An Inventory of Reported Characteristics for Home Computers, Robots, and Human Beings: Applications for Android Science and the Uncanny Valley

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Abstract

The uncanny valley refers to a state of perceptual or cognitive experience at which an increasingly humanlike figure becomes strange, rather than increasingly more familiar or acceptable. This formulation, however, is predicated upon a clear notion of what *human likeness* is. Human likeness is a vague term that requires clarification if it is to be used as an independent variable in experimentation in android science. This paper inventories various reported characteristics of home computers, robots, and human beings. The purpose of this is to delimit empirical research in android science on those robot features necessary for the experience of the uncanny and for the formation of social relationships.

Uncannily Human

A world populated with humanlike androids could lead to “a new lifestyle with robots” (Ishiguro, 2005a, p. 5) for human beings. The question remains as to whether it is possible to design robots that are sufficiently humanlike to be assimilated into social relationships and the complex culture of human beings. An android is defined as “an artificial system that has humanlike behavior and appearance and is capable of sustaining natural relationships with people” (see Ishiguro, 2005a; MacDorman, Minato, Shimada, Itakura, Cowley, & Ishiguro, 2005). Indeed, one benchmark of the successful design of a social robot is this ability to sustain long-term, *natural* relationships with people (MacDorman & Cowley, in press; see also Ramey, 2005a, in press). One difficulty for the formation of social relationships, however, is the purported uncanny valley effect (Mori, 1970/2005).

The uncanny valley refers to a state of perceptual or cognitive experience at which an increasingly humanlike figure becomes strange, rather than increasingly more familiar or acceptable (see Mori’s original [1970/2005] formulation; Mori, 2005).[1] Although Mori’s principle has been around for over thirty years, little systematic empirical and theoretical research in the behavioral and engineering sciences has been conducted on the parameters of the uncanny valley effect (although see Chaminade, Hodgins, & Kawato, 2005; Ishiguro, 2005b; Keysers & Gazzola, 2005; MacDorman, 2005; Ramey, 2005b).

There are some researchers (e.g., Hanson, Olney, Pereira, and Zielke, 2005) who maintain that the uncanny valley does not exist or at least can be escaped through careful design; Hanson et al. (2005) recently concluded that participants rating real and non-real stimuli “showed no sign of the repulsion that defined the ‘valley’ of Mori’s uncanny valley” (p. 7). They thus advocated that either the valley does not actually exist beyond Mori’s intuition or is innocuous for robotics design and should no longer be avoided. To account for the difference in whether people experience the uncanny valley or not, other researchers (e.g., Ramey, 2005b) have argued that the uncanny valley should not be regarded as unique to the concerns of humanoid robotics. Rather, the uncanny valley effect is a member of a class of cognitive and perceptual states of uncertainty at category boundaries (i.e., *humans* and *robots*) for a novel stimulus (i.e., *humanlike android*). Freud (1919/2003), for example, advocated how personal knowledge and knowledge of context influence the experience of stimuli (e.g., as the uncanny or the mundane).[2]

At the very least, the notion of the uncanny valley and its relevance to android science is predicated upon a clear notion of what *human likeness* is (be it in the researcher’s design and methodology or the participant’s interpretation). ‘Human likeness’ is a vague term that requires clarification if it is to be used as an independent variable in experimentation. That is, to what extent something is humanlike will depend on what the stimulus is. (An extremely realistic humanlike foot on a robot is likely not as uncanny an experience as an extremely realistic humanlike face; of course, this intuition requires empirical analysis.) This paper is a preliminary inventory of various reported characteristics of home computers, robots, and human beings in order to delimit empirical research in android science to those features (their presence or lack thereof in design) necessary for the experience of the uncanny.

Method

Participants. Fifty-eight (N = 58) undergraduates (mean age 20.87 yrs) participated in this study for course credit. Participants were randomly assigned to one of four experimental conditions: Human-Computer (n = 13),

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[1] Although as Freud (1919/2003) noted in his influential account of the uncanny, “beyond doubt… the word is not always used in a clearly defined sense” (p. 123).

[2] Freud (1919/2003): “Even when Pygmalion’s beautiful statue comes to life, this is hardly felt to be uncanny… The false semblance of death and the raising of the dead have been represented to us as very uncanny themes. But again, such things are commonplace in fairy tales. Who would go so far as to call it uncanny when, for instance, Snow White opens her eye again? And the raising of the dead in miracle stories – those of the New Testament, for example – arouses feelings that have nothing to do with the uncanny” (p. 153).

Human-Robot (n = 15), Robot-Human (n = 13), and Computer-Human (n = 14).

Materials and Procedure. A target task incorporated in a brief demographic questionnaire was used. In this study, participants were asked to consider a typical instance of an item. As an example, they were to consider a typical "desk," not a specific "desk" that they could remember or were currently in. They then were to answer several questions.[3]

(1) What does it look like on the outside? Describe its appearance or visible parts.

(2) What does it do? What can it do? How does it behave?

