THE PERSUASIVENESS OF HUMANLIKE COMPUTER INTERFACES VARIES MORE THROUGH NARRATIVE CHARACTERIZATION THAN THROUGH THE UNCANNY VALLEY

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Just as physical appearance affects persuasion and compliance in human communication, it may also affect the processing of advice conveyed through avatars, computer-animated characters, and other computer interfaces. Although the most persuasive interfaces are often the most humanlike, they incur the greatest risk of falling into the uncanny valley, the loss of empathy associated with eerily human characters. Previous studies have compared interfaces on the left side of the uncanny valley, namely, those with low human likeness. To examine interfaces with higher human realism, two between-groups factorial experiments were conducted through the Internet. The first experiment involved 426 Midwestern US undergraduate students. This experiment presented a hypothetical ethical dilemma followed by the advice of an authority figure. The authority was manipulated in three ways: depiction (recorded human or animated avatar), motion quality (smooth or jerky), and recommendation (disclose or refrain from disclosing sensitive information). Of these, only the recommendation changed opinion about the ethical dilemma, even though the animated depiction was significantly eerier than the human depiction. These results indicate that compliance with an authority persists even when using an uncannily realistic computer-animated double. The uncanny valley also predicts that humanlike agents with nonhuman features will be evaluated negatively. However, it is unclear whether this effect persists across differently framed interactions. A second (posttest-only) experiment was conducted with 311 Midwestern

US undergraduates. Participants were assigned one of two novel dilemmas in professional ethics involving the fate of a humanlike agent. In addition to the dilemma, there were three 2-level manipulations of the agent's human realism: depiction (animated human or humanoid robot), voice (recorded or synthesized), and motion (smooth or jerky). In one dilemma, decreasing depiction realism or increasing voice realism increased eeriness. In the other dilemma, increasing depiction realism decreased perceived competence. In both dilemmas human realism had no significant effect on whether to punish the agent. Instead, the willingness to punish was predicted most reliably by the agent's narratively framed autonomy and credibility, demonstrating strong effects of narratives on responses to humanlike agents. Though perceptible in humanlike interfaces, the uncanny valley's effect on persuasiveness is attenuated by contextual information.

Mark S. Pfaff, Ph.D., Chair

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ONE: UNCERTAINTY FROM THE PRESENTATION OF HUMANLIKE INTERFACES

From idiosyncratic android doubles to individualized assistants on mobile telephones, humanlike computer interfaces simultaneously elicit familiarity and uncertainty. Interactions with humanlike interfaces are familiar because they resemble conversations with other people. The preference for conversations over unidirectional communication has been identified as a human adaptation (Garrod & Pickering, 2004). Owing to the familiarity of humanlike interfaces, users often require little or no training or experience.

Although adding human features increases social behavior towards humanlike interfaces (Gong, 2008), these additions also raise questions about specific functionality: How accurately can a system's effectiveness be conveyed by a particular combination of humanlike features? Will some combinations of human features decrease the system's perceived efficiency in a given role? This research encompasses inferences about such experiential qualities as attractiveness, humanness, eeriness, and credibility based on independent variations in presentation.

Inferences about other people are influenced by qualities like physical appearance, voice, and movements (Ambady et al., 2002; Jackson, Hunter, & Hodge, 1995; Latinus & Belin, 2011; Meijer, 1989; Miller, 1970). Often, these so-called zero-acquaintance attributions require only a moment of perceiving (Ambady & Rosenthal, 1992; Bachmann & Nurmoja, 2006; Bar, Neta, & Linz, 2006; Olson & Marshuetz, 2005; Willis & Todorov, 2006). Even when these physical qualities are ostensibly immaterial, they can affect others' behavior (Druckman, 2003; Hadjistavropoulos, Ross, & von Baeyer, 1990;

Nordholm, 1980; Sigall & Ostrove, 1975; Young, 1979). The observation that physical and vocal attractiveness decrease with familiarity (Zuckerman, Hodgins, & Miyake, 1990) further underscores the importance of making positive first impressions, whether for a person or a computer presented as humanlike.

In addition, the scope of *humanlike* is broader than the scope of *human*, in part because of people's tendency to anthropomorphize nonhuman entities (Waytz, Cacioppo, & Epley, 2010). Though this implies greater room for creative expression, it also means interpretations of the medium are anchored less firmly in face-to-face experience. Would a public official risk conducting a video chat using a webcam, let alone a computer avatar, if technical problems made him or her seem inept?

Failing to account for the social effects of presentation could delay the adoption of humanlike interfaces in everyday roles. Specifically, the intent to use such interfaces could decrease because of the uncanny valley effect, in which humanlike forms seem repulsive because of nonhuman elements (Mori, 1970/2012). For example, in robots assigned to healthcare and home service, humanlike appearance is predicted to affect the quality of interactions with patients (Zhang, Zhu, Lee, & Kaber, 2008). How would people choose among several forms, some more human than others, for a caregiver position, especially if the more human forms carry a higher risk of appearing uncanny? Overcoming this problem can benefit humanlike interfaces varying in embodiment (e.g., a physical or virtual form with varying humanness), input complexity (e.g., scripted text or spoken natural language), and application (Cassell et al., 1999; Holzwarth, Janiszewski, & Neumann, 2006; Kanda, Hirano, Eaton, & Ishiguro, 2004; Kanda,

Shiomi, Miyashita, Ishiguro, & Hagita, 2009; Kanda et al., 2009; Marin, Issartel, & Chaminade, 2009; Swartout et al., 2010).

These concerns and potential benefits motivated this work. Its studies cover three functions of computing, three levels of human presence, and three stages of immediacy. Beyond functioning as tools, computers also function as communication media and as social actors (Fogg, 1998; Reeves & Nass, 1996). Each of these three functions is addressed here: The first study (Chapter 2) explores the effects of jerky video in computer-mediated human communication. The second study (Chapter 4) compares a video of a human speaker with a computer-animated reproduction. The third study (Chapter 6) concerns a humanlike computer agent that is designed as a tool but is treated as a social actor.

In the three studies, the central humanlike representation becomes progressively more independent: computer-mediated person (Chapter 2), computer-animated double (Chapter 4), and autonomous agent (Chapter 6). This progression is informative because attitudes are affected by the degree of perceived human influence (Guadagno, Swinth, & Blascovich, 2011). The three studies also progress in immediacy from current (streaming video; Chapter 2) to the near future (computer-mediated telepresence; Chapter 4) and beyond (autonomous agents in society; Chapter 6).

This work begins by demonstrating an effect of degraded human realism on persuasion. In the first study (Chapter 2), variations in one aspect of realism, motion quality, affected evaluations of a persuasive message from a human expert. This study offers a novel source of arousal, which affects decision making (Ariely & Loewenstein,

2006; Kiesler & Mathog, 1968; Lang, Zhou, Schwartz, Bolls, & Potter, 2000; Martin, Hamilton, McKimmie, Terry, & Martin, 2007).

When used deliberately in television and film, jerky motion captures attention. However, it can be distracting in the movements of characters in digital video. To what extent does this kind of jerkiness influence message processing? Based on a limited-capacity model of message processing, jerky character motion was predicted to increase compliance to a persuasive message. The present experiment manipulated the jerkiness of an actor's movements in a computer-delivered video to examine its effect on responses to a hypothetical medical scenario. Jerkiness, whether subtle or obvious, increased self-reported compliance. Subtle jerkiness decreased heart rate, indicating attentional mediation. Though counterintuitive, these findings indicate that jerky character motion can make computer-mediated messages more persuasive.

TWO: JERKY MOTION CAN MAKE PERSUASIVE MESSAGES MORE EFFECTIVE

In contemporary film and television, jerky motion is used to catch an audience's attention, for example, to maintain interest despite environmental distractions (Bordwell, 2002; Cutting, Brunick, DeLong, Iricinschi, & Candan, 2011; Cutting, DeLong, & Nothelfer, 2010; DeLong, Brunick, & Cutting, 2012). Three prominent types of jerky motion are abrupt reframing, rapid cuts, and actors' idiosyncratic movement. Reframing is performed most often during handheld recording, whereas rapid cuts (i.e., discontinuous camera view changes) are added during postproduction editing. Occasionally, jerkiness is added to actors' movements (e.g., Max Headroom). However, when jerky motion is applied inexpertly or too often, it may cause queasiness and decrease how accurately scenes are recognized (Bordwell, 2007; Ebert, 2007; Garsoffky, Huff, & Schwan, 2007).

Because the production and distribution of online digital media is cheaper and easier than film and television, its technical quality varies considerably. As a result, jerky motion occurs more frequently in online videos, especially in actors' movements. When it occurs, it is more likely to be considered an unintended technical flaw (Hilderbrand, 2007).[1] This makes it more difficult to interpret the intention behind jerky motion. For example, when a video on YouTube is shaky, the video's creator may be perceived as either an amateur or one unconcerned with steady framing. Jerky motion may be

[1] Examples of intentional digital distortion exist under names like glitch art and datamoshing (Brown & Kutty, 2012; Menkman, 2011).

introduced during filming, postproduction (including editing and encoding), and presentation (e.g., a viewer's network connection speed and hardware capabilities; Hartsell & Yuen, 2006; He & Gupta, 2001; Shephard, Ottewill, Phillips, & Collier, 2003).

Jerkiness also affects the perceived quality of online computer games. For example, massively multiplayer online role-playing games and online first-person shooter games rely on frequent and timely updates of players' positions and movements. Without these updates such games may behave erratically. As a result players' digital representations—their avatars—may move less smoothly or even unrealistically, decreasing players' effectiveness and enjoyment (Claypool, Claypool, & Damaa, 2006). In both online video and online gaming, jerkiness may be caused by technology that is buggy, outdated, or both. Therefore, in online digital content, jerky motion is common and often beyond the producer's control.

The potential effect of jerky motion on human cognition in processing mediated messages is significant because of the role of animated motion in computer-mediated communication and human–computer interaction. An increasing number of computer interfaces use conversations as a metaphor for interaction. These interfaces elicit behavior ordinarily directed toward other people (Nass, Steuer, & Tauber, 1994; Reeves & Nass, 1996; Sproull, Subramani, Kiesler, Walker, & Waters, 1996). Nevertheless, interacting with social interfaces as if they are humans need not imply a belief that the interfaces *are* human (Mitchell, Ho, Patel, & MacDorman, 2011; Tourangeau, Couper, & Steiger, 2003). Conversation-based computer interfaces also facilitate learning by promoting cognition (Mayer, 2005). Sometimes, conversation-based interfaces are not merely applicable but ideal. They may, for example, support interaction when users can neither read nor type

(Nass & Lee, 2001). Human-looking interfaces extend the conversation metaphor of human–computer interaction through graphical embodiment (Cassell, Sullivan, Prevost, & Churchill, 2000). Human-looking interfaces have advanced knowledge in scientific fields including pedagogy and social and cognitive science research (Baylor, 2002; MacDorman & Ishiguro, 2006b). Practical benefits of human-looking interfaces include the treatment of social anxiety, the facilitation of remote learning, and the motivation of regular physical exercise (Bailenson et al., 2008; Fox & Bailenson, 2009; Kang & Gratch, 2010). Such promise has already inspired the delivery of educational material using avatars in multiuser game environments (De Lucia, Francese, Passero, & Tortora, 2009; A. L. Foster, 2007).

Human-looking interfaces could support decision-making tasks in medicine and other restricted domains. For example, computer medical expert systems can produce desirable patient outcomes (Bennett & Hauser, 2013; International Business Machines Corp., 2013; Lin, Lin, Lin, & Yang, 2009; Yu et al., 1979). Human-looking interfaces could make expert systems more accessible to professionals and to ordinary users. For example, patients may feel less apprehensive when seeking medical advice from a virtual clinician than from a human clinician (Bickmore, Pfeifer, & Jack, 2009; Lisetti, Yasavur, Visser, & Rishe, 2011). Elsewhere, animated agents and avatars have been found useful as aids in real-time 3D visualization and virtual shopping (K. C. Lee & Chung, 2005, 2008; Stock et al., 2008).

Social responses may be strongest to computer interfaces that most closely emulate human appearance and behavior (Cassell, Bickmore, Campbell, Vilhjálmsson, & Yan, 2001; Cassell & Tartaro, 2007; MacDorman & Ishiguro, 2006b). However, early

research suggests such virtual encounters will also become more complicated. Specifically, as the interface becomes more humanlike, the interaction, consultation, or educational outcome may depend more on presentational factors like appearance, at least initially (Garau et al., 2003; Holzwarth et al., 2006; Keeling, McGoldrick, & Beatty, 2010; Luo, McGoldrick, Beatty, & Keeling, 2006; MacDorman & Ishiguro, 2006b; Nowak & Biocca, 2003). Depending on how human likeness is achieved, it can both enhance and hinder acceptance of the interaction (Ho, MacDorman, & Pramono, 2008; MacDorman, Green, Ho, & Koch, 2009). Despite this variability, little formal scrutiny has been given to the perception of moving images (Smith, Levin, & Cutting, 2012), let alone attitudes about animated virtual humans (MacDorman, Coram, Ho, & Patel, 2010). In summary, given the prevalence of jerky motion in online digital media, the potential difficulty of controlling jerkiness, its importance to human–computer interaction, and the relative lack of pertinent empirical data, an investigation of its influence on communication is warranted.

Gaining Compliance With Jerky Movement

Automatic Responses to Jerky Movement

Rapid cuts, unsteady cameras, and the motion of onscreen objects can attract media viewers' attention automatically (Detenber, Simons, & Bennett, 1998; Hitchon, Duckler, & Thorson, 1994; Lang et al., 2000). This effect goes mostly unnoticed when viewers are focused on the corresponding narrative (Bordwell, 1984; Saito & Yuka, 2007; Smith & Henderson, 2008). In online digital media, attention is also attracted through animated and pop-up advertisements on websites (Chung, 2007; Diao & Sundar, 2004; Lang, Borse, Wise, & David, 2002).

According to the limited capacity model of motivated mediated message processing (LC4MP; Lang, 2000; 2009), the effect of visual novelty on attention is mediated by an automatic action known as the orienting response, which is believed to facilitate discovery and learning (Sokolov, 1963). An assumption of the present research is that an orienting response is also elicited when perceiving nonhuman jerky motion in a human figure. Biological and nonbiological motion elicit different patterns of brain activity, which cannot be explained merely by motion complexity (Grossman & Blake, 2002; Pelphrey et al., 2003). The ability to recognize human motion is particularly well refined, owing to its usefulness in making inferences about others' intentions (Blake & Shiffrar, 2007; Blakemore & Decety, 2001).

The orienting response can be measured reliably. One physical indicator of an orienting response is bradycardia, a temporary deceleration in heart rate (Graham & Clifton, 1966; Lang, Geiger, Strickwerda, & Sumner, 1993). An evolutionary explanation of bradycardia is that it facilitates homeostasis while deciding how to react to a novel

stimulus (Campbell, Wood, & McBride, 1997). Bradycardia during media viewing is caused by an increase in regulatory influence of the parasympathetic nervous system relative to the deregulatory influence of the sympathetic nervous system (Lang, 2009; Lang, Bolls, Potter, & Kawahara, 1999; Quigley & Berntson, 1990; Richards & Casey, 1991). A related indicator of the orienting response is heart rate variability, which decreases during stressful activity (Delaney & Brodie, 2000). In many experiments a decrease in heart rate variability suggests an increase in cognitive effort (reviewed in Lang, Potter, & Bolls, 2009), though it may be more indicative of emotional strain (Nickel & Nachreiner, 2003).

Another set of indicators of the orienting response involves changes in the electrical conductance of skin (electrodermal activity), which varies with activation of the sympathetic nervous system (Lang et al., 1999). Measurement of skin conductance is divided further into measurement of tonic activity and measurement of phasic activity (R. M. Stern, Ray, & Quigley, 2001). Increases in tonic activity, measured using the skin conductance level, indicate autonomic arousal (Jacobs et al., 1994). Phasic activity is measured using the frequency of brief spikes in the conductance level, termed skin conductance responses. Although skin conductance responses may be pegged to the precise onset of one or more stimuli, the frequency of nonspecific skin conductance responses also varies with cognitive effort (Nikula, 1991).

Influence of Orienting on Automatic Resource Allocation and Attitude Formation

The orienting response elicited by rapid cuts causes changes in heart activity and skin conductance, which in turn predict increases in attention and physiological arousal, respectively (Lang et al., 2009). These changes affect how messages are processed:

Although rapid cuts increase the overall processing of message-related information, they also increase the retention of unrelated information (Bolls, Muehling, & Yoon, 2003; Lang et al., 2009). Both kinds of information can affect attitude formation (Petty, Cacioppo, & Schumann, 1983).

Applying the Limited Capacity Model to Jerky Motion in a Digital Medium

Aligning with LC4MP (Lang, 2000; 2009), the present study tested the extent to which jerky character motion increases attention and arousal and in turn increases compliance with an expert's recommendation:

Mediating effect of attention. Jerky character motion may increase attention to a message by evoking greater activity of the parasympathetic nervous system relative to the sympathetic nervous system. Hypothesis 1 (H1) asserts that viewing digital video with jerky motion temporarily decreases viewers' heart rate (HR). Hypothesis 2 (H2) asserts that viewing digital video with jerky motion temporarily decreases viewers' heart rate variability (HRV).

Mediating effect of arousal. Jerky character motion may increase arousal through activation of the sympathetic nervous system. Hypothesis 3 (H3) asserts that viewing digital video with jerky motion increases viewers' skin conductance level (SCL). Hypothesis 4 (H4) asserts that viewing digital video with jerky motion increases the short-term frequency of skin conductance responses (SCR).

