Why Send the Terminator To Do R2D2's Job?: Designing Androids As Rhetorical Phenomena

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ABSTRACT
In this paper, I first discuss aspects of human engagement with androids as social actors and rhetorical agents. Next, I examine specific characteristics (embodied and social intelligence, behavior, morphology and aesthetics) of humanoid robots to compare the underlying theoretical concepts associated with each for learning, teaching and engagement; these features are in turn connected to user expectations when interacting with androids. Finally, I conclude with android design development theory rooted in these user expectations and considered through a social constructivist lens.

General Terms
Android, Design, Human Factors, Robot, Theory

Keywords
Actor, Android, Communication, Human-Robot Interaction, Learning, Rhetorical Phenomena, Robot, Social

1. INTRODUCTION
As an example of robots in the role of rhetorical actors, in 1982, Feigenbaum and McCorduck suggested roboticists develop a "geriatric robot" that would serve the elderly as a healthcare assistant, coach and companion, combined into one "down-home useful" machine [10]. Today, robots are capable of these tasks and indeed do serve in this role in homes and medical facilities [13]. An important component of robots such as these is understanding how to design for natural human-robot interactions so communication is effective and efficient. A key problem in the Human-Robot Interaction (HRI) domain is to find the optimal combination of machinelike and humanlike interface attributes to support people's goals (e.g., to assist an immobile user) as well as fulfilling the robot's functional use (e.g., to be strong enough to lift a patient), including the very basic notion of communication.

According to Bonsiepe, a rhetorical phenomenon is "when verbal and visual signs are connected" [2]. Rhetorical phenomena -- through which a social actor explains, excuses, substantiates, denies or neutralizes their actions -- are open to interpretation by oneself or another [16]. In addition, these phenomena are intersubjective because they operate around the awareness of other actors who have the capacity to evaluate the account and thereby make the social actor accountable and visible within a particular moral framework [16]. Therefore, a roboticist thinking about the very nature of designing an android that communicates effectively with humans must consider throughout development that robots and humans use rhetorical phenomenon for understanding in a perpetual and ongoing way, and, in fact, view each other as holistic entities of dynamic visual and verbal signs. The purpose of this paper is to explore the potential ambiguities of human-robot interactions through a sociocultural lens, with a focus on understanding implications of humanlike robot embodiment and behaviors combined with user expectations surrounding android design.

This paper also focuses on explaining the use of anthropomorphic models to improve the functionality and behavioral characteristics (including processes such as learning and physical actions) for effective human-robot communication of androids in human-robot dyads. To clarify, for the purpose of this paper, an *android* is a physically embodied agent with varying levels of anthropomorphic appearance, intelligence and autonomy. The words *robot* and *android* will be used interchangeably.

Palinscar explains the social contructivist lens as a, "…focus on the interdependence of social and individual processes in the co-construction of knowledge" [21]. An android designer (or developer) using a social constructivist [21] approach to rhetoric must be aware of three canons: (1) the forces that shape designers (history, background knowledge, discourse community, social context), (2) the social forces that shape users (designers must adjust their media according to user goals, assumptions, context, and knowledge), and (3) how designers see users (designers must have an idea of who they are developing for). This way of examining rhetorical phenomena guides and informs all decisions and judgments throughout robot design and development.

Before going further, it is also important to clarify what is meant in this paper by *design*. Rosenman and Gero [23] offer a useful and relevant definition: "Design is a purposeful human activity in which cognitive processes are used to transform human needs and intent into an embodied agent…..design is about the transition of concepts from the sociocultural environment to the description of technical objects." This definition combines a social constructivist view of rhetorical phenomena (sociocultural awareness), with a direct correlation to embodied agents, such as androids. In the case of robotics, a *designer* or *developer* is also a roboticist, someone involved in an aspect of robot design.

2. DESIGNING ANDROIDS FOR SOCIALNESS

A great deal of study has been performed recently on robots that feature functions for communicating with humans in social ways [3,4]. This research has applications for designing robots used in any human-robot interaction, such as in entertainment, education and service scenarios. However, it is necessary to investigate what types of psychological reactions are evoked in humans by robots that are either like or unlike user expectations for robot socialness.