Participants were then asked to provide ten characteristics of a typical instance of the mentioned item. The following example was provided:

(1) *Made of wood, flat, got 4 legs…*

(2) *Has me sitting in it, just sits there, pile stuff on it…*

After participants completed this task, they were asked to look over the characteristics in each column and consider them with respect to another item: "For example, pretend that I asked you to circle all features of a typical 'desk' that would also apply to a typical 'table.' For example, a 'table' can be made of wood, is normally flat, and has four legs. It also just sits there and can have stuff piled on it. It is also good because it helps you get good grades because you can study better with it." It is important to note that this second task item was not made known to participants before completing the first task.

After any questions were answered, participants in the Human-Computer, Human-Robot, Robot-Human, and Computer-Human conditions completed the target task in the manner of the orientation ask described above. As an example, consider the Human-Robot condition: Each participant first listed no more than ten characteristics of a *human being* and then circled those features that a *robot* also possessed.

Results and Discussion

Reported characteristics were transcribed and are summarized in the following Tables.[4] Table 1 displays the proportion of shared human, computer, and robot properties and attributions overall. Tables 2 and 3 display the frequencies of specific properties and attributions in the Human-Robot Condition and the Robot-Human Condition, respectively. Table 4 displays summary data with respect to face properties.

Two contrasts are immediately evident from Table 1. First, Robots have more in common with humans than computers do (Human-Robot vs. Human-Computer). Second, humans have more in common with robots than computers do (Robot-Human vs. Computer-Human). (Humans and computers do not appear to have much in common, and tables for Human-Computer and Computer-Human data are, thus, omitted from the present report.)

Table 1. Proportion of Shared Human, Computer, and Robot Properties and Attributions

Condition	Physical Appearance
Human-Computer (n = 13)	.06
Human-Robot (n = 15)	.42
Robot-Human (n = 13)	.31
Computer-Human (n = 14)	.11

Note. In the condition "Human-Computer," participants were asked to list features of humans and subsequently were asked to indicate which features were shared with computers. The n refers to number of participants. The labels Human-Robot, Robot-Human, and Computer-Human conditions follow on this logic.

There appears to be support for the idea that humanlike robots are not only possible but acceptable in terms of a mapping of physical appearance. There is a correspondence between a robot's appearance and a human being's physical appearance. That is, robots and humans seem to share major physical appearance features. However, there are two points of caution here. First, human beings have less in common with robots (Robot-Human) than robots have with human beings (Human-Robot). This makes sense given that robots (*a fortiori* androids) are presumably modeled after the human image. This may also point to a further asymmetry relevant to design. A human being may allow other entities to possess human physical features up to a point. However, if one notes the properties of that other entity, a human being will be less willing to identify with these *foreign* category properties. Human beings will remain steadfastly loyal to their own category's attributes. It is, thus, worth investigating what features are shared between robots and human beings (see Tables 2 and 3).

Table 2. Frequencies of Properties and Attributions of Human-Robot Condition

Condition	Physical Appearance	Shared
General comments		
2 arms, 2 legs, 1 torso, head	1	1
2 sexual types male or female	2	0
woman	1	0
male female parts	2	1
sexual dimorphism	2	0

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[3] A third question was (3) What are its positive features? What are its positive contributions? These analyses are omitted from the present report because a similar question concerning negative features was not included originally.

[4] The Tables are necessarily influenced by the author's *a priori* notions of types and tokens, but they are presented *in detail* to provide researchers with a preliminary inventory of relevant reported characteristics. In addition, characteristics of the abilities and actions of home computers, robots, and human beings are omitted from the present report owing to space limitations.

height	1	1
tall or short	1	1
between 5 and 6 ft.	1	1
weight	1	1
stands on two legs	1	0
symmetric	1	1
belly button	1	0
body	2	2
head with eyes, nose, ears…	1	0
head	5	4
neck	1	0
shoulders	1	1
torso	1	1
front	1	0
back	2	1
beautiful or ugly	1	0
fat-skinny	1	1
can be different skin, race colors	2	0
curvy body nice shaped	1	0
breasts	1	0
nice butt	1	0
nice calf muscles	1	0
curvy	1	1
clothes	2	0
Total	*40 (.27)*	*18 (.29)*
Organic appearance		
hair	6	1
hair length	1	0
both male, female has hair	1	0
hair on top of head	2	0
long brown hair, straight	1	0
skin	4	0
Total	*15 (.10)*	*1 (.02)*
Mechanical appearance		
Total	*0 (0)*	*0 (0)*
Face		
face	3	2
2 eyes, a nose, and a mouth	1	1
eyes	3	3
2 eyes	6	2
2 eyes on the front of the head	1	1
blue/green eyes	1	0
ears	4	1
2 ears	3	0
2 ears on the side of head	2	1
mouth	7	2
smile	2	1
lips	1	1
lip gloss	1	0
nose	9	2
Total	*44 (.29)*	*17 (.27)*
Arms and legs		
arms	4	4
2 arms	9	8
legs	4	3
2 legs	8	6
muscular legs, defined	1	0
Total	*26 (.17)*	*21 (.33)*
Hands and feet		
2 hands and 2 feet	1	1
hands and feet	1	0
hands	2	2
2 hands	1	1
hand, arm	1	1
every hand has 5 fingers	1	0
fingers	2	0
nails	1	0
painted toe/finger nails	1	0
10 fingers and 10 toes	2	1
10 fingers	2	0
foot, leg	1	0
feet	2	1
2 feet	2	0
every foot has 5 toes	1	0
toes	2	0
10 toes	2	0
Total	*25 (.17)*	*6 (.10)*

Note. The *n* refers to the total number of properties minus uncodeable (Maximum $n = 150$; Total $n = 150$; Shared $n = 63$).