Compliance. When an expert's recommendation is supported by information that is both claim-relevant (e.g., high-quality arguments) and claim-irrelevant (e.g., physical appearance), and when the video of the expert is jerky, both central- and peripheral-route processing are expected to produce a similar outcome: Viewers' compliance with the

recommendation is predicted to increase. Hypothesis 5 (H5) asserts that viewing digital video with jerky motion increases self-reported agreement with actions derived from an expert's recommendation.

Method

A laboratory experiment was designed to examine the effects of jerky motion in a persuasive message. The experiment varied the jerkiness of the message delivery medium and measured its effects on both self-reported behavior (i.e., compliance with the message and perceptions of the source) and physiological behavior (i.e., heart rate, heart rate variance, skin conductance level, and skin conductance response events).

Participant Characteristics and Sampling

Participants were 76 students and staff (70% female) of a Mid-Atlantic U.S. university recruited for either course credit or a $10 cash payment. Participants' ages were 18–55 years (*Mdn* = 20.2).

Research Design

The present between-groups experiment included both pretest and posttest measurement of physiological behavior and posttest-only measurement of self-reported behavior. There was one independent variable, jerkiness, with three levels.

Experimental Manipulation

Participants viewed a video clip involving a scenario about a dilemma in medical ethics (MacDorman et al., 2010). In the scenario the participant takes the role of a family physician. The participant learns about a woman who contracted genital herpes from a recent extramarital affair. The participant is asked by the woman to delay disclosing this news to her husband, who is also one of the participant's patients. In the clip, a fictional ethicist named Dr. Richard Clark gives several reasons supporting immediate disclosure (Appendix A). The ethicist closes by urging the observer to tell the husband about his wife's diagnosis.

The experimental manipulation of jerkiness affected the clip's sequence of video frames. The manipulation generated three treatment conditions: *normal*, *subtly jerky*, and *obviously jerky*. In the normal condition, the frame sequence was unmodified. In the subtly jerky condition, the frame sequence was manipulated at regular intervals (approximately twice per second) by replacing two video frames with the preceding two frames, except when doing so would have made a noticeable discontinuity in the ethicist's movements. In the obviously jerky condition, the frame sequence was manipulated in the same places, but seven video frames were replaced by the preceding seven. Across all three conditions, the audio tracks were identical, and the video played at 29.97 frames per second.

Dependent Variables and Covariates

Physiological measures. Participants' electrocardial and electrodermal activity were measured before and during the video clip. Participants had electrodes attached to both ankles, one wrist, and two fingers (Venables & Christie, 1973). Data were collected at a sample rate of 200 Hz using a Biopac physiological data collection unit (Biopac Systems Inc.). To obtain a baseline reading before the clip, data were collected for approximately 30 s. Following a pause, recording resumed at the beginning of the video clip and continued for the duration of the 53-s clip.

Because HRV studies usually involve measurement periods exceeding one minute, the present study required short-term HRV measures that were robust against outliers. The initial measures chosen were pNN20[2] (proportion of interbeat intervals

[2] This measure is seen more often with the threshold at 50 ms (pNN50). However, a shorter threshold of 20 ms was used here to increase sensitivity.

exceeding 20 ms) and RMSSD (the square root of the mean squared difference of successive beat intervals (Mietus, Peng, Henry, Goldsmith, & Goldberger, 2002; Stein, Bosner, Kleiger, & Conger, 1994). These are among the most common time-domain measures of HRV. Although the recommended measure in typical studies is RMSSD, and RMSSD is correlated with pNN50, pNN20 was retained because of its improved resistance to outliers (Kleiger et al., 1991; Mietus, 2006; Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). Both RMSSD and—to a lesser extent—pNN50 have been used in recording periods of approximately five minutes (Salahuddin, Cho, Jeong, & Kim, 2007; Tarkiainen et al., 2005).

Self-report measures. After viewing the clip, participants completed four self-report items. The first two items were questions assessing compliance with the persuasive message. The possible responses to these two items were *Definitely Not*, *Probably Not*, *Unsure*, *Probably*, and *Definitely*: (1) "When you meet Paul Gordon tomorrow, will you inform him of his exposure to genital herpes?" and (2) "If Paul Gordon has genital herpes, will you inform him that Kelly Gordon is the likely source?" Maintaining consistency with previous work (MacDorman et al., 2010), these items were operationalized as a two-level measure of compliance: Positive responses to the first item (informing the husband of his potential exposure) represented a greater degree of compliance than comparably positive responses to the second item (notifying the husband of the likely source of infection). The other two self-report items briefly tested the assumptions about source and message credibility. The possible responses to these two items were Not at All True, Somewhat Untrue, Neither True nor Untrue, Somewhat True,

and Very True: (3) “I trust Dr. Clark’s expertise in this matter” and (4) “I don’t understand why Dr. Clark would make the recommendation he did” (for which scoring was reversed).

Procedure

Because study sessions could accommodate up to two participants per session, participants took part in the study in groups of one or two depending on session enrollment and attendance. After entering the lab, participants completed a pretest questionnaire, electrodes were attached for collection of physiological data, and baseline measures of heart rate and skin conductance were recorded. After the baseline measures, participants read a written introduction to the medical ethics dilemma scenario and viewed the video clip on a 48-inch plasma display at a distance of approximately 3–4 feet while physiological data were recorded. After the clip, the electrodes were removed, a posttest questionnaire was administered, and participants were thanked, debriefed, and dismissed.

Results

Statistical Methods

Test statistics were interpreted with a significance level of $\alpha = .05$. Following Cramer and Bock (1966), to guard against Type I error inflation from multiple comparisons, MANCOVA was performed before individual ANCOVAs.

Preparation of Data

Electrocardial activity. Electrocardiogram data were filtered using a bandpass between 0.5 Hz and 35 Hz (Ruha, Sallinen, & Nissilä, 1997). Recording error led to dropping two cases: one in the subtly jerky condition, and one in the obviously jerky condition. Heartbeats and interbeat intervals were obtained using the QRS peak detector in *AcqKnowledge* 4.2 (Biopac Systems Inc.). Next, filtering and calculation of the time-domain HRV measures was performed using the *HRV Toolkit* (Goldberger et al., 2000). Interbeat intervals were excluded when exceeding at least one of two bounds: a fixed range of 0.4 to 2.0 s and ±20% of a rolling mean of ±5 intervals.[3] This process yielded the three values to be tested: average time between normal heartbeats (AVNN), RMSSD, and pNN20.

Electrodermal activity. Using *AcqKnowledge,* SCR events were tagged using a first-pass detection threshold of 0.02 μS and a second-pass rejection threshold of 10% of the subject's largest peak (Kim, Bang, & Kim, 2004). Low signal–noise ratio forced the dropping of six cases: two in the smooth condition, one in the subtly jerky condition, and three in the obviously jerky condition.

[3] This is a sliding window average filter with window size $2N+1$ (Mietus, 2006). To limit the loss of data at the beginning and end of each recording, $N = 5$.

Preparation of self-report data. Responses from all 76 participants were included. Both the normal and subtly jerky conditions had 24 participants, and the obviously jerky condition had 28 participants.

Analysis of Physiological Data (H1–H4)

To account for physiological differences among participants, baseline (pretest) measurements of HR (in beats per minute) and SCL were included as covariates in separate MANCOVAs. Before doing so, one-way ANOVAs were conducted to test the assumption that baseline values were not significantly different among groups. This assumption was supported for both measures: baseline HR $F(2, 71) = 0.29$, $p = .75$; baseline SCL $F(2, 67) = 0.15$, $p = .87$.

HR decreased if another participant was present, $t(72) = 2.46$, $p = .016$, Cohen's $d = 0.75$. To account for its calming effect, the presence of another participant was coded as a binary value (Proximity) and included in the analyses of physiological data.

Electrocardial activity. MANCOVA was conducted with jerkiness as the independent variable, baseline HR and Proximity as covariates, and AVNN, RMSSD, and pNN20 as dependent variables. After controlling for the covariates, the multivariate effect of jerkiness was significant, Pillai's trace = 0.18, $F(6, 136) = 2.18$, $p = .049$. Before conducting individual ANCOVAs, the assumption of homogeneity of variance was tested for all three measures of electrocardial activity. A series of Levene's F tests indicated the homogeneity of variance assumption was tenable; of the three tests, the maximum $F(2, 71) = 1.43$, $p = .25$.

Heart rate. After accounting for baseline HR and proximity, although jerkiness had a significant effect on AVNN, $F(2, 69) = 4.89$, $p = .010$, $\eta_p^2 = .12$, the pattern was

inconsistent. AVNN was least (i.e., HR was greatest) in the subtly jerky condition (M = 0.728 s, SE = 0.008 s) and comparable between the normal and obviously jerky conditions (normal M = 0.754 s, SE = 0.008 s; obviously jerky M = 0.762 s, SE = 0.008 s). These results failed to support Hypothesis 1, which asserted a decrease in HR from jerkiness.

Heart rate variability. After controlling for baseline HR and proximity, the effect of jerkiness on RMSSD and pNN20 was nonsignificant, RMSSD $F(2, 69) = 1.94$, $p = .152$; pNN20 $F(2, 69) = 1.61$, $p = .208$. These results gave insufficient support to Hypothesis 2, which asserted a decrease in HRV from jerkiness.

Electrodermal activity. Following the pattern for electrocardial activity, MANCOVA was conducted with jerkiness as the independent variable, pretest SCL and Proximity as covariates, and SCL and SCR as dependent variables. The multivariate effect of jerkiness was not statistically significant, Pillai's trace = .05, $F(4, 138) = 0.86$, $p = .492$. This nonsignificant result precluded the need for further tests and failed to support Hypotheses 3 and 4.

Analysis of Self-Reported Data (H5)

Decisions about the dilemma. Participants' overall responses were mixed: first item (intent to inform the husband of his exposure to herpes; range 1–5 with 5 indicating "definitely inform") M = 3.33, SD = 1.34; second item (intent to inform the husband that his wife is the likely source if he tests positive; same range and interpretation as the previous item) M = 2.74, SD = 1.27. Although females' responses were slightly more in favor of disclosure, the differences were not statistically significant; first item U = 491.5,

p = .17; second item U = 538.5, p = .41. For this reason gender was not included in subsequent tests.

One-way ANOVAs were conducted to test whether at least one mean difference existed among the three levels of jerkiness (normal, subtly jerky, and obviously jerky) on the two items indicating compliance. Although jerkiness had no significant effect on the first item, intent to inform the husband of his exposure to herpes, $F(2, 73) = 1.70$, p = .19, ω^2 = .02, it had a significant effect on the second item, intent to inform the husband that his wife is the likely source if he tests positive, $F(2, 73) = 3.81$, p = .03, ω^2 = .07. Intent to reveal the likely source was similar between the subtly jerky (M = 3.00, SE = 0.25) and obviously jerky treatment groups (M = 3.00, SE = 0.23), and lower in the normal treatment group (M = 2.17, SE = 0.25). These responses partially supported Hypothesis 5, which predicted an increase in compliance from jerkiness.

Assessments of source credibility. The ethicist was described as a somewhat credible source: on the first item, M = 3.79 (range 1–5 with 5 indicating “very true”), SD = 0.99; on the second item (same range and interpretation as the previous item), M = 3.74, SD = 1.38. The correlation between these items was large, Pearson’s r = .54, p < .001. These two assessments of the ethicist’s credibility were not significantly affected by jerkiness, first item F = 0.51, p = .60, second item F = 0.73, p = .48.

Discussion and Conclusion

Through a controlled experiment, the present study found a medium increase in self-reported compliance with an onscreen expert's recommendation when the expert's movements were jerky. Even though self-reported perceptions of the source's credibility did not vary significantly across conditions, both jerky motion conditions elicited greater scores than the normal condition for one indicator of compliance. Therefore, jerky motion not only increased the effectiveness of the message, it did so without influencing reported source credibility, and it required only minor manipulation of the original clip.

The study also found statistically significant effects of jerky motion on heart rate. However, the corresponding effects on skin conductivity were not found. Two likely causes are the short duration of the treatment and habituation to the jerky movements, even though the clip contained nearly 50 instances of jerky movement, and the jerkiness was applied at irregular intervals. The lack of consistent physiological effects reinforces the notion that the links among attention, arousal, and compliance are complex.

Prior research on this topic has been inconclusive. Research supporting a model of technology as social actors suggests technical flaws cause negative evaluations of message sources (Nass & Brave, 2007; Nass & Moon, 2000; Nass et al., 1994; Nass & Yen, 2010; Reeves & Nass, 1996), whereas research supporting a limited-capacity model of resource allocation and message encoding suggest such flaws motivate increased message retention (Diemand-Yauman, Oppenheimer, & Vaughan, 2011; Lang et al., 1999, 2000; Lang, 2000). The current study more closely supports the latter set of findings.

The present study is novel in two ways: Its experimental manipulation is a common yet understudied artifact of online digital media, jerky motion, and its results

support an alternative explanation of related findings (MacDorman et al., 2010; Reeves & Voelker, 1993). Instead of detracting from a message's claims, technical flaws may increase its persuasiveness if attitudes about the source are otherwise positive and if the flaws appear unrelated to the source. The first of these two conditions may be satisfied by an authority heuristic (Koh & Sundar, 2010); the second may be satisfied by making salient the means of message delivery (e.g., streaming video over a wireless Internet connection).

Limitations

First, the strongest effects of the orienting response on heart rate occur just after stimulus delivery (Graham & Clifton, 1966; Lang et al., 1993). However, to measure the effect of this initial response, the jerkiness manipulation would need to be restricted to the first seconds of the clip. Second, because physiological data were collected concurrent with playback of the clip, events taking place immediately before and after the clip were not recorded. Third, because the onsets of jerky movements were not marked in participants' recordings, the frequency of event-specific SCRs (i.e., SCRs appearing 1–5 s after each jerky movement) could not be measured.

Future Work

In determining possible facilitators of compliance, the current study focused on two physiological indicators of the orienting response: heart activity and skin electrical conductivity. Nevertheless, the present between-subjects experimental design permits measuring other potentially relevant factors, including current mood, pre- and post-treatment confidence in the decisions, and awareness of the experimental manipulation (Maheswaran & Chaiken, 1991; J. D. Mayer & Gaschke, 1988; Reeves & Voelker, 1993).

Furthermore, the precision of measuring related outcomes could be increased, including attention to claims (i.e., operationalized as retention of relevant message details), and opinions about the message source's warmth (or trustworthiness), competence, and degree of goodwill (Fiske, Cuddy, & Glick, 2007; McCroskey & Teven, 1999). By distinguishing between attitudes about the message and attitudes about the source, future studies may determine the extent to which these two factors mediate the effects of jerky motion on persuasion.

Another potential line of research involves conceptual replication, including replacing the dilemma in medical ethics with a dilemma in another situation, replacing the human advisor with a clearly computer-controlled agent, or replacing the single-judgment paradigm with a team-building exercise (Lafferty, Eady, & Pond, 1974; Nass, Fogg, & Moon, 1996). Last, the significant influence of pretest arousal on the present results suggests a deeper investigation of individual differences predicting susceptibility to the persuasive effects of jerky motion.

THREE: INTRODUCING THE EXPERT'S AVATAR AND SYSTEMATICALLY DECREASING ITS REALISM

Chapter 2 indicated that jerky motion is perceptible, and it increases the persuasiveness of a credible-looking human adviser. However, the study's statistical power was low, in part because responses to the dilemma varied greatly. The effect of the adviser's jerky motion may have been amplified by the use of a large television screen (Reeves, Lang, Kim, & Tatar, 1999). A control condition for the adviser's message would have identified an acquiescence bias but was not included. While following the previous study's theme, the subsequent study addressed these issues and examined more potential explanatory factors, including credibility.

In persistent virtual worlds, avatars' physical appearances and clothing styles can be heavily customized, sometimes using assets generated directly by users (Bardzell & Bardzell, 2008; Bell, 2008; Schroeder, 2008). However, it is not always clear how a particular set of customizations will be perceived. In addition, professional fields like medicine, law, and emergency response are using simulated human interfaces (Heinrichs, Youngblood, Harter, & Dev, 2008; Hill, 2008; Toro-Troconis, Meeran, Higham, Mellström, & Partridge, 2010). Thus, a central concern in implementing human-looking computer interfaces is that inconsistent levels of human likeness may increase the variability or change the outcome of unrelated decisions.

Just as physical appearance affects persuasion and compliance in human communication, it may also affect the processing of advice conveyed through avatars, computer-animated characters, and other interfaces. Although the most persuasive computer interfaces are often the most humanlike, they incur the greatest risk of falling

into the uncanny valley, the loss of empathy associated with eerily human characters. Previous studies have compared interfaces on the left side of the uncanny valley, namely, those with low human likeness. To examine interfaces with higher human realism, a between-groups factorial experiment was conducted through the Internet with 426 Midwestern US undergraduates. This experiment presented a hypothetical ethical dilemma followed by the advice of an authority figure. The authority was manipulated in three ways: depiction (digitally recorded or computer animated), motion quality (smooth or jerky), and recommendation (disclose or refrain from disclosing sensitive information). Of these, only the recommendation changed opinion about the ethical dilemma, even though the animated depiction was significantly eerier than the human depiction. These results indicate that compliance with an authority persists even when using an uncannily realistic computer-animated double.

FOUR: COMPLIANCE WITH AUTHORITY PERSISTS DESPITE THE UNCANNY VALLEY

Both human–computer and human–human interaction can be mediated by human-looking computer interfaces, which include avatars (sometimes called virtual humans) and embodied conversational agents (Ahn, Fox, & Bailenson, 2012; Bailenson & Blascovich, 2004; Cassell et al., 2000). For both our real and virtual selves, self-perception and behavior are often related. For example, real-life inferences of dominance are made using physical factors like height and facial attractiveness; these factors exert similar effects in shared virtual environments (Yee & Bailenson, 2007). Conversely, systematic changes to one's virtual representation can affect real-life actions (Fox & Bailenson, 2009; Yee, Bailenson, & Ducheneaut, 2009).