Research has found humans tend to have either extremely positive or extremely negative attitudes toward novel communication technologies [19]. If robots are currently regarded as a novel communication technology, and adding humanlike dimensions to a robot's design adds even more complex layers to user expectations, it is reasonable to say there is the possibility that humans may have negative attitudes or emotions toward these robots. Then, one might ask, why ever develop a humanoid robot as opposed to a zoomorphic or purely industrial robot? Why design for socialness in a robot at all?

The issues surrounding the social *acceptance* of humanoid robots, or androids, are extremely complex. If a robot is meant to complete tasks that are more social in nature, for the robot to engage in meaningful social interaction with people requires it to possess a degree of humanlike qualities in form and/or behavior. However, it is true the degree of anthropomorphism in these qualities is not a simple problem to solve. Human-Computer Interaction research has indicated people's expectations of an interactive technical system elicits strong anthropomorphic paradigms, even when not embodied in a humanlike way, which overly increases a user's expectations of the system's performance [11]. And, in social robotics, the ideal android paradigm should not necessarily be indistinguishable from a human. It is indeed possible, as Mori [18] hypothesizes, that making androids too humanlike may repulse users. In addition, highly humanoid robots or those designed with a "too perfect" appearance may give an impression of intelligence so superior to the user that they become undesirable objects to interact with. Recently, we coined the term *invisible machinery* to refer to robots that, through humanlike design and behavior, elicit a sense in the user that the object is natural or living [4]. The successful design of social humanoid robots should seek to create feelings that encourage the user to believe in the abilities and sophistication of the system so they do not expect errors. The social aspect of this class of android encourages users to think of these entities as more than simply tools, but also as believable and engaging social actors. The following paragraphs delve into some concrete examples from Human-Robot Interaction literature to seek reasons to embody social robots in a humanoid form.

3. SOCIALNESS AND EMBODIMENT TIED TO LEARNING AND TEACHING

As stated throughout this paper, androids that are designed to be autonomous must interact with users in the most natural way possible, depending on a matrix of reasons, including user expectations, robot functions, and so on. There will be a much less natural set of interactions between the user and the robot if it does not have some degree of social intelligence, even for what might be considered utilitarian tasks, such as in space exploration, where robots typically hand tools to human astronauts or gather information solely through camera feeds. Bypassing social intelligence in the robot's design actually adds to the user's cognitive load, requiring the user to learn and act differently towards that particular robot in order to be effective as a team with a common goal or task [7]. Designing a robot with a human form allows it to work in human spaces and potentially use tools meant for human hands, as in the case of NASA's Robonaut [1].

Another reason to employ social capabilities and some level of humanlike embodiment in a robot is that the robot's training or learning will be easier from a user's standpoint. Human-robot interactions that allow the robot to learn through physical imitation, experience, feedback and other social learning relieve some of the daunting programming duties associated with the complexities of customizing a robot for individual contexts, situations and uses. If an android is capable of different means of learning, rather than having each movement programmed for every activity that the robot is to perform, it can observe humans perform a task, then imitate that action. The human coach can then correct aspects of the robot's actions if necessary. In social robots, similar to humans, learning is the internalization and application of skills, tasks and information. Robot learning has unique circumstances because the teacher's knowledge – if the teacher is human – is very different; humans perceive the world through different sensory modes and with different insights and therefore have different models of knowing, what is known, and how it is known [11]. Davenport and Prusak [6] define knowledge as, "a fluid mix of framed experience, contextual information, values and expert insight that provides a framework for evaluating and incorporating new experiences and information." First, people attend to the content (prior experience, contextual information) and then they acknowledge the purpose of the knowledge (framework for evaluation). Therefore, a robot understanding humanlike learning, as well as social cues, is critical for effective human-robot communication, ease of interaction and sharing knowledge.

A final reason for imbuing robots with social interaction capabilities is that human pedagogy's social characteristics will allow the robot to learn more effectively from fewer examples and generalize to other situations. The social aspect of learning goes beyond imitation [15]. Through generalization, a robot may be able to respond to many different kinds of situations without being explicitly told what to do by the user. For example, a robot could learn to correct problems in situations that are similar, and even predict difficulties in these similar situations before they occur.

4. ENGAGEMENT, BELIEVABILITY AND EMOTIONS

The user's level of involvement or potential for finding the android appealing is one definition of engagement, and it indicates how much the user is attracted by the android or how familiar or distant she feels to it. The relevance of the android's roles and functions and its design aspects (aesthetics of appearance, behavior and communication), as well as its personality, all have an effect on engagement. Engagement is closely tied to believability.

