left or right shoulder (e.g. Costa & Ricci Bitti, 2000; Goffman, 1976), affects users' perceptions of human likeness and variables related to user acceptance.

1.2. On the human likeness of android and humanoid robots

A glance at the digital collection of contemporary robot developments provided by the Institute of Electrical and Electronics

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Engineers (IEEE, 2012) demonstrates that about 70 out of the 158 robots shown are constructed to look or behave humanlike. Depending on how easily they can be distinguished from real people, humanlike robots are typically referred to as *humanoids* or *androids*. Whereas *humanoid* robots often come with extremities like arms, legs or a head but still have an overall mechanical look, *android* robots are intended to mimic human beings as realistically as possible, e.g. by covering the mechanical body with silicon skin (cf. Hirai, Hirose, Haikawa, & Takenaka, 1998; IEEE, 2012; MacDorman & Ishiguro, 2006; Nishio, Ishiguro, & Hagita, 2007).

Why would you build humanoids or androids in the first place? One reason often given by roboticists is that humanlike extremities are necessary to operate in an environment that originally was built for human beings (e.g. Hirai et al., 1998). Other researchers hold that only robots that are perceived as real people and therefore treated as such will be able to elicit natural responses in human communication partners (e.g. MacDorman & Ishiguro, 2006). The degree to which users actually attribute human likeness—or more far-reaching: anthropomorphism—to robots therefore constitutes a variable of high interest in the study of human–robot interaction.

Following Epley, Waytz, and Cacioppo (2007), the essence of anthropomorphism is described as "imbuing the imagined or real behavior of nonhuman agents with humanlike characteristics, motivations, intentions, and emotions" (p. 864). Anthropomorphic inferences thereby go beyond the observable looks and behavior of an artificial agent. They include the ascription of intentionality or traits that distinctly imply human nature (Eyssel, Hegel, Horstmann, & Wagner, 2010). When it comes to user perceptions of humanlike robots, the *uncanny valley* phenomenon (Mori, 1970) has received widespread attention. It assumes a curvilinear relationship between a robot's humanlike features and a user's evaluation of that robot. If a robot displays a rather high degree of human similarity in its appearance but at the same time still acts or looks somewhat "inhuman," perhaps as a result of imperfect motion, it is associated with a negative feeling of "uncanniness" (Ho & MacDorman, 2010; Mori, 1970). Recent empirical results indicate that such eerie feelings might arise from uncertainty that users have to deal with when being confronted with a blend of humanlike and machine-like qualities (Burleigh, Schoenherr, & Lacroix, 2013; Mara & Appel, submitted for publication; Yamada, Kawabe, & Ihaya, 2013).

In this paper, we argue that not only the visual design of a humanlike robot but also its behavioral attributes can influence impressions by human observers. We put an emphasis on nonverbal communication cues because their role in the experience of humanoid and android robots has rarely been explored to date. Our particular interest lay in the question of whether even a small change of a robot's head posture could have a significant impact on how this robot is perceived. We decided to focus on the study of lateral head tilt displays for three reasons: first, the head tilt is reported to be a very widespread and frequently occurring nonverbal cue in interpersonal communication; second, a comparably large body of empirical literature has dealt with its meaning in human–human interaction; and third, the manipulation of head tilts is a minimal and yet a potentially effective intervention in applied robotic contexts.

1.3. Nonverbal cues and head tilt

A substantial part of human communication is nonverbal. Many of the things individuals try to learn about each other in social interactions—e.g. emotional states or intentions of a person—are conveyed not only through words (Ambady & Weisbuch, 2010; Mehrabian, 1972). In recent years, the posture of the human head has been identified as an intriguing nonverbal cue. Much attention has been dedicated to the *head tilt* (or *head cant*), which refers to "cocking" the head toward the left or right side so that the horizontal line connecting the eyes is no longer parallel to the horizontal line connecting the shoulders (cf. Goffman, 1976; Halberstadt & Saitta, 1987; Henley, 1977). When asked to pose for a photograph, nearly three-fourths of people were shown to exhibit head tilting (Costa & Ricci Bitti, 2000). Even in historical portrait paintings, head tilts are a prevalent feature (Costa, Menzani, & Ricci Bitti, 2001). Observations of natural interaction settings reveal that about 40% of people cock their heads (Halberstadt & Saitta, 1987).

By shifting our heads sideways we dampen the arousal brought about by eye contact in friendly face-to-face communication, as suggested by Eibl-Eibesfeldt (1988). Several authors described lateral head tilting as a determinant for flirting (Eibl-Eibesfeldt, 1970; Givens, 1978), as an indication of shyness (Givens, 1978; McGrew, 1972), or conciliatory behavior (Otta, Lira, Delevati, Cesar, & Pires, 1994). Moreover, it was correlated with higher attractiveness ratings (Costa & Ricci Bitti, 2000; Krumhuber, Manstead, & Kappas, 2007; Otta et al., 1994).

Interestingly, in an analysis of historical paintings, the social role of the depicted persons predicted how pronounced their head cant was (Costa et al., 2001). Whereas tilt angles of up to 20° could be found for characters who expressed an adoration of God, aristocrats were rather shown with upright heads. This supports the assumption that head tilting is associated with submission, appeasement, ingratiation, or a request for protection. This meaning might have developed because head tilts expose a highly vulnerable part of the human body (the carotid artery) and reduce the overall height of a person (Goffman, 1976; Henley, 1977; Morris, 1977).

It is hardly surprising that the relation between head tilt and the perception of human likeness has never been examined in the context of interpersonal communication. In general, you could justifiably call anthropomorphism a variable of negligible relevance in the study of human beings.[1] Regarding human–robot studies, no experimental research to date has examined head tilts conveyed by humanlike robots and their impact on anthropomorphic inferences made by users. However, there are empirical studies that have dealt with robotic nonverbal behavior. Most of them either tried to answer applied questions having to do with the effective integration of a robot's speech, gaze and deictic gestures, or they examined user impressions on a broader level of mixed behavioral cues. The former type of research includes case studies in which robots indicate directions by gaze, head movements, or pointing gestures and human interaction partners need to understand where the robot wants them to look or go (e.g. Breazeal, Kidd, Thomaz, Hoffman, & Berlin, 2005; Brooks & Breazeal, 2006; Hegel, Gieselmann, Peters, Holthaus, & Wrede, 2011). This is of particular interest for the use of humanlike robots in practical scenarios, e.g. in museums (Kuno et al., 2007; Yamazaki, Yamazaki, Burdelski, Kuno, & Fukushima, 2010).

Other studies examined the impact of various nonverbal cues on the acceptance and impression formation by human users. In comparison to speech-only conditions, humanlike robots that combined verbal and mixed nonverbal stimuli were found to induce higher user engagement (Moshkina, Trickett, & Trafton, 2014). Also, human–robot dialogues in which the robot exhibited nonverbal behavior were perceived as more natural and comfortable (Liu, Ishi, Ishiguro, & Hagita, 2012; Salem, Eyssel, Rohlfing, Kopp, & Joublin, 2013) and humanlike mimics led to higher likeability ratings of a robot (Eyssel et al., 2010). Not least of all, human interaction partners were more likely to anthropomorphize robots when

[1] The study of *dehumanization effects* (see, e.g., Haslam, 2006) might be an exception.