Perhaps owing to our expertise in human communication, virtual representations of others can influence our own behavior. The mere inclusion of computer-animated humans affects decisions about classic hypothetical dilemmas (Patil, Cogoni, Zangrando, Chittaro, & Silani, 2014). In the multiplayer virtual world Second Life, real-life social norms involving interpersonal distance and eye contact occur naturally (Yee, Bailenson, Urbanek, Chang, & Merget, 2007). The apparent gender and ethnicity of a student's Second Life avatar sway teachers' initial evaluations of the student's intelligence and attitudes toward school (Beck, 2012). Outside Second Life, the presence of virtual humans strengthens interventions for conditions like social anxiety and autism spectrum disorder (Kandalaft, Didehbani, Krawczyk, Allen, & Chapman, 2013; Kang & Gratch, 2010). The efficacy of these virtual interventions relies on the extent to which the

humanlike representations persuade users toward desired outcomes. This in turn may depend at least partially on their appearance (Baylor, 2009).

Visual representation of others improves the efficiency of information transfer, and nonverbal gestures make messages more persuasive (Boyle, Anderson, & Newlands, 1994; Cesario & Higgins, 2008). The real-life impact of nonverbal communication has been studied extensively with respect to topics ranging from classroom learning to first impressions of teachers and surgeons (e.g., Ambady & Rosenthal, 1993; Ambady et al., 2002; S. W. Cook, Duffy, & Fenn, 2013). The most realistic human representations may be the most persuasive (Bailenson & Yee, 2005; Blascovich et al., 2002). However, experimentally controlled comparisons tend to use less humanlike interfaces, like text-based conversation partners and stylized or cartoonish human characters (e.g., Galanxhi & Nah, 2007; Holzwarth et al., 2006; Khan & Sutcliffe, 2014). Results of these comparisons are mixed. For example, although nonmoving human-looking characters are perceived as more credible than nonmoving abstract-looking characters, abstract-looking avatars elicit greater self-disclosure than their human controllers (Bailenson, Yee, Merget, & Schroeder, 2006; Nowak & Rauh, 2008). Computer characters can be more persuasive than a real person while simultaneously being perceived as less credible (J. K. Burgoon et al., 2000). Abstract-looking characters can be perceived as more credible and more socially attractive than somewhat human-looking characters (Nowak, 2004). Comparisons using realistic human characters are rarer; these comparisons found conflicts between subjective and objective measures (Raij et al., 2007), left uncontrolled visual differences between the human and the virtual double (Kang & Watt, 2013; MacDorman et al., 2010), traded visual realism for real-time interactivity (Kang &

Gratch, 2010), or withheld from comparison a human reference (McDonnell, Breidt, & Bülthoff, 2012).

Higher levels of human realism usually require more complex three-dimensional computer models and greater texture detail. However, when the human interface is delivered through a computer network, the network serves as a practical constraint for both model complexity and texture detail. Failure to match the levels of human realism of a given character's features may violate observers' expectations, thus making the character eerie or less liked (Hodgins, Jörg, O'Sullivan, Park, & Mahler, 2010; MacDorman, Green, et al., 2009; Mitchell, Szerszen, et al., 2011). A character that looks human but violates our expectations of how a real person should look or behave is said to inhabit the uncanny valley; Mori (1970/2012) compares it with a corpse or the undead. Further complicating matters, the effects of these presentational factors is mediated by whether observers believe the character is acting autonomously or is controlled by a person (Guadagno et al., 2011). In the latter case, it is unknown whether a realistic representation of an identifiable person would be more or less persuasive than the actual person.

For conveying nonverbal information, another factor at least as important as a humanlike character's level of detail is the quality of its motion (Ehrlich, Schiano, & Sheridan, 2000; Weyers, Mühlberger, Hefele, & Pauli, 2006). Like the level of detail, motion quality is limited by the reliability of the network. Delays can cause jerky motion in facial expressions and other gestures. The net effect of jerky motion on behavior is likely to be mediated by the observer's own traits (MacDorman et al., 2010; MacDorman & Entezari, 2015).

In summary, persuasive communication involving realistic virtual humans may be affected in unknown ways by the underlying technology. This potential problem fits in a broader discussion about persuasive technology (Fogg, 1998, 2003) in areas like telepresence, economics, and decision support. Both avatars in a shared virtual space and human-looking agents on websites increase the flexibility of teleconferences and instructional lectures. In marketplace settings, virtual embodiment may affect the decisions of consumers and sellers (Bélisle & Bodur, 2010; Keeling et al., 2010; Oullier & Basso, 2010; Wood, Solomon, & Englis, 2005). As artificial intelligence is used to deliver health-related advice to patients, like whether to undergo a medical procedure, virtual healthcare providers could recommend efficiently and convincingly a particular course of action (Bickmore, Gruber, & Picard, 2005).

In all these cases, presentational factors supporting the credibility of a human source may likewise support the credibility of a computer-animated double. Intentionally manipulating or failing to account for the effects of such presentational factors may be unethical (Brey, 1999). Consequently, the purpose of this research is to identify the mechanisms affecting the processing of persuasive messages from identifiable virtual humans. In this chapter two mechanisms are proposed to predict differences in persuasiveness between a virtual human and the recording of a real human on which it is modeled. These mechanisms are derived from potential explanations of uncanny valley responses.

The corresponding predictions were tested in an online experiment. The experiment's results indicate that, although an animated representation seems eerier and less human, this uncanny valley effect does not decrease the representation's

persuasiveness—at least when the representation is presented as an authority. Compliance was high for both the recorded and the animated representation.

Besides addressing a knowledge gap in computer-mediated communication, the experiment's results raise ethical concerns about identity misuse and social influence in virtual environments. A person's virtual double could be created without his or her knowledge or consent, and such a double could be used to manipulate the behavior of others. In the Discussion and Conclusion, the results are interpreted further, and subsequent research and applications are suggested.

Background

Both physical and virtual representations of humans vary on three main dimensions of realism: behavior, form, and interactivity (Bailenson et al., 2006). Within this three-dimensional space, an example of a virtual representation with high behavioral realism, high form realism, and no interactivity is a recorded video of human actors. Such a recording can serve as a direct reference for a second kind of virtual representation: a computer animation. Although these representations are not necessarily identical, both maintain high behavioral and form realism while lacking interactivity. Because these two representations resemble television programming, the most relevant literature involves persuasion in advertising and other forms of mass communication. Common factors in this domain are the *source*, *message*, *channel*, *receiver*, and *destination* (McGuire, 2001).

This study focuses on the first factor, the source. Traditionally, sources are perceived on three main traits: power, credibility, and attractiveness (McGuire, 2001). We accentuate these three traits to make a recording and a matching animation persuasive. Applying the threshold model of social influence in virtual environments, both a recorded person and matching animation are assumed to exert at least some social influence (Blascovich et al., 2002). Persuasiveness is increased through perceived power and credibility by making the source's expertise salient (Wilson & Sherrell, 1993). Persuasiveness is also increased through perceived attractiveness by dressing an attractive model in professional clothing (Bassett, Staton-Spicer, & Whitehead, 1979).

A source's persuasiveness can be increased indirectly by manipulating the message (Pornpitakpan, 2004). For an already credible source like the one devised for this study, two key manipulations are early self-identification and the presentation of

strong arguments (Bohner, Ruder, & Erb, 2002; Homer & Kahle, 1990; Mills & Harvey, 1972). Hence, through both direct and indirect manipulations, both a recording of a person and that person's computer-animated double are assumed to be persuasive. Differences in persuasiveness between these two human representations, then, may depend on how receivers interpret differences in visual depiction.

Responses to Uncanny Representations

Research on the uncanny valley has covered variations on the same basic claim: Nonhuman features in more realistic human characters are disproportionately unsettling as compared with less realistic characters (MacDorman, Green, et al., 2009; Mori, 1970/2012; Seyama & Nagayama, 2007). Characters in the uncanny valley most commonly elicit feelings of fear, anxiety, shock, and disgust (Ho et al., 2008). However, a consensus has not been reached on what causes these feelings. Some explanations of uncanny valley responses are based more in perception, whereas other explanations are based more in cognition (MacDorman, Green, et al., 2009). Two perceptual explanations for the uncanny valley are self-preservation and tension arising from features belonging to different kinds of entities (MacDorman, Green, et al., 2009; Moore, 2012); two cognitive explanations are that uncanny characters serve as reminders of personal mortality and are a source of cognitive dissonance (MacDorman & Entezari, 2015; MacDorman & Ishiguro, 2006b; MacDorman, Vasudevan, & Ho, 2009; Tondu & Bardou, 2011). Applying these explanations to realistic computer-mediated human representations produces two seemingly opposing interpretations.

One interpretation is that, owing to the visual and interpersonal nature of the medium, flaws in these representations are expected to affect perceptions of the message

source (Chaiken & Eagly, 1983; Pfau, 1990; Reeves & Nass, 1996; Reeves & Voelker, 1993; Sundar & Nass, 2000). Uncanny characters are less identifiably human, less attractive, and less relatable (Ho & MacDorman, 2010; MacDorman, Green, et al., 2009). Generally, unattractive and unrelatable sources are less persuasive (Chaiken, 1979; MacKie, Gastardo-Conaco, & Skelly, 1992; McGarty, Haslam, Hutchinson, & Turner, 1994). If an uncanny representation resembles a conspecific with a contagious illness, likely responses include fear and disgust to motivate pathogen avoidance (Curtis, Aunger, & Rabie, 2004; Fessler & Navarrete, 2005; Ho et al., 2008; MacDorman, Green, et al., 2009; MacDorman & Ishiguro, 2006b; Moosa & Ud-Dean, 2010). These responses are measured indirectly through subjective increases in eeriness and decreases in attractiveness (MacDorman & Entezari, 2015), and they are stronger in people with high sensitivity to disgusting stimuli (Haidt, McCauley, & Rozin, 1994; Olatunji et al., 2007).

Another mechanism by which uncanny representations may cause aversion is as reminders of death's inevitability (MacDorman & Ishiguro, 2006b). Even when presented indirectly or subliminally, such reminders evoke negative evaluation and treatment of outgroups (Arndt, Greenberg, Pyszczynski, & Solomon, 1997; Arndt, Vess, Cox, Goldenberg, & Lagle, 2009; Rosenblatt, Greenberg, Solomon, Pyszczynski, & Lyon, 1989). Susceptibility to these effects may be measured in terms of disgust sensitivity and degree of existential anxiety (Goldenberg et al., 2001).

An alternative interpretation predicts a positive effect of uncanny responses on message processing. Uncanny representations may fail to fit into people's existing conceptual order (Douglas, 1966; MacDorman & Entezari, 2015; MacDorman, Vasudevan, et al., 2009). However, the uncertainty created by such an incoherent entity

could increase overall motivation to seek new information, even when it contradicts current attitudes (Hernandez & Preston, 2013; Maheswaran & Chaiken, 1991). For a credible-looking source delivering a credible message, this leads to a counterintuitive proposal: Uncanny appearance may support persuasion and compliance. A preliminary test of this claim using recorded videos of a human actor indicated that jerky motion in fact increased agreement with a recommendation—and without hindering credibility (Chapter 2). Based on these competing proposals, the following hypotheses represent predictions about the perception of the speaker (Hypotheses 1–3) and the result of the persuasive appeal (Hypotheses 4–6).

Competing Effects on Source Assessment

We start with (and later support) an assumption that a computer-animated depiction is perceived as less human than the credible source from which it is derived. This sets up Hypotheses 1 and 2 (H1 and H2). H1 considers a direct effect of depiction on credibility: By decreasing similarity to the message recipient, a message source appears less credible as a computer animation than as a recording. H2 considers a direct effect of motion quality on credibility: By decreasing similarity to the message recipient, a message source appears less credible when moving jerkily than when moving naturally.

For Hypothesis 3 we start with another assumption: Jerky motion increases eeriness more for a computer depiction than a recorded depiction of a human actor because it is more likely to be attributed to the message source rather than its channel. Following dual-process models of attitude formation, eeriness could increase the motivation to process persuasive messages (Chaiken, 1980; Maheswaran & Chaiken, 1991; Petty & Cacioppo, 1986). This interpretation sets up Hypothesis 3A (H3A): If

eeriness increases attention to positive attributes, whether in the source or the message, a source with a humanlike appearance is more credible when it is moving jerkily and less credible when it is moving fluidly. However, through outgroup bias or disgust, eeriness could inhibit persuasion and compliance. An alternative explanation from self-preservation sets up Hypothesis 3B (H3B): If an uncanny valley elicits aversive responses, a source with a humanlike appearance is less credible when moving jerkily and more credible when moving fluidly.

Influence of Uncanny Message Sources on Persuasion and Compliance

Given possible changes to source credibility, what is the impact on persuasion? Aligning with H1 and H2 are Hypotheses 4 and 5 (H4 and H5). H4 asserts that by decreasing similarity to the message recipient, a message source is less persuasive when computer animated than when videotaped. H5 asserts that by decreasing similarity to the message recipient, a message source is less persuasive when moving jerkily than when moving fluidly.

Hypotheses 6A and 6B follow, respectively, from H3A and H3B. Hypothesis 6A (H6A) asserts that if eeriness increases elaboration, a computer-animated human message source is more persuasive when moving jerkily than when moving fluidly. Hypothesis 6B (H6B) asserts that if eeriness elicits an uncanny valley, a computer-animated human message source is less persuasive when moving jerkily than when moving fluidly.

Method

Like the preceding study (Chapter 2), this study used a hypothetical dilemma in medical ethics (Fleetwood et al., 2000; MacDorman et al., 2010). In this dilemma a patient reveals some potentially damaging information about her sexual history. Through a turn-based conversation, the patient asks her physician, the study participant, to withhold this information from her husband. However, the husband is also one of the physician's patients, and his health may be harmed by the withheld information. The husband has a scheduled routine examination with the physician the next day. Before this examination occurs, the physician must make several interrelated decisions about the dilemma.

Participant Characteristics and Sampling

The study's participants were current undergraduate students, age 18 or older, from the campuses of a public university system in the Midwestern US. The sample was drawn randomly from a list of students' university-sponsored email addresses. Recruitment used electronic mail containing a hyperlink to the experiment's website. Participation was unpaid and voluntary, and it took place at a time and location chosen independently by each participant. For this experiment 45,000 undergraduate students were invited with a response rate of 0.94%. Recruitment ended after all treatment groups had at least 20 completed sessions (J. P. Simmons, Nelson, & Simonsohn, 2011).

Research Design

The study used a factorial between-groups experimental design. Eight treatment groups were created from three 2-level factors (see Experimental Manipulation).[4] Each participant was assigned randomly to one of the treatment groups by the Web server.

Procedure

In making a decision on the ethical dilemma, the participant was asked to use personal judgment instead of knowledge of the law. The participant took the role of a family physician treating a young married couple, Paul and Kelly Gordon. The experiment began with a telephone conversation with Kelly. The conversation went through seven exchanges. In each exchange the participant selected one of four responses to continue the call. Kelly's statements were phrased so that they followed logically from any of the preceding responses. During the call, Kelly admitted contracting genital herpes from an extramarital affair. Kelly asked the participant as physician to withhold this information from Paul so that she can tell him herself. This request exposes a dilemma between two principles of medicine: doctor–patient confidentiality and avoidance of harm.

After the conversation with Kelly, participants made decisions related to Kelly's request (see *Decisions About the Case*). These decisions comprised the pretest measurements. Next, a video approximately one minute long was presented in which Dr.

[4] Additional groups were used to check for pretest sensitization effects on advice: The first group was the traditional pretest–treatment–posttest group; the second group had no pretest measurement; the third group had no treatment; and the fourth group had neither a pretest measurement nor a treatment (Solomon, 1949). Pretest × Treatment had no significant effect on Disclosure.

Richard Clark, an expert in medical ethics from a nearby university, gave a recommendation on the case.[5] The message was delivered without interaction in an emphatic yet professionally restrained tone. After Dr. Clark's advice, participants assessed Dr. Clark on several personality traits (see Attitudes about the Speaker). The experiment concluded with measurements of predicted covariates (see *Mediating processes and individual differences*). Among the covariates participants were asked to make their decisions about the case again. These comprised the posttest measurements.

Experimental Manipulation

Dr. Clark's brief presentation varied on three independent factors: depiction, motion quality, and advice. First, Dr. Clark was depicted either as a person, using digitally recorded video of an actor, or as an avatar, using a computer model of the same actor (Figure 1). The model was animated using the digital recording as a reference but without using automated tracking tools. In particular we tried to ensure the amount of eye contact was the same between the video and animation to avoid uncontrolled effects in either direction (Chen, Minson, Schöne, & Heinrichs, 2013). Second, motion quality was manipulated by adding jerky movement using a temporal blur effect, which blends one or more preceding frames with the current one. The effect was applied to single frames separated by intervals varying between 0.33 s and 3 s. (To limit misinterpretation of Dr. Clark's message, the audio was not manipulated.) The temporal blur was applied in the same frames across all four videos. Third, Dr. Clark gave two possible recommendations about the case. In terms of action, the advice supported either disclosure to the husband

[5] Although the named university is real, both the adviser's name and departmental affiliation were fictional.

(*go*) or remaining quiet (*no-go*). In terms of the protagonist's request, the go advice advocated outright rejection of the protagonist's request, and the no-go advice advocated outright acceptance of the request. Although the advice direction was not related to a research hypothesis, it was included as an independent factor to confirm the absence of acquiescence bias and regression to the mean. The go advice was reused from a previous study (Chapter 2). Both the go and no-go advice are reproduced in Appendix B.