The challenge of a universally engaging android design will lie heavily with user personalization, modification and customization of robot features such as voice, gaze, behaviors, human- vs. machinelike appearance; the elements that Norman [20] refers to as composing the *visceral* design.

At the visceral level, users make quick judgments about what is good or bad [20], sending signals to the muscles and alerting the brain. This step begins the affective processing, which is biologically determined. Norman [20] describes the behavioral level as not conscious and it includes reflective thought. Cues to the user's visceral level closely match those described by Dunn [8].

As described by Norman [20], *behavioral design* is the pleasure and effectiveness of use and *reflective design* is tied-in to a user's self-image, personal satisfaction and memories -- no one android can fulfill all users' needs, task-based or pleasure-based. So, the designer must understand the user for whom the product is intended. Behavioral design is about use, and performance matters to users. Here is where the designer must understand how people will use a product; most often, this is discovered through observation [20].

Norman [20] also states that long-lasting emotional connections to products develop over time and are fostered by user memories and associations, which connects again to the social constructivist view of rhetorical design. He explains *reflective design* as being equal to a user's self-image [20].

Believability is not necessarily the idea that a humanoid robot appears to be human, but rather that the robot matches the users' expectations of a humanoid shape and, therefore, humanlike qualities, such as with verbal communication. One term Dunn [8] uses to explain this phenomenon is *morphology*, a word that describes the user's perception of "the degree to which an object …measures up to their perception of living forms, based on their own body-centric cognitive constructs about what constitutes the parts of a living form." Dunn [8] describes the important concepts behind his use of the term *morphology* as the assumption that people project their own meaning and experience of embodiment onto the patterns implied by the stimulus. Therefore, a robot's capacity to be able to engage in meaningful social interaction with people inherently requires the employment of a degree of anthropomorphic, or humanlike, qualities in both form and behavior.

The challenge for the android designer here is balancing this set of characteristics to fulfill the robot's functional use while also developing an android that does not violate user expectations, alarm the user or otherwise promote a negative affect. An example of this might be developing an android that is larger in overall proportion than the user so that the robot is usable for relevant physical tasks in caregiving. Although the robot may need to be a larger physical size in order to function effectively (such as lift a physically disabled user), the scale of the robot itself may intimidate the intended user, at least initially. Overcoming design obstacles such as this will depend upon the designer's careful consideration of the user's expectations.

Properties of human-human interaction in one-on-one situations may be successfully applied to digital systems, such as androids, to support effective communication when each actor's activities are clearly visible to each other; Erickson and Kellogg refer to these as "socially translucent systems" [9]. Erickson and Kellogg [9] explain three components to these systems: *visibility*, *awareness* and *accountability*. These characteristics allow users to draw on their social experience and structure their interactions with each other. Designing a robot so that such socially significant information is visible will bootstrap people's level of involvement and the potential to find the android appealing or engaging.

Furthermore, the use of humanlike features for social interaction with people [3,14] can facilitate our social understanding; it is the explicit design of anthropomorphic features, such as a head with eyes and a mouth, that may facilitate social interaction. Humans use social rules for their interactions with computers, or, as Reeves and Nass explain, media are an equation with real life [22]. More broadly, Reeves and Nass state that people's interactions with computers and new media are fundamentally social and natural [22]. If we accept the hypothesis that people automatically treat robots as new media and therefore, as social actors, it logically follows that people must also unconsciously apply their culture-specific norms and preferences during human-robot interactions.

When discussing androids as engaging and believable objects, it is important to note that users transform shapes and sounds into complex mental constructs [8]. Dunn [8] states that people imbue these constructs with "affection and expectation and endow them with attitudes and emotions….They react to, describe and remember them almost as they might other people." Our own recent studies [4,5] have indicated user expectations and preferences for humanlike robot appearance match Dunn's [8] explanation, with users matching expected robot capabilities and behaviors to the outward anthropomorphic design affordances and also attributing agency and emotion to androids, even describing them in human terms. Therefore, design challenges identified here are to create valid sets of characteristics that mesh with the user's expectations of the robot's behavior. For example, if an android has "eyes," a user expects the robot can see, or has the ability to match eye contact or recognize the user in a humanlike way. The eyes are an affordance and the user is matching their own mental construct of humanlike eyes and their function to that of the robot's eyes. This concept presents a challenge to roboticists designing androids: keep in mind the users' expectations and preferences.