Table 3. Frequencies of Properties and Attributions of Robot-Human Condition

Condition	Physical Appearance	Shared
General comments		
“human like”	1	0
looks like human	1	1
masculine figure like a male	1	1
may be android-like	1	0
uniform	1	0
unnatural	1	0
may have bolts	1	0
a fan to cool itself	1	0
different sizes	1	1
a little shorter than me	1	0
big	1	1
chubby	1	1
compact	1	0
box-like	1	0
boxy	2	0
wide	1	0
solid	1	1
stiff	1	0
hard	1	0
smooth surface	1	0
stable	1	1
stands upright	1	1
square/round	1	0
breakable	1	1
geometric	1	0
green stripes	1	0
head	2	2

rotating head	1	0
slinky shaped neck to move	1	0
torso	1	1
no clothes	1	0
Total	*33 (.31)*	*12 (.35)*
Organic appearance		
Total	*0 (0)*	*0 (0)*
Mechanical appearance		
data board	1	0
disk-drive	1	0
places on structures to insert info	1	0
chips	1	0
electric	1	0
machine	1	0
mechanical	1	0
made of metal, metal parts, steel	10	0
grey/metallic	1	0
silver	1	0
shiny	6	2
possible plastic	1	0
wheels	4	0
nails	1	0
a metal piece	1	0
outlets for various plugs	1	0
screen	1	0
antennas, transmitter	2	0
lights	1	0
blinking lights	1	0
flashing lights	1	0
bright lights	1	0
has a keyboard	1	0
lots of buttons, tons	2	0
buttons, perhaps colors	2	0
Total	*45 (.42)*	*2 (.06)*
Face		
Scary face	1	0
Imitation of human face	1	1
Pair of eyes	1	0
Eyes, possibly	1	1
Lights as eyes, red	2	0
Optical apparatus	1	1
Rectangle mouth	1	0
Slits in side of head for ears	1	0
Total	*9 (.08)*	*3 (.09)*
Arms and legs		
arms and legs	1	1
arms	1	1
2 arms	2	2
arm-like structure	1	1
extending arms	1	1
2 hands, 2 legs	1	1
legs	2	2
2 legs	2	2
Total	*11 (.11)*	*11 (.32)*
Hands and feet		
10 fingers and toes	1	1
feet	1	1
2 feet	1	1
wheels, on	1	0
wheels for feet	2	0
hands	1	1
2 hands	1	1
tong-like hands to grab things	1	0
opposable thumbs	1	1
Total	*10 (.09)*	*6 (.18)*

Note. The n refers to the total number of properties minus uncodeable (Maximum n = 130; Total n = 108; Shared n = 34). There were 18 non-responses subtracted from the maximum n.

Given the inventory of properties and attributions (Tables 2 and 3), it becomes clear that certain *type* features (e.g., face features) parallel between human beings and robots, though their *tokens* are not equivalent (see Table 4).

Table 4. Frequency (and Proportion) of Face Properties

Condition	Face	Shared
Human-Computer (n = 122)	38 (.31)	0 (0)
Human-Robot (n = 150)	44 (.29)	17 (.27)
Robot-Human (n = 108)	9 (.08)	3 (.09)
Computer-Human (n = 120)	0 (0)	0 (0)

Note. The Face column refers to frequency (and proportion of Total n) of face properties. The Shared column refers to frequency (and proportion of all shared features) within that condition.

It is immediately clear that facial features are very important for the identification of human beings, whereas this class of properties is not so for robots or computers. Given that only 8% of robot features are facial features, whereas the comparable percentage for human beings is about 30%, *robots are not stereotypically defined by their face*. One might nonetheless expect that facial features attributed to robots would comprise a substantial amount of the features later attributed to human beings, but this is not the case. Robots are allowed to have human faces (Human-Robot, 27% of all shared features), but human beings are not allowed to have robot faces (Robot-Human, 9% of all shared features). Closer inspection reveals why this is the case. Robot facial features are quite different from human facial features. Participants' reported features like "scary face," "lights as eyes," and "slits in side of head for ears," and "rectangle mouth." The stereotypical robot face is a terrifying caricature of a human being's face.

General Discussion

The present paper investigated those features and attributions of human beings and robots that are stereotypically associated with them. This preliminary inventory is required because *human likeness* is a necessary variable for (a) the design of humanlike androids in android science and (b) the empirical and systematic investigation of variables relevant to the uncanny valley effect in robotics research and android science. Future research should no longer rely on *intuitions* (cf. Mori, 1970/2005) but rather be based on empirical inquiry.

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