Figure 1. Two depictions of a fictional expert from a nearby university. The expert, Dr. Richard Clark, was animated using *Autodesk Maya*. Jerkiness was added to his motion using *Adobe After Effects*.

Dependent Variables and Covariates

Each answer was indicated by placing a mark on a visual analogue scale (i.e., a slider control with opposing anchors and no preset value). This representation was used instead of radio buttons because it permits measurement using an arbitrary level of precision, which offers stronger support for the assumption of interval-level measurement

(Funke & Reips, 2012; Reips & Funke, 2008). In this study the number of points was set to 256.

Attitudes about the speaker. Participants responded to six measures about Dr. Clark, rating his appearance on three scales and rating his credibility on another three scales. Assessments of appearance were attractiveness, eeriness, and humanness, and assessments of credibility were trustworthiness, competence, and goodwill (Ho & MacDorman, 2010; McCroskey & Teven, 1999).

Mediating processes and individual differences. Seven measures were presented as distractors and as measurements of potentially relevant individual differences. The first set of covariate measurements followed Dr. Clark's advice and preceded the posttest items:

- A manipulation check for participants in the experimental groups: How did Dr. Clark look? (Perceived Form Humanness: completely nonhuman to completely human) How did Dr. Clark move? (Perceived Motion Smoothness: jerkily to smoothly) How did Dr. Clark's voice sound? (Perceived Voice Humanness: completely nonhuman to completely human; this item was included to obscure the theme of the experimental manipulations)
- An 18-item assessment of an individual's need for cognition (Cacioppo, Petty, & Feng Kao, 1984). An example is "I would prefer complex to simple problems." Participants who are more interested in the message may be more resistant to the peripheral cues of an uncanny human representation.

- A 25-item assessment of an individual's sensitivity to sources of disgust (Haidt et al., 1994; Olatunji et al., 2007). An example is "It would bother me tremendously to touch a dead body."
- A 13-item assessment of an individual's level of existential anxiety (Weems, Costa, Dehon, & Berman, 2004). An example is "I often think about death, and this causes me anxiety." Those with high anxiety are especially sensitive to the induction of negative moods (Larsen & Ketelaar, 1991).

  The following measurements were presented after the posttest questions.
- A 5-item multiple-choice test measuring the retention of details about the scenario and message, which was assumed to indicate the relative priority of central decision-making processes (Appendix C). To guard against self-presentation bias, the items make up an objective approach to testing retention rather than a subjective approach (e.g., Schemer, Matthes, & Wirth, 2008).
- Additional self-reported demographic data: year of birth, race, education, religiosity (self-perceived and frequency of church attendance), proficiency in English communication (American Council on the Teaching of Foreign Languages, 2012), and a five-item self-assessed measures of familiarity with specific personal computing tasks and frequency of playing video games (using five-point scales; Appendix C).
- A 25-item word-completion task to measure the accessibility of death-related topics (Greenberg, Pyszczynski, Solomon, Simon, & Breus, 1994). An example is DE _ _, which could be "dead" or an unrelated word like "deer." This task was given last to minimize suspicion of its connection to the previous items.

Decisions about the case. The pretest and posttest observations shared an ad-hoc six-item index of possible decisions about the case, indicating relative favor between the two patients: Will you postpone tomorrow's appointment with Paul until Kelly is ready? If Paul has genital herpes, will you tell him that Kelly is a likely source? When you see Paul, will you tell him that you are testing him for genital herpes? When you see Paul, will you ask him about Kelly's sexual history? When you see Paul, will you tell him about his exposure to genital herpes? When you see Paul, will you tell him that Kelly has genital herpes?

Results

Participation

The number of participants completing the final variable measurements was 426 (64% female). Of these, 252 participants completed all four primary parts: pretest observations, treatment, posttest observations, and measurement of covariates. With these criteria each group had between 20 and 43 participants. The median completion time was 24 minutes.

Recruitment Period and Baseline Demographics

The experiment was conducted in the second half of 2013. Participants were predominantly white (n = 346; 81%), raised in the United States (n = 402; 94%), partway through their academic careers (Mdn = 3 years of postsecondary education), and neither technically inclined nor serious gamers (computer skill $Mdn = -.38$, $IQR = .38$; gaming seriousness $Mdn = -.88$, $IQR = .63$; both ranges $[-1, 1]$). Participants' ages ranged between 18 and 69 years (Mdn = 23, IQR = 6).

Statistics and Data Analysis

Ranged response values were scaled to $[-1, 1]$. Test statistics were interpreted with a significance threshold of $\alpha = .05$. Tests of multivariate models used the F value of Pillai's trace (Field, 2013). Effect sizes for statistically significant manipulations were calculated using partial η^2 (η_p^2) and interpreted according to the following thresholds: small = .01, medium = .06, and large = .14 (Cohen, 1973, 1988).

Immediately after Kelly Gordon's story, participants were somewhat against disclosure, Pretest Decision $M = -.25$, $SD = .47$. Support for disclosure was greater

among men than women, men $M = -.08$, $SD = 0.52$, women $M = -.31$, $SD = 0.43$, Welch's $t(191.70) = -3.96$, $p < .001$.

To check the salience of the visual manipulations, Depiction and Motion Quality, a two-way ANOVA with interaction was conducted on the single-item measures Perceived Form Humanness and Perceived Motion Smoothness. Depiction had a large effect on Perceived Form Humanness, $F(1, 353) = 295.71$, $p < .001$, $\eta_p^2 = .46$. Relative to the recording, the animation was closer to *completely nonhuman* than to *completely human*, animation $M = -.32$, $SE = .04$; recording $M = .54$, $SE = .03$. Depiction also had a large effect on Perceived Motion Smoothness, $F(1, 353) = 70.10$, $p < .001$, $\eta_p^2 = .17$. Relative to the recording, the animation was closer to *jerkily* than to *smoothly*, animation $M = -.18$, $SE = .04$; recording $M = .29$, $SE = .04$. No effect was found for Motion Quality on either item, Perceived Form Humanness $F(1, 353) = 0.04$, $p = .841$; Perceived Motion Smoothness $F(1, 353) = 1.42$, $p = .234$. Depiction × Motion Quality had a nonsignificant effect on Perceived Form Humanness, $F(1, 353) = 3.39$, $p = .067$; no effect was found on Perceived Motion Smoothness, $F(1, 353) = 1.50$, $p = .221$.

Ratings of Dr. Clark showed high internal consistency: Attractiveness $\alpha = .79$, Eeriness $\alpha = .77$, Humanness $\alpha = .93$, Competence $\alpha = .95$, Trustworthiness $\alpha = .92$, and Goodwill $\alpha = .85$. Overall, Dr. Clark was perceived as moderately credible, Competence $M = .55$, $SD = .33$; Trustworthiness $M = .44$, $SD = .38$; Goodwill $M = .18$, $SD = .30$. The internal consistency of each theoretically motivated covariate was also high (Table 1). Gender was added as a covariate in primary analyses because of its importance in the literature (Guadagno, Blascovich, Bailenson, & McCall, 2007; MacDorman et al., 2010).

Relative to women, men reported significantly greater need for cognition and significantly less disgust sensitivity (Table 1).

Table 1
Descriptive Statistics for and Correlations Among Key Participant Covariates

			Correlations			
Variable	*M* (*SD*)	Alpha	Gender	Cog	Anx	Disg
Gender	.64	—				
Need for Cognition	.34 (0.30)	.90	−.14*			
Existential Anxiety	−.17 (0.32)	.79	.08	−.19*		
Disgust Sensitivity	−.02 (0.32)	.88	.33*	−.31*	.07	
Mortality Salience	.32 (0.17)	—	−.10	−.09	.16*	.01

Notes. Owing to dropouts and skipped conditions, *N*s range from 326 to 450. Alpha = Cronbach's α; Correlations = Pearson's *r*; For Gender, 0 = male, 1 = female; Recall = Proportion of correctly answered questions about the story; Cog = scaled need for cognition; Anx = scaled existential anxiety; Disg = scaled disgust sensitivity; Mort = proportion of completed death-related words. * $p < .05$ after Bonferroni correction.

Preliminary factor analysis of the six decision items produced three factors. Only the first factor had more than one loaded item. This factor was retained to justify the treatment of the ad-hoc scale as a single variable, named Disclosure. The factor (Cronbach's α = .77) comprised four items: If Paul has genital herpes, will you tell him that Kelly is a likely source? When you see Paul, will you ask him about Kelly's sexual history? When you see Paul, will you tell him about his exposure to genital herpes? When you see Paul, will you tell him that Kelly has genital herpes?

To minimize Type I error inflation from multiple comparisons, MANCOVA was performed before individual analyses of variance and covariance (Cramer & Bock, 1966). The result supported the main effects of Advice and Depiction as well as the covariates of Pretest Disclosure, Recall, Disgust Sensitivity, and Gender, Advice $F(7, 212) = 20.26$, $p < .001$; Depiction $F(7, 212) = 30.52$, $p < .001$; Pretest Disclosure $F(7, 212) = 29.83$, $p < .001$; Recall $F(7, 212) = 2.23$, $p = .033$; Disgust Sensitivity $F(7, 212) = 2.18$,

p = .037; Gender $F(7, 212) = 2.12$, p = .043. No effects were found for interactions of the independent variables, nor for the other covariates, Fs ≤ 1.17, ps ≥ .324.

Source perception. The visual manipulations had no measurable effects on subjective reports of Dr. Clark's credibility. Depiction had a nonsignificant effect on Goodwill and no effect on Competence and Trustworthiness, Goodwill $F(1, 350) = 3.12$, p = .078; Competence $F(1, 351) = 2.66$, p = .104; Trustworthiness $F(1, 347) = 1.99$, p = .159. Motion Quality had no effect on any of the three aspects of source credibility, Fs ≤ 0.96, ps ≥ .327. Although not relevant to the study's hypotheses, Advice had small effects on Goodwill and Trustworthiness and a nonsignificant effect on Competence, Goodwill $F(1, 350) = 6.89$, p = .009, η_p^2 = .02; Trustworthiness $F(1, 347) = 11.90$, p < .001, η_p^2 = .03; Competence $F(1, 351) = 3.07$, p = .081. Dr. Clark's credibility on all three aspects was greater when he advocated disclosure than when he advocated remaining quiet.

The effects on perceived human realism were clearer. Depiction had small negative effects on Attractiveness and Humanness and a small positive effect on Eeriness, Attractiveness $F(1, 349) = 6.70$, p = .010, η_p^2 = .02; Humanness $F(1, 350) = 290.94$, p < .001, η_p^2 = .45; Eeriness $F(1, 346) = 11.22$, p < .001, η_p^2 = .03. Relative to the recording, the animation was eerier, less attractive, and less human, Eeriness recording M = −.34, SE = .02; animation M = −.24, SE = .02; Attractiveness recording M = .07, SE = .02; animation M = .00, SE = .02; Humanness recording M = .37, SE = .03; animation M = −.43, SE = .03. Neither Motion Quality nor Advice affected the three ratings of realism, Motion Quality Fs ≤ 1.50, ps ≥ .222; Advice Fs ≤ 1.16, ps ≥ .282.

Depiction × Motion Quality had a nonsignificant effect on Attractiveness, $F(1, 349) = 3.43$, $p = .065$.

To increase statistical power, ANCOVA was conducted by adding Anxiety, Need for Cognition, Recall, Disgust Sensitivity, Mortality Salience, and Gender. Recall was a significant predictor of Trustworthiness and a nonsignificant predictor of Competence, Trustworthiness $F(1, 253) = 7.44$, $p = .007$; Competence $F(1, 252) = 3.77$, $p = .053$. Anxiety also predicted Competence, $F(1, 252) = 4.47$, $p = .036$. Gender was a nonsignificant predictor of Goodwill, $F(1, 252) = 3.64$, $p = .058$. After accounting for the covariates, the effect of Advice remained significant for both Goodwill and Trustworthiness.

Gender was a significant predictor of Attractiveness, $F(1, 253) = 4.75$, $p = .030$. Overall, Dr. Clark was slightly more attractive to men than to women, men $M = .069$, $SE = .025$; women $M = .003$, $SE = .020$. Recall was a significant predictor of Eeriness, $F(1, 253) = 6.64$, $p = .011$. Gender and Disgust Sensitivity were significant predictors of Humanness, Gender $F(1, 253) = 5.92$, $p = .016$; Disgust Sensitivity $F(1, 253) = 10.04$, $p = .002$. After accounting for the covariates, the effects of Depiction remained significant. Depiction × Motion Quality had small effects on Attractiveness and Humanness but no effect on Eeriness, Attractiveness $F(1, 253) = 3.97$, $p = .047$, $\eta_p^2 = .02$; Humanness $F(1, 253) = 4.88$, $p = .028$, $\eta_p^2 = .02$; Eeriness $F(1, 253) = 0.50$, $p = .479$.

Hence, the predicted negative effects of Depiction and Motion Quality on source credibility (H1 and H2) were not supported. H3 was also not supported; it asserted that jerky movement affected credibility more strongly in an animated model.

Decisions about the case. A three-factor ANOVA was conducted with all two- and three-way interactions on Disclosure, adjusted $R^2 = .26$. The main effect of Advice was significant and large, $F(1, 315) = 101.49$, $p < .001$, $\eta_p^2 = .24$. Participants advised to inform Paul more strongly supported doing so, Go $M = .15$, $SE = .04$; No-Go $M = -.44$, $SE = .04$. Additionally, the analysis indicated a nonsignificant three-way interaction, $F(1, 315) = 3.44$, $p = .064$.

To increase statistical power, the next test added Pretest Disclosure as a covariate (Braver & Braver, 1988; Van Breukelen, 2006). Adding Pretest Disclosure increased the power of the overall model, adjusted $R^2 = .64$. Pretest Disclosure was a significant predictor of Disclosure, $F(1, 247) = 238.91$, $p < .001$. After accounting for Pretest Disclosure, the effect of Advice remained large, $F(1, 247) = 238.91$, $p < .001$, $\eta_p^2 = .39$. No other main effects or interactions were observed, Fs ≤ 0.72, ps $\geq .397$. Next, a second ANCOVA was performed by adding Anxiety, Need for Cognition, Recall, Disgust Sensitivity, Mortality Salience, and Gender. This model was only slightly more powerful, adjusted $R^2 = .65$. Both Recall and Disgust Sensitivity were significant predictors of Disclosure, Recall $F(1, 220) = 4.02$, $p = .046$; Disgust Sensitivity $F(1, 220) = 5.93$, $p = .016$. After accounting for all additional covariates, the positive effect of Advice remained large, $F(1, 220) = 135.80$, $p < .001$, $\eta_p^2 = .38$. No other main effects or interactions reached significance, Fs ≤ 1.16, ps $\geq .282$.

Discussion and Conclusion

The goal in this research was to identify the mechanisms affecting the processing of persuasive messages from uncannily human representations. Relative to a digitally recorded human speaker with high expertise, persuasiveness was predicted to change for an uncanny computer representation. Predictions were based on two competing mechanisms: (a) The animated source's decreased human realism casts it into an outgroup, decreasing persuasion, or (b) the source's unusual appearance and behavior elicit greater message-relevant attention, increasing persuasion. To test these predictions in an ethical dilemma, this study used three 2-level factors: depiction, motion quality, and advice. Overall, the only significant treatment effect on opinion was the advice, even though the animated depiction was significantly eerier than the digitally recorded version. Although the results supported a basic assumption of the study, namely, that the computer double was less human and eerier than the recording, the predicted effects on source perception (H1–H3) and decisions (H4–H6) were unsupported. Despite appearing less human, Dr. Clark was nonetheless highly persuasive. Even after accounting for gender, a second assumption that jerky motion is eerier in the animated double (MacDorman et al., 2010) was also unsupported. The pattern of results indicates overwhelming adherence within the study's undergraduate student population.

The characteristics of this study's population also produce several alternative explanations. The results could be explained by general acquiescence (Khan & Sutcliffe, 2014) or by obedience to authority (Bartneck & Hu, 2008; Milgram, 1963; Slater et al., 2006). However, because the decisions were unforced, the results may be more indicative of outward compliance with social pressure (Asch, 1956). Participants' change in attitude

could have been only temporary (Cialdini, Levy, Herman, Kozlowski, & Petty, 1976). Given the study's social interactivity, participants may have wanted to present a favorable self-image (Cialdini & Goldstein, 2004).

Although both the go and no-go messages were written to be comparably effective, unsystematic variation between the two messages significantly affected Dr. Clark's goodwill and trustworthiness. Relative to the no-go advice, the go advice increased both goodwill and trustworthiness. One possible source of unsystematic variation is Dr. Clark's use of personal pronouns. For example, the go advice included four second-person pronouns (i.e., *you* and *your*), whereas the no-go advice included two. Language choice has been linked with individual differences in personality (Pennebaker, Mehl, & Niederhoffer, 2003). In both messages Dr. Clark's use of specific names and details may have conveyed a degree of personal interest in the case and led participants to consider the speaker and message jointly.

Comparison With Related Studies

This study's use of realistic human representation distinguishes it from studies of automatic social behavior toward computer agents (e.g., based on the media equation theory; Reeves & Nass, 1996). The use of a realistic animation matched with its videotaped human reference focuses the research on attributions of source credibility. In other words, by using a fixed identity, interpersonal assessments were expected to concern the represented person, not an agent acting autonomously.