Beyond task-oriented goals of a robot and rooted in context and communication, an example of user preferences and expectations that effect human-robot interactions with androids is a turntaking one: should the robot initiate a conversation with its owner? In order to do so, it would need to assess its user's emotional state [20]. The robot should then be designed to remember user behavior (e.g., when a robot companion interrupts an owner who is speaking and is reprimanded, the robot remembers and can learn and revise its actions next time). To be more effective at interacting with humans, a robot will have to consistently and accurately read and interpret user vocal tones, facial expressions and body language and will need to understand idiomatic aspects of speech (as well as natural language) – all to recognize and react to user emotions [20].

Similarly, Norman [20] recommends the robot display its own emotional state so the user can effectively and efficiently understand when the robot is confused or "exhausted" (as when its power is low). By the same token, the designer must avoid representing "fake" emotions. In recent studies, [4,5], users commented that video of a childlike robot seemed "insincere" or "fake" because the robot inappropriately (out of the user-expected social context) asked for hugs from a human user. The level of engagement, as defined previously, is low if the android's emotions appear inaccurate or not humanlike, and must build on the user's knowledge of how and when emotions should be represented.

Closely tied to displaying emotion is the appearance of a robot's personality. When a robot exhibits personality (whether intended by the designer or not), a number of effects occur. First, personality can serve as an affordance for interaction. A number of humanoid robot toys were purposefully developed with personalities in order to engage people and encourage the toy's use [17]. Robot personality can also impact task performance, in either a negative or positive sense. Goetz and Kiesler [12] examined the influence of two different robot personalities on user compliance with an exercise routine. In this study, Goetz and Kiesler [12] discovered that simply instilling a robot with a charming personality will not necessarily ensure the most effective cooperation of a human with a robotic assistant. While potentially influential, personality is not itself the defining rhetorical factor in a robot's design.

Norman [20] explains that emotions change the way humans solve problems, which is clearly a function of rhetoric. If aesthetics change a user's emotional state, aesthetics also change how an object is used. Norman [20] posits that positive emotions stimulate creative thinking, while negative emotions stymie this type of thought process; if a user feels good (about using a product), it encourages problem solving. If, for example, a user encounters a usability problem with an android, someone in a positively affected state is more likely to be satisfied by seeking a workaround or alternate solution than a user in a negatively affected state.

5. CONCLUSIONS

As Reeves, Nass [22] and Norman [20] explain, and most of us have experienced anecdotally, people become engaged with inanimate objects as more than simple tools. People name their cars, boats or computers, which historically have not always been designed to encourage an anthropomorphic affect. In the realm of android development, the social construction of individual user experiences, histories, expectations, uses and contexts of uses cannot precisely be predicted and universally designed for in one perfectly usable robot and must be extremely adaptive. Besides differing levels of humanoid design, a certain level of user customization and personalization may help to mitigate these issues in everyday use, as well as reduce the issues involved in the daunting task of developing a universal android design. For example, if a user is uncomfortable speaking with a home-use service robot because it is too social an action for a purpose, they may need an option to make the robot simply act on command with only nonverbal responses, such as an affirmative nod.

Making connections and linking knowledge through a mental model, or schemata, is an effective way to bootstrap user design expectations for androids. If users can develop an understanding of behaviors from the robot's design, then they will be able to effectively use the robot. In other words, an individual's past experiences help to support the creation of schemata, and schemata help to decode rich and dynamic media like androids. Robot appearance and behavior tied closely together through a series of user schemata can increase the complexity of an android – or alternately, simplify it – depending on user needs and expectations. This process of learning is not at odds with sociocultural meaning-making, but is an additional way people develop knowledge and understanding.

Our research must begin by examining user expectations about androids and interactions with them, and build toward advancing ease-of-use and communication. Simply put, as designers and roboticists, we must determine how to best tailor android language, behavior and appearance for an infinite variety of contexts and user experiences. Keeping in mind the needs of those for whom we are developing robots will ensure a greater likelihood that the messages will be understood as they are intended.

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