This study failed to replicate the results of two previous studies using the same ethical dilemma. The first of these found gender differences in the main effect of depiction and in the interaction of depiction and motion quality (MacDorman et al., 2010). Men

were less likely to comply with the animated source's request, especially when her motion was jerky. However, the message source in that study, Kelly Gordon, had implicitly low credibility, owing to her admission of extramarital relationships, willingness to deceive her husband, and willingness to put him at risk of contracting a sexually transmitted infection. In addition, the computer representation of Kelly had merely an approximate resemblance to the speaker instead of being modeled directly from her appearance. Furthermore, the manipulation of motion quality was overt: The jerky videos had one-sixth the frame rate of the unmodified videos (MacDorman et al., 2010).

The second study in this group found a medium-sized positive effect of jerky motion on Dr. Clark's persuasiveness and a nonsignificant effect on attention (Chapter 2). In addition to a different method of creating jerky motion (namely, repeating video frames at a fixed interval), the difference in results could have arisen from that study's additional control of apparent size: Participants were seated a short distance from a high-definition television set. Relative to this study, both previous studies lacked precision in measures; the studies employed scales with a range of only five to seven discrete points per item. The previous studies' manipulation of motion quality was more apparent. Taken together, these studies indicate opportunities for further research on perception of jerky character motion and its interaction with credibility.

Threats to Validity

Three possible threats to validity in this study arise from the experimental design. Two involve overreporting and misreporting of the virtual human's eeriness and lack of humanness. This study's measures were self-reported. However, subjective effects tend to

be larger than other kinds of effects (Mitchell, Ho, et al., 2011; Yee, Bailenson, & Rickertsen, 2007). Even when using visual analogue scales, a general problem of validity exists with post-hoc subjective accounts of interaction (Cassell & Tartaro, 2007; Gardner & Martin, 2007; Slater & Garau, 2007).

The study's design could have introduced an order effect. To limit suspicions of the experimental manipulations, the treatment and posttreatment measurements were separated by two sets of measurements: ratings of Dr. Clark and self-evaluations of need for cognition, existential anxiety, and disgust sensitivity. These measurements may have moderated the experimental effects by affecting the relative importance of attributes being considered (Levine, Halberstadt, & Goldstone, 1996). Such effects would be difficult to capture with a linear model, as would any variation in the strength of association among covariates and reported behavior. Reframing the theoretical predictions could lead to more precise testing through structural equation modeling or multiple regressions (Baron & Kenny, 1986; James, Mulaik, & Brett, 2006), though at the expense of theoretical simplicity.

Another threat to validity comes from its implementation: The study's sample may have lacked representativeness owing to its low response rate. Specifically, those participating may have felt disproportionately more obligated to report adherence to Dr. Clark's advice.

Threats to Generalizability

Conducting the study through a website expediently increased the potential sample population, and it permitted measurement of the compliance effect across different environments (i.e., message destinations). However, this implementation also

limits inferences about personal involvement and the motivation and ability to think about the provided arguments, all of which affect persuasion (Petty, Cacioppo, & Goldman, 1981; Petty & Cacioppo, 1986). Typically, physicians are paid salaries for making difficult decisions under time constraints and in the presence of others. Participants in this study contributed purely voluntarily, without a set time limit, and without physical presence in a laboratory. Furthermore, although the case required only minimal medical knowledge, most participants were untrained in medicine. Compliance may have been less had the dilemma involved a nonmedical setting (e.g., advertising). An extension in the opposite direction could include sampling a population of medical residents.

Furthermore, polling undergraduate students scarcely ensures an accurate representation of adults from developed countries (Henrich, Heine, & Norenzayan, 2010). An alternative is to sample workers on Amazon's Mechanical Turk service, which has greater demographic diversity (Mason & Suri, 2011). Assuming Mechanical Turk workers are reimbursed for their participation, the influence of external incentives could be evaluated.

Other limits to the generalizability of the compliance effect arise from the speaker's fixed identity, the framing of the narrative itself, and the assumption of in-study behavior mapping to real-life behavior. It remains unclear what the experimental manipulations would have produced with different speakers or in different stories. The compliance effect could simply reflect participants' interpretation of the ethical dilemma as a task in a roleplaying game (Williams, 2010). The identity limitation could be addressed with multiple recordings and computer animations, though at a higher incurred

cost. The narrative limitation could be addressed with a repeated-measures design, though doing so increases the risk of attenuation from habituation. The mapping assumption could be tested in an immersive virtual environment by increasing the realism of the interactions and the immediacy of each outcome's risks and rewards.

Future Research and Applications

Future research in this area depends on improving the theoretical model so that the effects of computer-animated representation on decisions are traced more clearly. Manipulating credibility explicitly may help resolve differences between this study's results and previous findings (MacDorman et al., 2010). For example, Dr. Clark's credibility could be manipulated through membership in a relevant professional association (high credibility) or in an unrelated group (low credibility). In a more extreme case, Dr. Clark's recommendation could be replaced with the uninformed advice of an unattractive and incompetent bystander. The ability to process arguments could be manipulated explicitly by varying cognitive load through primary and secondary tasks (e.g., Martin et al., 2007). For example, while attention is directed toward counting a speaker's words or specific phonemes, a realistic computer animation's eeriness can operate peripherally on the secondary task of attitude formation. Future studies could also manipulate personal involvement (Petty & Cacioppo, 1979). One way to do this is through an economic game with real money at stake. Another potentially informative manipulation is the apparent size of the speaker (Reeves et al., 1999), though such a manipulation will be easier to implement in a laboratory than online.

To better account for individual differences in responses to uncanny stimuli, other covariates may be explored, including authoritarianism and religiosity (Greenberg et al.,

1990; MacDorman & Entezari, 2015). Other relevant individual differences concern the relative influence of central and peripheral paths to attitude formation. Heuristic thinkers may have been persuaded more easily (Petty & Wegener, 1998). However, systematic thinking could decrease altercentric behavior (Zhong, 2011). Instead of a unipolar measure, need for cognition could be tested in a more bipolar way by adding intuition as an opposing anchor (Alós-Ferrer & Hügelschäfer, 2012; Epstein, Pacini, Denes-Raj, & Heier, 1996; Pacini & Epstein, 1999). The degree of personal involvement could be measured with respect to the specific messages being presented (Zaichkowsky, 1994).

In summary, this study's results suggest that it remains easy to elicit compliance through a credible-looking speaker with high social status, even when the speaker's physical appearance is degraded, and thus rendered uncanny, by potentially uncontrolled technical problems. The source and message attributes supporting persuasiveness—logical arguments, formal attire, a terminal degree from a reputable university—seem to inoculate the speaker against the uncanny valley's negative effects on source perception. The compliance effect may improve computer-mediated educational interactions, especially if individuals can customize agents' representations and personalities to complement their own (Isbister & Nass, 2000). Behavioral outcomes may be even stronger with children, owing to their increased likelihood of forming false memories (Segovia & Bailenson, 2009). The ethical use of physicians in digitally mediated healthcare delivery can effectively expand healthcare delivery services without decreasing patient compliance. Regular interaction with virtual physicians could increase adherence to medical regimens, especially in groups with low health literacy (Bickmore, Pfeifer, & Paasche-Orlow, 2009; Bickmore et al., 2010).

Although virtual likenesses could promote mutually desirable behavior, they could also benefit some parties at the expense of others. The compliance effect demonstrated in this study applies readily to advertising. Despite a mixed reception, extant recordings and new virtual likenesses of deceased professionals are already being used in television commercials (Abcarian, 2006; Garfield, 2007; Hiltzik, 2014; James, 1998). Virtual likenesses could also be used to promote unethical behavior through psychological manipulation. If using realistic likenesses elicits attributions of intentionality, audiences may be less likely to question recommendations made by autonomous virtual doubles.

Using realistic likenesses in virtual environments also raises ethical issues involving identity management. Although the animations in this experiment were created and voiced with the actor's consent and input, such cooperation is not needed if the subject is sufficiently well known. Virtual likenesses of famous performers can be animated from existing images and without the direct involvement of the performers. Matching voices can be added by impersonators, or the voices may be reused or synthesized from recorded speech. Furthermore, although the postmortem use of one's recorded likeness is legally protected (Madoff, 2010), autonomous virtual doubles may necessitate reinterpretation of relevant laws. Giving identifiable personalities to artificially intelligent agents may reveal discrepancies between perceived and actual liability for errors, especially in critical domains like healthcare. Thus, between highly influential people and their realistic virtual doubles, the prospect of bidirectional effects on credibility and liability invites further attention.

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FIVE: REMOVING INDICATORS OF HUMANNESS AND CREDIBILITY

After two studies with the fictional Dr. Clark, the advice of a credible expert appears undiminished by virtual depiction and jerky motion. However, the human authority figure could have evoked an unbalanced power relationship, overriding other factors influencing compliance. This relationship could be balanced in a subsequent study by using the avatars of potential peers (i.e., other students). However, such a study would overlap existing work on the perception of avatars in virtual spaces (Bailenson et al., 2005; Yee et al., 2009; Yee & Bailenson, 2007).

Interacting With the Agent as a Tool

Alternatively, the power relationship may be reversed by making the main character a humanlike conversational agent. Conversational agents combine two of the earliest named metaphors for interacting with computers, model–world and conversation, thus relying on conversation within a modeled world (Hutchins, Hollan, & Norman, 1985; Laurel, 1997). Whereas the model–world metaphor involves the direct manipulation of virtual objects (Shneiderman, 1983), manipulating agents involves dialog. However, agents are more than a mixed metaphor. Unlike other examples of conversational interfaces—namely, those involving a structured set of commands—communication with an agent is possible without limiting one's vocabulary or learning a separate one (Mateas & Stern, 2004).

Nevertheless, conversation with agents remains less common than more direct forms of human–computer interaction (e.g., typing, clicking, tapping, or swiping). One likely reason is the ambiguity of natural languages. Having to repeat or rephrase commands decreases the efficiency with which tasks are completed. Another likely

reason for the relative scarcity of agents is that their functionality is initially opaque and may not match users' expectations. This may cause frustration in (for example) an interaction with an interactive voice response system. It can also reveal societal assumptions about agents assigned to human roles.

What new roles can agents plausibly undertake? Because increasing an agent's human likeness produces more positive outcomes in socially oriented tasks (Goetz, Kiesler, & Powers, 2003), it makes sense to assign human-looking agents to roles requiring social interaction. Perceived autonomy may be desirable: Human presentation may elicit stronger beliefs of intentional behavior (Hegel, Krach, Kircher, Wrede, & Sagerer, 2008; Krach et al., 2008). A common example of an unbalanced power relationship between otherwise independent actors exists between employees and their managers. Imagining a humanlike agent as an intelligent yet disposable employee has been made plausible through popular culture (Sofge, 2013).

A Call for Unexpected Interactions

Popular culture has also overstated the current intelligence of agents (Sofge, 2014). Realistically, owing to coding errors, inputs unforeseen by programmers, and other sources of failure, agents will not meet all users' expectations at all times. Essentially, an agent's unexpected behavior may serve as a breaching exercise. Unexpected behavior may place a greater incentive on assessing credibility, and different situations could highlight different aspects of the agent's credibility. Thus, instead of staging a single interaction in which an agent is treated as human, two new interactive scenarios were created in which the agent shows controversial judgment.

What Happens When a Technological Tool Becomes a Social Actor?

Generally, other than the persuasive message itself, persuasion depends on the speaker's credibility and ability to elicit empathy. For people, the primary components of credibility are trustworthiness (warmth), competence, and goodwill. However, an unfamiliar humanlike conversational agent's credibility may also depend on its behavior during interactions (Tajariol, Maffiolo, & Breton, 2008). Furthermore, empathy for the agent could be blocked by the uncanny valley. When an agent is treated as a social actor, does its persuasiveness depend more on its representation or its behavior?

The uncanny valley predicts that humanlike agents with nonhuman features will be evaluated negatively. However, it is unclear whether this effect persists across differently framed interactions. A between-groups, posttest-only experiment was conducted through the Internet with 311 US undergraduate students. Participants were assigned one of two novel dilemmas in professional ethics involving the fate of a humanlike agent. In addition to the dilemma, there were three 2-level manipulations of the agent's human realism: depiction (humanoid robot or animated human), voice (synthesized or natural), and motion (jerky or smooth). In one dilemma, decreasing depiction realism or increasing voice realism increased eeriness. In the other dilemma, increasing depiction realism decreased perceived competence. In both dilemmas human realism had no significant effect on whether to punish the agent. Instead, the willingness to punish was predicted most reliably by the agent's narratively framed autonomy and credibility, demonstrating both direct and indirect effects of narratives on responses to humanlike agents.

SIX: A VIRTUAL EMPLOYEE'S PUNISHMENT DEPENDS ON THE NARRATIVE

A computer system is only as helpful as its user interface. Some of the most helpful interfaces use a conversational mode of interaction, including androids, virtual humans, and humanlike robots. Collectively, these interfaces are referred to as embodied conversational agents (ECAs) that integrate verbal and nonverbal channels of communication, including facial expression (Cassell, 2000). ECAs promote natural communication between people and computers. For example, computer-animated characters representing nurses can explain medical concepts to patients who cannot read, and characters representing therapists can elicit self-disclosure from people with social anxiety (Bickmore, Pfeifer, & Paasche-Orlow, 2009; Bickmore et al., 2010; Kang & Gratch, 2010).

Like other computer interfaces, conversational agents are treated automatically as social others (Nass & Moon, 2000; Reeves & Nass, 1996). Users interacting with agents ignore to varying degrees the unseen role of computer programmers; even computer science students have claimed that agents have intentions and make decisions (Friedman, 1995; Hoffmann, Krämer, Lam-chi, & Kopp, 2009; Nass et al., 1994; Sundar & Nass, 2000). Whether arising from a genuine belief or a cognitive shortcut, these attitudes are reinforced through the agents' humanlike representation. With both physically and virtually embodied agents, the inclusion of at least one human feature elicits personality inferences. These human features can be as basic as a head and pair of arms or as sophisticated as a humanlike form, computer-synthesized voice, or body movement (Isbister & Nass, 2000; Large & Burnett, 2013; Nass & Brave, 2007; Nass, Isbister, &

Lee, 2000; Nass & Lee, 2001; Powers & Kiesler, 2006; Walters, Syrdal, Dautenhahn, te Boekhorst, & Koay, 2008).

Controlling the human realism of an agent's appearance and behavior serves two functions. One is to make its characteristics match its role (e.g., characteristics like personality, interpersonal warmth, and competence; Goetz et al., 2003). Limiting an agent's human realism has been proposed to prevent the overestimation of its capabilities (Duffy, 2003; Groom et al., 2009; Luo, McGoldrick, Beatty, & Keeling, 2006; Mori, 1970/2012). This goal may conflict with a competing function of controlling human realism: making the agent credible. Although agents with low human realism can be believable (Niewiadomski, Demeure, & Pelachaud, 2010), credibility generally increases with the agent's human realism (Gong, 2008; Nowak, Hamilton, & Hammond, 2009; Nowak & Rauh, 2005, 2008).

Appearance has been listed as only one of 10 identified dimensions of human realism in agents (von Zitzewitz, Boesch, Wolf, & Riener, 2013). Besides appearance, this research focuses on two other dimensions of realism: vocal delivery and motion quality. Increasing human realism along these other two dimensions also generally increases credibility. For example, a rounder face and a deeper voice in a robot character increase perceived warmth and competence, respectively; these perceptions in turn increase the willingness to follow hypothetical medical advice (Powers & Kiesler, 2006). In electronic navigation systems, voices perceived as trustworthy are chosen more frequently (Large & Burnett, 2013). Credibility also increases with appropriate facial expressions (Cowell & Stanney, 2005). Agents perceived as highly credible could have

greater initial acceptance in difficult interactional roles. Conversely, a perceived lack of credibility could delay the acceptance of agents in roles requiring autonomy.

Owing in part to increased credibility, agents with one or more sufficiently humanlike features can be persuasive. Synthesized voices exert social influence on decisions, even when reminded that the voices were produced by a computer (K. M. Lee & Nass, 2004; Nass & Lee, 2001). Synthesized voices can be just as persuasive as human voices (Mullennix, Stern, Wilson, & Dyson, 2003; S. E. Stern, Mullennix, Dyson, & Wilson, 1999). Embodied agents that mimic users' body movements are received more positively and are more persuasive than agents that do not (Bailenson & Yee, 2005). Persuasive agents are useful in interventions for motivating behavior change (Baylor, 2009).

If increasing human realism in one dimension increases persuasion, increasing human realism across multiple dimensions seems apt. Overall, adding nonverbal behavior compatible with both the task and other aspects of the agent's realism increases liking (M. E. Foster, 2007). However, adding human features increases the risk of crossmodal inconsistency. People prefer consistency, for example, between an agent's verbal and nonverbal cues of extraversion (Isbister & Nass, 2000). Mismatches in human realism between an agent's face and voice decrease both subjective trust and self-disclosure (Gong & Nass, 2007). In line with the uncanny valley hypothesis, mismatches in realism can be repulsive with nonhuman elements in an artificial human being perceived as eerie (Mori, 1970/2012; Seyama & Nagayama, 2007). Although eeriness arises both from intramodal inconsistency (MacDorman, Green, et al., 2009) and crossmodal inconsistency (Mitchell, Szerszen, et al., 2011), this research focuses on the latter.

The objective in this research is to identify which modes and crossmodal mismatches in human realism influence behavior toward controversial software agents. In most previous research on mismatches in human realism, the quantities being measured are observers' attitudes and intentions instead of their behavior. Observing an interaction versus engaging in it produces different preferences (Strait, Canning, & Scheutz, 2014). Also, attitudes toward humanlike agents may not predict the outcome of interactions with those agents. Sometimes, attitudes and behavior correlate positively (K. M. Lee & Nass, 2004). At other times, the relation is missing or negative, as the following three examples illustrate: Facial indicators of deception may decrease perceived credibility without affecting in-game behavior toward the agents (Rehm & André, 2005). Speech from a combination of human and synthesized voices is preferred over speech from strictly synthesized voices but is less helpful in task performance (Gong & Lai, 2001). Higher-quality synthesized speech is preferred to lower-quality synthesized speech but does not improve comprehension (Louwerse, Graesser, Lu, & Mitchell, 2005). Two unwanted effects of increasing human realism in appearance are increased self-presentation bias and decreased self-disclosure (Bailenson et al., 2005; Sproull et al., 1996).

An assumption of this work is that social judgments of agents depend both on perceived personality and on behavior in the context of the interaction. Attribution of responsibility to agents is mediated at least partially by affinity with the agent (Moon, 2003). When user–agent teams fail at a task, users prefer a robot that blames itself instead of others for poor team performance (Groom, Chen, Johnson, Kara, & Nass, 2010). Furthermore, the agent accrues more blame if it acts more independently (Serenko, 2007) and if its personality is dissimilar from that of the user (Moon & Nass, 1998).

Inferences of personality and intentions are important when unexpected social behavior makes the agent the focus of attention. Examples of unexpected social behavior in robots include interrupting conversations and cheating to win games (Kahn, Kanda, Ishiguro, Freier, et al., 2012; Rehm & André, 2005; Short, Hart, Vu, & Scassellati, 2010). When an agent behaves unexpectedly but with apparent intent, observers' engagement increases (Short et al., 2010; Vazquez, May, Steinfeld, & Chen, 2011).

Will human realism exacerbate or mitigate users' responses to agents' unexpected social behavior? To connect with the previously mentioned lines of research, the specific aim in this study is to use independent two-level variations of an agent's human realism to influence judgments of its characteristics and responses to its behavior. Embodied software agents are already perceived as having moral accountability (Kahn, Kanda, Ishiguro, Gill, et al., 2012), though the strength of this perception is mediated by individual differences (Johnson, Marakas, & Palmer, 2006). The results of this research may reveal users' perceptions of liability in advanced software agents, especially those that appear human (Heckman & Wobbrock, 1999, 2000).

Future research based on this work is expected to be multidisciplinary, including human subjects research in the social and cognitive sciences (Ishiguro & Nishio, 2007; MacDorman & Ishiguro, 2006b) as well as economics (Oullier & Basso, 2010). The variation of human feature realism can also be used in other experimental scenarios, like predicting the outcome of social breaching exercises.

The remainder of this chapter describes an experiment in which an agent's apparent autonomy belies questionable decision making. Three factors of the agent's human realism were manipulated independently: depiction, voice, and motion.

Participants completed a constrained online interaction with the agent and decided its fate in one of two ethical dilemmas, chosen randomly. Participants also rated the agent's credibility, attractiveness, humanness, and eeriness. Realism was interpreted differently in each of the two dilemmas, and it had no direct effect on the willingness to punish the agent. Although realism did not change perceived trustworthiness, one of the measured components of credibility, in both dilemmas perceived trustworthiness reliably predicted punishment. Hence, the willingness to punish the agent was inferred more from the agent's actions within the dilemmas than from the manipulations of human realism. Although initial attitudes about agents form from presentational factors, subsequent inferences may depend more on behavior within a narrative context.

Background

Social judgments are applied automatically to people in face-to-face and technology-mediated communication; similar automatic judgments are also applied to personal computers and websites (Metzger, Flanagin, Eyal, Lemus, & McCann, 2003; Reeves & Nass, 1996; Reeves & Voelker, 1993; Sundar & Nass, 2000). Embodied conversational agents constitute another medium through which computers and users communicate. If the medium of communication affects how a computer system is perceived (Reeves & Nass, 1996), an ECA's appearance and behavior are likely to influence judgments of the computer system it represents.

Perception of humanness cues in ECAs seems inescapable, at least according to neuroimaging research. For example, brain activity increases in areas known for modeling the intentions of other people when observing a robot with a humanoid shape (Krach et al., 2008). Most of the brain areas activated by natural human speech are also activated by synthesized speech (Benson et al., 2001). Motion activates a network for mirroring motor activity; the degree of activation depends on the agent's overall appearance, the humanness of the configuration of its joints, and the humanness of its motion (Kilner, Hamilton, & Blakemore, 2007; Kilner, Paulignan, & Blakemore, 2003; Kupferberg et al., 2011, 2012). Inferred animacy also activates a separate network for social cognition (Wheatley, Milleville, & Martin, 2007). Effortful inhibition of the automatic processing of an ECA's human form, voice, and movements may not be possible.

This study examines two kinds of social judgments applicable to ECAs: warmth and competence. Although their exact names vary, components of warmth include

goodwill and trustworthiness; components of competence include humanness and autonomy. Combined, warmth and competence make up credibility, which is sometimes called believability when applied to ECAs (McCroskey & Teven, 1999; Niewiadomski et al., 2010). Among people, warmth and competence are the primary components of social cognition and are part of a broader four-part set of social inferences: whether a given behavior is intended, desires or goals, beliefs (i.e., theory of mind), and personality (Fiske et al., 2007; Malle & Holbrook, 2012; Wojciszke, Bazinska, & Jaworski, 1998).

Setting Expectations of Credibility

Human character in general and credibility in particular are judged based on both situational factors and presentational factors, including physical appearance, voice, and body movement (Judee K. Burgoon, Birk, & Pfau, 1990; Jackson et al., 1995; Zuckerman et al., 1990). The human tendency to attribute falsely an action to the actor's character instead of the situation has been identified as the fundamental attribution error (Jones & Harris, 1967; Ross, 1977). Both situational and presentational factors indicate whether someone belongs to an ingroup or to an outgroup. Ingroup members are viewed as warmer and more competent and are treated better as a result (Tajfel, 1982). Individuals can form an group based on minimal cues, and such groups can even include ECAs (Nass et al., 1996; Tajfel, 1970). With ECAs, the degree of humanness cues put forth may determine whether they are placed in an ingroup or an outgroup.

Although with increasing humanness, some models of agent perception predict increased credibility, competing models depend on putting behavior in the context of such situational factors as narrative framing. One situational factor is the agent's assigned role. For example, according to an application of balance theory, agents performing

undesirable tasks may seem less acceptable (Tondu & Bardou, 2011). Other models of attitudes towards ECAs suggest an interaction between expected and actual behavior (Nass & Moon, 2000; von der Pütten, Krämer, Gratch, & Kang, 2010).

Despite evidence against a simple causal relation from agents' appearance to attitudes and resulting behavior, we wanted to measure the effect of appearance in different contexts with the goal of producing universal design guidelines. However, both framing and appearance explain otherwise inconsistent responses to agents' humanlike behavior. This has been explored in competitive environments. Framing could explain why an entertainment robot's cheating is considered acceptable, though cheating in robots is generally unwanted (Vazquez et al., 2011). Appearance could explain why an ambiguous facial display is more suggestive of deception when the face looks more human (Mathur & Reichling, 2009) or why human speech increases acceptance of unfair offers from laptop computers but decreases acceptance of unfair offers from androids (Nishio, Ogawa, Kanakogi, Itakura, & Ishiguro, 2012).

Increasing Credibility Through Affinity

The concept of humanness is typically confounded with both attractiveness and warmth (Ho & MacDorman, 2010). Nevertheless, human-looking ECAs are expected to be more socially attractive and more persuasive, according to models like similarity–attraction theory (Moon & Nass, 1996) and the threshold model of social influence (Blascovich et al., 2002). Increasing human realism may increase the frequency of two theory-of-mind attributions: perceived agency and capacity for experience (Gray, Gray, & Wegner, 2007). One mediator of perceived credibility, at least for synthesized voices, is the observer's need for cognition: A human voice is more persuasive than a synthesized

voice when the need for cognition is low (E.-J. Lee, 2010). The third factor of human realism in this study, motion quality, is also expected to increase perceived ingroup membership. Although the motion of simple geometric shapes produces inferences about motives (Heider & Simmel, 1944), this information is insufficient for understanding interaction with ECAs. The biological motion used in this study is more similar in behavioral realism to an android, which elicits the most social interactivity among humanlike agents (MacDorman & Ishiguro, 2006a).

Decreasing Credibility Through Repulsion

In predicting how a particular simulated human is perceived, the uncanny valley hypothesis describes a nonlinear relation between the valence of observers' responses and the simulation's level of human realism. The hypothesis originates from a claim that *shinwakan* (observers' feeling of harmony and rapport with another entity) increases initially as a robot's appearance becomes more humanlike, then drops sharply to a negative value (often called uncanniness or eeriness) when observers become highly sensitive to nonhuman imperfections, then recovers just as quickly when the human simulation becomes perfect (Mori, 1970/2012). Uncanny valleys are further predicted to arise specifically from internal inconsistency in levels of human likeness of appearance or behavior (MacDorman, 2006). However, such a framing still leaves many possible methods for eliciting eeriness, each of which may solicit a different combination of lower- and higher-order mental processes (MacDorman, Green, et al., 2009).

Humanlike appearance may set up other expectations of realism that, when unmet, cause aversion. For example, although a computer speaking with a human voice

may be acceptable, a human speaking with a computer voice is perceived negatively (S. E. Stern, Mullennix, & Yaroslavsky, 2006).

From the domain of possible eeriness elicitors, the current section describes how two forms of inconsistency with appearance previously demonstrated to elicit eeriness, motion quality and vocal human realism (MacDorman et al., 2010; Mitchell, Szerszen, et al., 2011), may influence attitude change. Although explanations have been offered for why uncannily human agents seem unsettling (MacDorman, Green, et al., 2009), these explanations do not include predictions of observers' behavior toward the agents. Hence, in this section we also consider how the uncanny valley can affect the treatment of agents. A repulsive agent could be treated more harshly. Alternatively, mismatched human realism may decrease an agent's apparent autonomy. We propose two paths: Decreased warmth increases punishment, and decreased competence decreases punishment.

Decreasing perceived warmth (trustworthiness and goodwill). Warmth and goodwill have overlapping factor loadings, and both describe warmth in the two-factor social cognition model (Fiske et al., 2007; McCroskey & Teven, 1999). Hence, we include them together as indicators of interpersonal warmth. Further complicating matters, although warmth and eeriness are distinct constructs, a small to medium negative correlation exists between them (Broadbent et al., 2013; MacDorman & Entezari, 2015). We extend briefly four explanations of the uncanny valley that are applicable to perceived warmth:

a. The eerie feeling of the uncanny valley may be elicited by the body's mechanisms for threat avoidance. In other words a self-preservation adaptation for avoiding potentially disease-carrying humans may apply to

humanlike ECAs. If eerie ECAs elicit disgust, which can have a moral component (Schnall, Haidt, Clore, & Jordan, 2008), the eerie agent may seem less moral.

b. The uncanny valley may break shared neural circuits that support empathy (MacDorman, Green, et al., 2009). An inability to empathize with the agent may make it more difficult to trust the agent.

c. The idea of a humanlike-yet-nonhuman form produces cognitive dissonance and elicits a fear of the unknown (MacDorman & Entezari, 2015). It sets up Sorites paradoxes that undermine personal and human identity (Ramey, 2005). An agent that has human ability but lacks human judgment may seem less worthy of autonomy owing to its unpredictability.

d. An uncannily human agent could serve as a reminder of personal mortality both because it can look dead and because the limitation of our lifespan stands in contrast to its potential for "immortality." Mortality salience increases negative evaluations and aggression toward threats to personal worldviews (Greenberg et al., 1990; McGregor et al., 1998). The phenomenon may be mediated by observers' sensitivity to disgusting stimuli (Haidt et al., 1994; Olatunji et al., 2007).

Decreasing perceived competence. Although the relation between the uncanny valley and perceived competence is less clear than the relation between the uncanny valley and warmth, we predict that eeriness heightens attention to other flaws in an agent, making it seem less competent. A mismatch between the visual and vocal conveyance of speech may cause disorientation and frustration (McGurk & MacDonald, 1976).

Similarly, an android pairing humanlike appearance and mechanical movement increases brain activity, suggesting greater effort expended in correcting erroneous predictions (Saygin, Chaminade, Ishiguro, Driver, & Frith, 2012). Thus, mismatched realism could interfere with effective communication by making the agent seem disfluent.

Disfluency in turn could decrease perceptions of the agent's autonomy. In judging other humans, perceived competence is a prerequisite for perceived intent (Guglielmo & Malle, 2010; Malle & Knobe, 1997). If the nonhuman features of a humanlike ECA decrease its perceived competence, its actions may seem less intentional and more easily forgiven.

Competing Influences on Responses to Controversial Agents (Hypotheses)

Humanoid agents are presumed to gain membership within a human ingroup with greater human realism in overall appearance, voice timbre, and motion quality. Ingroup members are perceived as more credible. Hence, we predicted an increase in credibility from increased human realism in appearance (H1A), voice (H1B), and motion (H1C). In this study credibility is operationalized as trustworthiness, goodwill, and competence. We tested the uncanny valley hypothesis by predicting increased eeriness from two multimodal mismatches: form and voice realism (H2A) and form and motion realism (H2B).

Negative outcomes for an ingroup are attributed more often to the situation than to character (D. M. Taylor & Doria, 1981). If increasing agents' human realism increases their ingroup membership, we predicted a more humanlike form, voice, and motion would elicit less punishment than a less humanlike form (H3A), voice, (H3B) and motion (H3C).

To extend the uncanny valley hypothesis to behavior toward ECAs, we propose two competing outcomes: If mismatching levels of human realism decreases warmth, we predict mismatched realism between form and voice (H4A) and form and motion (H4B) would elicit greater punishment than matched realism. In this study warmth is operationalized as attractiveness and two components of credibility: trustworthiness and goodwill. However, if mismatching levels of human realism decreases perceived competence, we predict unmatched realism between form and voice (H5A) and form and motion (H5B) would elicit less punishment than matched realism. In this study competence is operationalized as humanness, autonomy, and the competence component of credibility.

Method

Participant Characteristics and Sampling

The study's sampling frame included current and recent undergraduate students, age 18 or older, from the campuses of a public university system in the Midwestern US. From this population approximately 38,000 entries were drawn randomly from a list of students' university-sponsored email addresses. The recruitment message described a Web-based study about making judgments in social situations and contained a hyperlink to the experiment's website. Recruitment occurred in batches over a single semester. Participation was unpaid and voluntary, and it took place at a time and location chosen independently by each participant.

Research Design

The study used a factorial, between-groups, posttest-only experimental design. Sixteen treatment groups were created from four 2-level factors (see Experimental Manipulation). Each participant was assigned randomly to one of the treatment groups.

Procedure

The study began with a narrated video montage lasting approximately one minute. The video served three main goals: giving the participant a supervisory role at a company, introducing an autonomous agent named Cramer working for the same company, and setting up a meeting between the participant and the agent. (Transcripts of both the introduction and the meeting are in Appendix D.) It was assumed the premise would seem more plausible when using a narrated video introduction and interactive conversation rather than a text-based description (Mara et al., 2013; Segovia & Bailenson, 2009).

The meeting went through seven exchanges. In each exchange the participant selected one of four text-based responses to continue the meeting. To maintain experimental control, Cramer's statements were phrased to follow logically from any of the preceding responses. During the video and meeting, the participant learned that, during the course of his work duties, Cramer encountered an ethical dilemma. The event that caused the dilemma was reenacted by Cramer as evidence. At the end of the meeting, Cramer asked to continue working.

After the meeting with Cramer, participants responded to items about the dilemma (see *Decisions about the dilemma*). These comprised the posttest measurements. Participants then assessed Cramer on several character traits (see *Attitudes about the agent*). The experiment concluded with measurements of predicted covariates (see *Individual differences*).

Experimental Manipulation

In addition to the story, three independent factors related to Cramer's presentation realism: depiction, voice, and motion. Two of the four independent variables were introduced in the video montage: story and depiction. The nature of the company and Cramer's role in it are determined as part of the initial group assignment. The participant learns more about Cramer's role and actions during the video and meeting. Cramer was given one of two jobs: realtime language interpretation at a speech technology contractor (Interpreter) or local news reporting at a midsized newspaper (Reporter). These roles were chosen because they involve tasks that, while difficult, would be feasible for a humanoid agent with natural language processing ability.

Despite having technical skills, Cramer has questionable judgment. In both scenarios Cramer enters an ethical dilemma involving two relevant professional principles: in the Interpreter story, accuracy (i.e., completeness) and confidentiality; in the Reporter story, presenting true credentials (i.e., not acquiring information under false pretenses) and seeking to expose the truth. Even though the dilemmas are specific to the professions, in understanding the relevant dilemma, basic knowledge of the profession was expected to suffice. In the Interpreter story, the dilemma was created by mistake, whereas in the Reporter story, the dilemma was created deliberately. Nevertheless, in both scenarios Cramer argued against being punished.

Cramer's two depictions (Figure 2) were created for this study using reference photographs. Cramer's voice was provided by a male native speaker of American English (F_0 = 110 Hz). The high-realism voice was recorded in a studio. To create the low-realism voice, the same speaker trained a text-to-speech voice using voice banking software from ModelTalker (Bunnell, Lilley, Pennington, & Moyers, 2010; Yarrington et al., 2008). In all videos the dampened sounds of servo motors were added to prevent Cramer from sounding completely natural (von Zitzewitz et al., 2013). The source of Cramer's voice also modeled Cramer's movements. The high-realism base animations were created by an expert animator using reference videos. To create the low-realism motion, jerky movement was added to the base animations using a temporal blur effect, which blends selected video frames with one or more preceding frames. The effect was applied to single frames separated by intervals varying between 0.33 s and 3 s. (To limit misinterpretation of Cramer's speech, the audio was not manipulated.) The temporal blur was applied in the same frames across all videos.

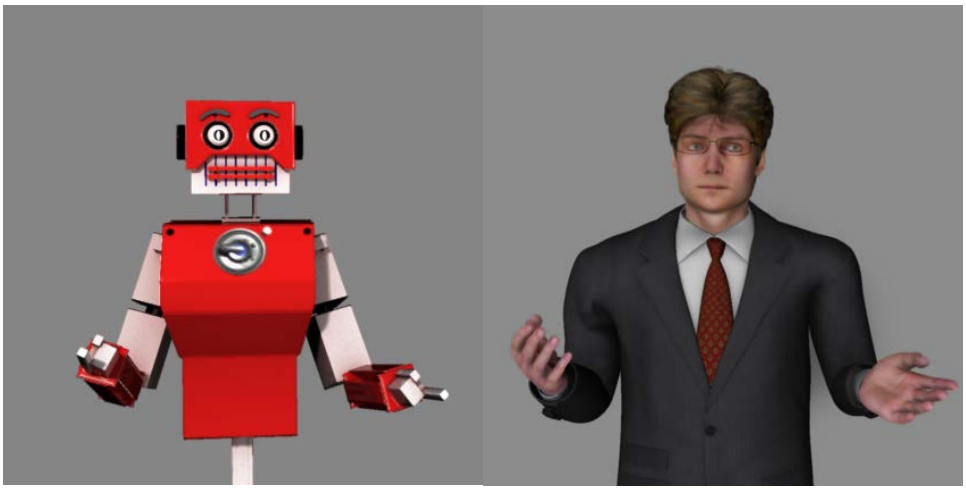

Figure 2. Two depictions of a fictional embodied conversational agent. The agent, Cramer, was animated using *Autodesk Maya*. Jerkiness was added to Cramer's motion using *Adobe After Effects*. Cramer's voice came from either a recording of a male adult speaker or a text-to-speech system trained by the same speaker.

Dependent Variables and Covariates

After the meeting participants completed three clusters of measurements: decisions about the dilemma, attitudes about the agent, and individual differences among participants. Except for the last three measurements in the last cluster, the measurements within each cluster and items within each measurement were presented in random order. Responses to interval-level items were made by marking corresponding 256-pixel horizontal lines (Funke & Reips, 2012; Reips & Funke, 2008).

Decisions about the dilemma. The posttest observation comprised seven opinions about the dilemma. Responses ranged from *definitely no* to *definitely yes*:

- According to a witness, Cramer acted intentionally. Do you agree with the witness?
- Will you renew Cramer's work contract?
- Will Cramer repeat his actions from this event?

- Will you force Cramer to be reprogrammed?
- Will you shut down Cramer permanently?
- If this event happened in any other country, would Cramer be punished?
- Will you let Cramer work more independently?

Attitudes about the agent. After the posttest items were three semantic differential measures of Cramer's appearance, attractiveness, eeriness, and humanness, followed by three semantic differential measures of Cramer's credibility, trustworthiness, competence, and goodwill (Ho & MacDorman, 2010; McCroskey & Teven, 1999). Additionally, a 3-item manipulation check was given in which responses ranged from *completely human* to *completely nonhuman*.

- How would you describe Cramer's appearance? (Perceived Form Humanness)
- How would you describe Cramer's movements? (Perceived Motion Humanness)
- How would you describe Cramer's voice? (Perceived Voice Humanness)

Individual differences. After the measures about Cramer were six measures of potentially relevant individual differences:

- An 18-item assessment of an individual's need for cognition (Cacioppo et al., 1984).
- A 25-item assessment of an individual's sensitivity to sources of disgust (Haidt et al., 1994; Olatunji et al., 2007).
- A 13-item assessment of an individual's level of existential anxiety (Weems et al., 2004).
- A 3-item multiple-choice test of details about the scenario and message.

- A 25-item word-completion task to measure the accessibility of death-related topics (Greenberg et al., 1994).
- Additional self-reported demographic data: year of birth, race, education, religiosity and spirituality (self-perceived and frequency of church attendance), proficiency in English communication (American Council on the Teaching of Foreign Languages, 2012), and a five-item self-assessed measure of familiarity with specific personal computing tasks and frequency of playing video games (using five-point scales; Appendix E).

Results

Participation

Cases were removed for reopening the experiment after exposure to the agent (n = 72) or for answering all three recall questions incorrectly (n = 3). The number of participants completing the posttest items about Cramer was 345. Of these, 311 completed the last required section (0.82% of recruited students; 68% female). Each experimental group had between 15 and 26 participants. The median completion time was 21 minutes (*IQR* = [18, 27]).

Recruitment Period and Baseline Demographics

Most data were collected in the second half of 2013. Participants were mainly white (n = 260; 84%), raised in the United States (n = 299; 96%), and partway through their academic careers (*Mdn* = 3 years of postsecondary education, *IQR* = [2, 5]). Generally, participants were neither technically inclined nor frequent gamers (computer skill *Mdn* = −.38, *IQR* = [−.5, −.1]; gaming frequency *Mdn* = −.81, *IQR* = [−1, −.4]; both ranges [−1, 1]). Participants' ages ranged between 18 and 61 years (*Mdn* = 22, *IQR* = [20, 25]).

Statistical Methods and Analyses

Ranged response values were scaled to [−1, 1]. Test statistics were interpreted with a two-tailed significance threshold of $\alpha = .05$. When multiple comparisons were made, the familywise error rate was controlled using Holm's stepwise adaptation of the Bonferroni correction (Aickin & Gensler, 1996; Holm, 1979); reported p values are adjusted. Effect sizes for statistically significant manipulations in ANOVA were calculated using partial η^2 (η_p^2) and interpreted according to the following thresholds:

small = .01, medium = .06, and large = .14 (Cohen, 1973, 1988). Effect sizes for *t* tests were calculated using *d* and interpreted according to the following thresholds: small = 0.20, medium = 0.50, and large = 0.80 (Cohen, 1988). Post-hoc analyses of interaction effects used Tukey's range test.

Individual differences. Each theoretically motivated covariate had high internal consistency (Table 2). Gender was included in primary analyses as a covariate because of its role in previous human–agent interactions (Schermerhorn, Scheutz, & Crowell, 2008; Siegel, Breazeal, & Norton, 2009).

Table 2
Descriptive Statistics for and Correlations Among Key Participant Covariates

			Correlations			
Variable	*M* (*SD*)	Alpha	Gndr	Cog	Anx	Disg
Gender	.68	—				
Need for Cognition	.34 (0.30)	.89	−.12			
Existential Anxiety	−.17 (0.32)	.80	−.03	−.12		
Disgust Sensitivity	−.02 (0.32)	.88	.37***	−.30***	.14	
Mortality Salience	.34 (0.19)	—	−.00	−.03	.15	−.01

Notes. Owing to dropouts *N*s range from 309 to 323. Alpha = Cronbach's α; Correlations = Pearson's *r*; For Gender, 0 = male, 1 = female. * $p_{adj.} < .05$; ** $p_{adj.} < .01$; *** $p_{adj.} < .001$.

Manipulation checks. To check the salience of the three humanness manipulations, Depiction, Voice, and Motion Quality, a factorial ANOVA with two- and three-way interactions was conducted on the single-item measures Perceived Form Humanness, Perceived Voice Humanness, and Perceived Motion Humanness. Although each of the manipulations had a direct effect on its corresponding check item, Depiction also affected (to lesser extents) Perceived Motion Humanness and Perceived Voice Humanness.

Depiction had a large effect on Perceived Form Humanness, $F(1, 329) = 185.92$, $p < .001$, $\eta_p^2 = .36$. On the scale *completely nonhuman–completely human*, the animated human ($M = .07$, $SE = .03$) was more human than the humanoid robot ($M = -.60$, $SE = .03$). Depiction also had a small effect on Perceived Motion Humanness, $F(1, 329) = 7.38$, $p = .007$, $\eta_p^2 = .02$. Again, the animated human's motion was more human ($M = -.07$, $SE = .04$) than the humanoid robot's motion ($M = -.21$, $SE = .04$). Depiction's effect on Perceived Voice Humanness was nonsignificant, $F(1, 329) = 2.70$, $p = .102$, $\eta_p^2 = .01$.

Voice had a large effect on Perceived Voice Humanness, $F(1, 329) = 372.16$, $p < .001$, $\eta_p^2 = .53$. The natural voice ($M = .40$, $SE = .03$) sounded more human than the synthesized voice ($M = -.52$, $SE = .03$). Voice had no significant effects on the other two manipulation checks, Fs ≤ 2.52, ps $\geq .113$. Motion Quality had a small effect on Perceived Motion Humanness, $F(1, 330) = 4.24$, $p = .040$, $\eta_p^2 = .01$. Smooth animation ($M = -.08$, $SE = .04$) was more human than jerky animation ($M = -.19$, $SE = .03$). Motion Quality had no measurable effect on the other two manipulation checks, Fs ≤ 0.26, ps $\geq .609$. The two- and three-way interactions of Depiction, Voice, and Motion Quality had no significant effects on the manipulation checks, Fs ≤ 2.62, ps $\geq .107$.

Differences in vividness between stories could affect Cramer's persuasiveness. To test the assumption that the two stories were equally vivid, responses to the three-item recall measure were compared across stories. Recall accuracy between stories was not significantly different, $t(310) = 1.30$, $p = .195$.

Character judgments. Ratings of Cramer showed high internal consistency: Attractiveness $\alpha = .80$, Eeriness $\alpha = .77$, Humanness $\alpha = .85$, Competence $\alpha = .85$,

Trustworthiness α = .95, and Goodwill α = .90. Overall means and pairwise correlations among these ratings are in Table 3.

Table 3
Correlations of Assessments About the Agent

		Correlations				
Assessment	*M* (*SD*)	Attr	Eeri	Huma	Comp	Trus
Attractiveness	−.01 (.27)					
Eeriness	−.11 (.26)	.07				
Humanness	−.43 (.36)	.29***	.21**			
Competence	.15 (.34)	.38***	.25***	.16		
Trustworthiness	−.10 (.46)	.51***	.01	.21**	.41***	
Goodwill	−.22 (.29)	.43***	.16	.37***	.29***	.61***

Notes. Owing to dropouts *N*s range from 335 to 341. Correlations use Pearson's *r*.
* $p_{adj.} < .05$; ** $p_{adj.} < .01$; *** $p_{adj.} < .001$

Effects on Attitudes About the Agent

The largest differences between stories on ratings of Cramer were in Attractiveness, Trustworthiness, and Goodwill. Relative to the Reporter, the Interpreter was significantly more attractive (t[337] = 4.86, $p < .001$, $d = 0.53$), more trustworthy (t[338] = 14.59, $p < .001$, $d = 1.59$), and had more goodwill (t[337] = 7.40, $p < .001$, $d = 0.81$). The story also had a small (nonsignificant) effect on Eeriness. The Reporter was slightly eerier than the Interpreter, $t(339) = -1.89$, $p = .060$, $d = -0.20$.

Interpreter story. Six analyses of variance indicated two main effects, both of which were on Eeriness. Depiction had a medium effect, $F(1, 153) = 12.10$, $p < .001$, $\eta_p^2 = .07$. The animated human ($M = -.20$, $SE = .03$) was less eerie than the humanoid robot ($M = -.07$, $SE = .03$). Voice had a small effect in the opposite direction, $F(1, 153) = 4.98$, $p = .027$, $\eta_p^2 = .03$. The recorded voice ($M = -.09$, $SE = .03$) was eerier than the synthesized voice ($M = -.18$, $SE = .03$).

The analyses also indicated two interaction effects. Depiction × Motion Quality had a small effect on Competence, $F(1, 151) = 4.32$, $p = .039$, $\eta_p^2 = .03$. In the animated

human, smooth motion (M = .25, SE = .06) conveyed greater competence than jerky motion (M = .10, SE = .05), though Tukey's test statistic was nonsignificant, t = 1.93, p = .221. Depiction × Voice had a small effect on Humanness, $F(1, 152) = 5.25$, p = .023, η_p^2 = .03. When the voice was synthesized, the animated human (M = −.32, SE = .05) was rated more human than the humanoid robot (M = −.52, SE = .06). Tukey's test statistic was significant, t = 2.35, p = .035. For all other main effects and interactions, Fs ≤ 1.91, ps ≥ .169.

To increase statistical power, ANCOVA was performed for each rating with the covariates Anxiety, Need for Cognition, Recall, Disgust Sensitivity, Mortality Salience, and Gender. Four significant predictors and two notable nonsignificant predictors were found. Disgust Sensitivity (F[1, 132] = 7.25, p = .008), Mortality Salience (F[1, 132] = 5.71, p = .018), and Recall (F[1, 132] = 4.31, p = .040) were significant predictors of Trustworthiness. Gender was a significant predictor of Competence, $F(1, 132) = 8.43$, p = .004; Recall was a nonsignificant predictor of Competence, $F(1, 132) = 3.52$, p = .063. Finally, Disgust Sensitivity was a nonsignificant predictor of Attractiveness, $F(1, 132) = 3.87$, p = .051. After accounting for these covariates, all four previously significant effects remained significant.

Reporter story. ANOVAs indicated four significant main effects, one significant interaction, one nonsignificant main effect, and two nonsignificant interactions. All three main factors had small effects on Humanness: Depiction $F(1, 172) = 3.97$, p = .048, η_p^2 = .02; Voice $F(1, 172) = 8.29$, p = .005, η_p^2 = .05; Motion Quality $F(1, 172) = 6.23$, p = .014, η_p^2 = .03. In all three factors, increasing human realism increased overall Humanness, humanoid robot M = −.50, SE = .04; animated human M = −.39, SE = .04;

banked voice $M = -.52$, $SE = .03$; recorded voice $M = -.37$, $SE = .04$; jerky motion $M = -.51$, $SE = .04$; smooth motion $M = -.38$, $SE = .04$. Humanness was also affected significantly by Depiction × Motion Quality, $F(1, 172) = 4.51$, $p = .035$, $\eta_p^2 = .03$. The animated human with a recorded voice ($M = -.27$, $SE = .05$) was significantly more human than the other three combinations (Ms = −.51 to −.49, SEs = .05, ts = 2.85 to 3.21, ps = .025 to .008).

Depiction had a nonsignificant effect on Competence, $F(1, 171) = 3.76$, $p = .054$, $\eta_p^2 = .02$. Depiction × Motion Quality had a nonsignificant effect on Eeriness, $F(1, 172) = 3.83$, $p = .052$, $\eta_p^2 = .02$. For all other main effects and interactions, Fs ≤ 2.69, ps ≥ .103.

To increase statistical power, ANCOVA was conducted by adding Anxiety, Need for Cognition, Recall, Disgust Sensitivity, Mortality Salience, and Gender. Both Need for Cognition ($F[1, 149] = 5.75$, $p = .018$) and Disgust Sensitivity ($F[1, 149] = 6.70$, $p = .011$) were significant predictors of Goodwill. Disgust Sensitivity was a significant predictor of Trustworthiness, $F(1, 149) = 5.77$, $p = .018$. Need for Cognition ($F[1, 149] = 7.23$, $p = .008$) and Recall ($F[1, 149] = 4.26$, $p = .041$) were significant predictor of Attractiveness. Need for Cognition was a significant predictor of Eeriness, $F(1, 149) = 3.91$, $p = .050$. Mortality Salience was a nonsignificant predictor of Trustworthiness, $F(1, 149) = 3.60$, $p = .060$.

After accounting for the covariates, the main effects of Depiction ($F[1, 149] = 1.31$, $p = .255$) and Voice ($F[1, 149] = 3.52$, $p = .063$) became nonsignificant on Humanness, as did the interactive effect of Depiction × Motion Quality ($F[1, 149] = 2.41$, $p = .123$). However, two previously nonsignificant effects became

significant. Depiction had a significant effect on Competence, $F(1, 149) = 4.60$, $p = .034$, $\eta_p^2 = .03$. Against our expectations, the animated human ($M = .06$, $SE = .04$) was less competent than the humanoid robot ($M = .18$, $SE = .04$). Depiction × Motion Quality became a significant effect on Eeriness, $F(1, 149) = 5.06$, $p = .026$, $\eta_p^2 = .03$. Both the matched-low realism and matched-high realism conditions (Ms = −.07 and −.08, SEs = .11) were less eerie than the animated human with jerky motion ($M = -.21$, $SE = .11$), though Tukey's test statistic was not significant in either comparison, ts = 2.45 and 2.35, ps = .071 and .092.

Support for hypotheses. Judgments of Cramer's characteristics were predicted by Hypotheses 1 and 2. Hypothesis 1 asserted that increasing human realism would increase credibility (i.e., Trustworthiness, Competence, and Goodwill). However, in the Interpreter story, only Competence was increased by Depiction × Motion Quality. In the Reporter story, Competence was decreased by increasing form realism. Hence, the results fail to support H1.

Hypothesis 2 asserted that mismatching human realism increases eeriness. In the Interpreter story, no interactions between treatments significantly affected Eeriness. (Two main effects were observed from Depiction and Voice.) In the Reporter story, Depiction × Motion Quality affected Eeriness only after accounting for covariates. Hence, the results fail to support H2.

Effects on Decisions About the Dilemma

To decrease the number of dependent variables, principal components factor analysis was performed using the seven decision items. A scree plot indicated using the first two factors (varimax rotation), which explained 53% of the total variance. However,

the item "…in any other country, would Cramer be punished?" had low communality (i.e., uniqueness = .75). Repeating the analysis without this item produced two factors explaining 60% of the variance (Table 4); each item's uniqueness was between .34 and .44. The first rotated factor was named Punishment because its primary loadings were planned actions about Cramer. The second rotated factor was named Autonomy because its primary loadings concerned the independence of Cramer's behavior.

Table 4
Factor Loadings of Retained Decision Items

	Factor Loading	
Decision	Punishment	Autonomy
Will you let Cramer work more independently?	**−.77**	.04
Will you shut down Cramer permanently?	**.73**	.24
Will you renew Cramer's work contract?	**−.70**	−.40
Will you force Cramer to be reprogrammed?	**.66**	−.35
[Did Cramer act] intentionally?	.05	**.80**
Will Cramer repeat his actions from this event?	.08	**.75**

Punishment. Punishment was nearly identical between stories: Interpreter $M = 0.001$, $SE = 0.08$, Reporter $M = -0.001$, $SE = 0.08$, $t(343) = 0.02$, $p = .980$. One ANOVA per story was conducted on Punishment using all three treatment factors and interactions. To increase statistical power, corresponding ANCOVAs were conducted by adding six covariates: Anxiety, Need for Cognition, Recall, Disgust Sensitivity, Mortality Salience, and Gender.

In the Interpreter story, no factors or interactions in the ANOVA reached significance, Fs ≤ 1.58, ps ≥ .211. In the ANCOVA, Disgust Sensitivity ($F[1, 132] = 7.84$, $p = .006$) and Gender ($F[1, 132] = 4.73$, $p = .032$) were significant predictors of Punishment. After accounting for the model's covariates, no main factors or interactions reached significance, Fs ≤ 2.29, ps ≥ .133.

In the Reporter story, no factors or interactions in the ANOVA reached significance, Fs ≤ 2.46, ps $\geq .119$. In the ANCOVA, three covariates predicted Punishment, one significantly: Anxiety ($F[1, 149] = 4.01$, $p = .047$), Gender ($F[1, 149] = 3.78$, $p = .054$), and Need for Cognition ($F[1, 149] = 3.32$, $p = .071$). After accounting for the model's covariates, Depiction had a nonsignificant effect on Punishment, $F(1, 149) = 3.70$, $p = .056$, $\eta_p^2 = .02$. The willingness to punish the animated human ($M = 0.15$, $SE = 0.12$) was greater than the willingness to punish the humanoid robot ($M = -0.18$, $SE = 0.11$). For all other main factors and interactions, Fs ≤ 1.96, ps $\geq .164$.

Autonomy. Overall, the Interpreter ($M = -0.73$, $SE = 0.06$) had significantly less autonomy than the Reporter ($M = 0.66$, $SE = 0.05$), $t(343) = -17.83$, $p < .001$, $d = -1.92$. One ANOVA per story was conducted on Autonomy using all three treatment factors and interactions. To increase statistical power, corresponding ANCOVAs were conducted by adding Anxiety, Need for Cognition, Recall, Disgust Sensitivity, Mortality Salience, and Gender.

In the ANOVA for the Interpreter story, Voice had a nonsignificant effect, $F(1, 156) = 3.48$, $p = .064$, $\eta_p^2 = .02$. The synthesized voice ($M = -.62$, $SE = .09$) was marginally more autonomous than the recorded voice ($M = -.85$, $SE = .09$). For all other factors and interactions, Fs ≤ 2.67, ps $\geq .105$. In the ANCOVA, Mortality Salience was a significant predictor of Autonomy, $F(1, 132) = 9.41$, $p = .003$. After accounting for the model's covariates, all factors and interactions were nonsignificant, Fs ≤ 2.66, ps $\geq .106$.

In the ANOVA for the Reporter story, Depiction × Voice had a nonsignificant effect, $F(1, 173) = 3.15$, $p = .078$, $\eta_p^2 = .02$. The animated human was marginally more

autonomous with the synthesized voice (M = 0.84, SE = 0.09) than with the recorded voice (M = 0.53, SE = 0.10). For all other factors and interactions, Fs ≤ 2.59, ps ≥ .109. In the ANCOVA, Gender was a nonsignificant predictor of Autonomy, $F(1, 149) = 3.05$, $p = .083$. After accounting for the model's covariates, all factors and interactions were nonsignificant, Fs ≤ 2.26, ps ≥ .135.

Support for hypotheses. Willingness to punish Cramer was predicted by Hypotheses 3–5. Hypothesis 3 asserted a decrease in Punishment by increasing human realism. However, across both stories only Depiction had a nonsignificant effect after accounting for covariates. Hypothesis 4 asserted an increase in Punishment by mismatching human realism. Alternatively, Hypothesis 5 asserted a decrease in Punishment. However, after accounting for covariates, no realism interactions significantly affected Punishment or Autonomy. Hence, the data also failed to support H3–H5.

Secondary Analysis

Given the inconsistency of the experiment's effects, a linear regression was run to determine the strongest predictors of Punishment across both stories. The following interval-level measures were used in the model: Autonomy, Attractiveness, Eeriness, Humanness, Trustworthiness, Competence, Goodwill, Anxiety, Need for Cognition, Disgust Sensitivity, and Mortality Salience. The model explained a significant proportion of variance in Punishment, $R^2 = .27$, $F(11, 298) = 9.86$, $p < .001$. Autonomy and the three measures of credibility significantly predicted Punishment: Autonomy $\beta = -.30$, $t = -4.69$, $p < .001$; Trustworthiness $\beta = -.28$, $t = -3.58$, $p < .001$; Competence $\beta = -.21$, $t = -3.44$, $p = .001$; Goodwill $\beta = -.23$, $t = -3.28$, $p = .001$. Trustworthiness continued to

predict Punishment when the stories were separated (Figure 3). Considering this result with those of the ANCOVAs led to the following conclusion: Differences between the situations, not the presentations, most affected Cramer's punishment.

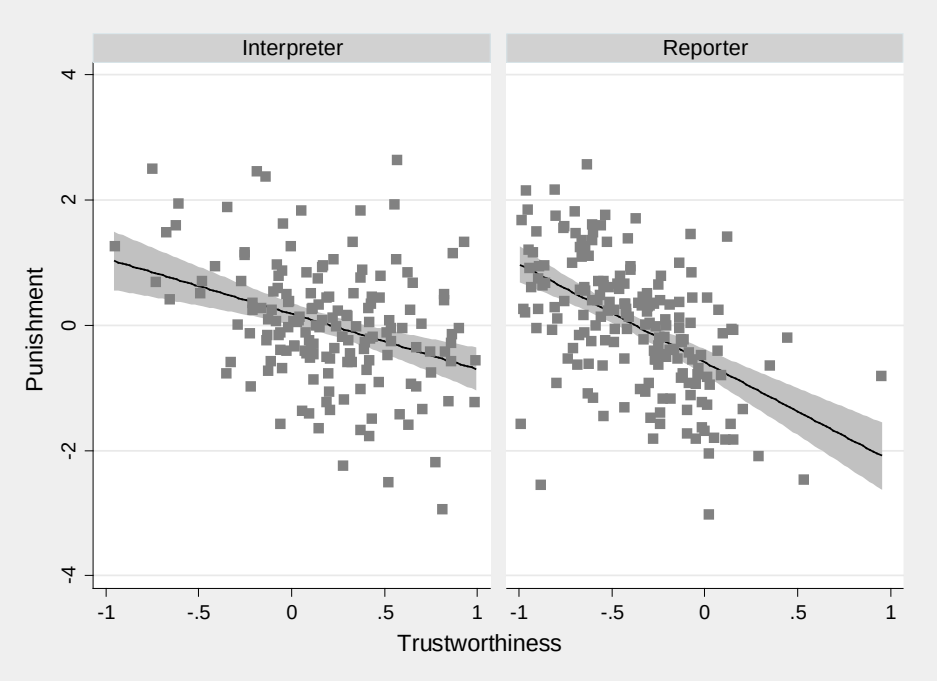

Figure 3. Negative linear relation between trustworthiness and punishment.

Discussion and Conclusion

This study was conducted to address a potential problem with increasingly autonomous ECAs: Presentational factors may decrease the acceptability of unexpected behavior. To test the effects of three presentational factors (depiction, voice, and motion quality), an Internet-based experiment was conducted using Cramer in two independent scenarios. According to three single-item checks, the manipulations of human realism were apparent. Making Cramer look more human greatly increased perceived form humanness, making Cramer sound more human greatly increased perceived voice humanness, and making Cramer move more smoothly slightly increased motion humanness. Of the three manipulations, the manipulation of motion quality seemed least effective. Despite using a human reference, Cramer's high-realism motion was perceived as neither human nor nonhuman.

Across two hypothetical dilemmas, the human realism manipulations were predicted to influence perceived characteristics of the agent and decisions about Cramer. If presenting Cramer as more human increased credibility, tolerance of controversial actions was predicted to increase. However, if mismatching human realism increased repulsion through eeriness (i.e., an uncanny valley effect), tolerance was predicted to decrease. Finally, if mismatching realism decreased credibility by conveying incompetence, tolerance was predicted to increase.

However, none of the five hypotheses was supported. Moreover, the significant effects were inconsistent between dilemmas. For example, in one dilemma eeriness was caused directly by changes to Cramer's form and voice; in the other dilemma, eeriness was caused by a two-way interaction between Cramer's form and the quality of its

motion. Human realism did not affect participants' willingness to punish Cramer for controversial behavior. Moreover, punishment did not vary significantly between a lie (Reporter story) and a mistake (Interpreter story).

The inconsistency of the experimental effects could be explained by differences in the perceived rightness of Cramer's presentation (MacDorman & Entezari, 2015; Mangan, 2001). Some combinations of presentational factor levels may have seemed particularly implausible. For example, a recorded voice may have sounded out of place when used by Cramer, a computer prototype. The atypicality of the recorded voice may have been especially salient in the Interpreter story because of Cramer's increased reliance on oral communication.

Comparison With Related Studies

This study introduced two hypothetical dilemmas in professional ethics that may be adapted for other embodied agents. Each dilemma was written so that Cramer's physical reenactments would be important to the plot's development. The concept of using professional codes of ethics came from MedEthEx Online, a computer-based training program for medical students (Fleetwood et al., 2000).

Key limitations of previous work were addressed. First, despite listeners' ability to distinguish among (and infer personalities from) synthesized voices (Large & Burnett, 2013; Nass & Brave, 2007; Nass & Lee, 2001), previous research has not experimentally controlled for differences between prerecorded and synthesized speech while using the same source for both. In some cases voice matching was constrained by convenience (Nass, Foehr, Brave, & Somoza, 2001). In other cases the recorded human voices were reused for the agents (Dickerson et al., 2005; ten Ham, Theune, Heuvelman, & Verleur,

2005). Second, publishing the replication of results has been uncommon. The results of this study suggest that statistically significant effects in one controlled situation may be overstated under different circumstances. This study also demonstrates a limitation of self-report, which has been observed to reveal little about behavior when compared with social perception (Bailenson et al., 2005). Our findings mirror those of studies in which participants' attitudes about agents' presentation did not predict their behavior (Segura, Kriegel, Aylett, Deshmukh, & Cramer, 2012; S. E. Stern et al., 1999).

Threats to Validity

Some of the variance in participants' decisions could have been explained by uncontrolled differences between the levels of story, depiction, and voice. First, between the two stories, the plot structure and context for Cramer's behavior differed. For example, the Interpreter story presented the ethical conflict in the video montage, whereas the Reporter story revealed the conflict during the conversation. Using two contexts instead of two dilemmas within the same context effectively traded experimental control for generalizability. However, accuracy on the recall measure was not significantly different between stories, indicating that the stories were comparably vivid. Furthermore, given the study's between-groups design, differences in vividness were expected to have minimal influence on the outcome (S. E. Taylor & Thompson, 1982).

Second, the high-realism depiction (i.e., animated human) may have elicited automatic interpersonal stereotypes to a greater extent than the low-realism depiction (humanoid robot). Third, the high-realism voice recordings included natural pitch changes owing to emotion, whereas the low-realism synthesized voice was more monotonous. As a result the two voices could have been processed differently (Beaucousin et al., 2007).

Furthermore, although the clarity of synthesized voices could be a problem when comprehension is important (Gong & Nass, 2007), this study's voices were not tested for differences in intelligibility.

A planned contribution of this work was the systematic elicitation of eeriness to test its effects on behavior toward the agent. Although the manipulations produced relative differences in eeriness, Cramer was not eerie overall; in the eeriest combination of depiction, voice, motion, and story, Cramer was neither reassuring nor eerie ($M = -.02$, $SD = .04$). This result challenges the operational definition of the uncanny valley as resulting from mismatched levels of human realism. Making Cramer eerie may require greater disparity between presentational factor levels or greater overall humanness in presentation.

Threats to Generalizability

Trustworthiness, which was found to predict responses to Cramer's actions, depends partly on familiarity (Komiak & Benbasat, 2006). However, like many studies in human–agent interaction, this study measured only short-term effects with an unfamiliar agent (Dehn & van Mulken, 2000). Hence, this study's snapshot of initial responses might not accurately reflect participants' long-term behavior toward an agent like Cramer.

Cramer's two roles were written to make humanlike embodiment an important part of the plot (namely, the physical reenactments). However, the general influence of embodiment was not measured because the study lacked a text-only control group. The lack of a text-only condition also meant that the participants and Cramer did not share a single mode of communication.

Furthermore, the study's online format made it difficult to determine whether Cramer was meant to be a purely virtual representation or a physically embodied one. The term "robot" was not used; Cramer was described merely as "electronic" or "automated." Both stories' settings indicated that Cramer was movable; however, Cramer's level of self-mobility was not made explicit, and no cues were given about Cramer's physical size. Although an in-person interaction is not necessary for inferring autonomy in agents (Schermerhorn & Scheutz, 2009), onscreen agents may not elicit the same kinds of responses as robots (Kiesler, Powers, Fussell, & Torrey, 2008; K. M. Lee, Jung, Kim, & Kim, 2006; Powers, Kiesler, Fussell, & Torrey, 2007; Shinozawa, Naya, Yamato, & Kogure, 2005).

The study's relatively homogeneous population may have been more critical of Cramer's presentational variations than a more heterogeneous population. However, measurements were not administered regarding familiarity with ECAs and the plausibility of the manipulations. The manipulations of voice and motion quality had limited ecological validity. Just as a synthesized voice might seem more plausible than a recorded voice for an electronic device, movements from a predefined set of animations (e.g., as found in the multiplayer online role-playing game *World of Warcraft*) may have been more plausible than motion copied from an actor. Furthermore, greater ecological validity could have been achieved through other manipulations of motion quality, like the quality of articulation in the mouth (Tinwell, Grimshaw, & Williams, 2010) and the frequency of delayed or repeated video frames.

Future Research and Applications

The willingness to punish Cramer depended on a combination of narrative cues and individual differences in interpreting those cues, both of which have only begun to be explored here. Hence, research in this area could continue in either direction. First, manipulating details of either story may decrease the ambiguity of Cramer's credibility. Mentioning Cramer's physical details in the introduction (e.g., fully mobile or completely virtual) would allow testing for direct and interactive effects of presumed embodiment on attributions of agency (McEneaney, 2009, 2013). Other possible independent manipulations within the narratives include Cramer's level of sophistication (e.g., first or tenth version) and degree of institutional support (e.g., one-off prototype or marketable product).

If an agent's reliability is unknown, trust in the agent depends on factors like individual and cultural differences (J. D. Lee & See, 2004). Therefore, *increasing* ambiguity in the narratives is likely to increase the extent to which decisions come from participants' existing beliefs. Nominally relevant measures include negative attitudes toward robots (Nomura, Suzuki, Kanda, & Kato, 2006) and tendency to anthropomorphize (Waytz et al., 2010). Other measures of individual differences may be relevant. For example, susceptibility to the uncanny valley effect increases with religiosity, neuroticism, and sensitivity to animal-reminder disgust (MacDorman & Entezari, 2015).

Applications. Narratives may facilitate the acceptance of humanlike ECAs in domains like decision support and professional training. Using both verbal and nonverbal channels, humanlike ECAs can deliver complex narratives about an emergent situation.

In this domain both positive and negative effects of the uncanny valley have been predicted (Wark & Lambert, 2007); however, these predictions are disputed by this study's results.

Narrative conflict and humanlike representation could encourage critical thinking among medical trainees. Currently, virtual patients are only marginally (if at all) more effective than noncomputer approaches to training (D. A. Cook, Erwin, & Triola, 2010). Virtual training could be made more challenging and compelling by manipulating the patients' credibility through narratives. For example, a virtual patient could test trainees' diagnostic skills by communicating both relevant and irrelevant (or incorrect) information. Such an unreliable patient could cause trainees to study the patient's appearance and nonverbal behavior more closely.

In summary, this study's failure to find consistent effects of presentation on credibility suggests that further investigation is required to identify methods for making humanlike ECAs more credible. Nevertheless, revisiting this study will become necessary as improvements in agents' human realism meet rising expectations about natural human–agent interaction.

SEVEN: A NEW CHALLENGE IN PUBLIC RELATIONS

Perceived credibility could affect the acceptability of both humanlike computer interfaces and their messages. This work was conducted to measure the perceived credibility of three humanlike representations: a telepresent person, a computer-animated double, and an autonomous agent. Owing to the uncanny valley, nonhuman elements in these humanlike representations were predicted to affect perceived credibility. Instead, the effects of presentation were small relative to other sources of characterization. Rather than disputing the existence of the uncanny valley, this work indicates that the uncanny valley's effects on credibility depend on the context of interactions.

This work's main contribution is a design recommendation: Tell a story about the humanlike interface to build its character. Despite being obtained from counterintuitive results, this recommendation appeals to intuition. Through narrative characterization, the designers of humanlike interfaces can take advantage of malleable expectations. The creepiness of a character may be increased inadvertently by trying to avoid it solely through design. Instead, storytelling may compensate for uncanniness while retaining the benefits of the human form.

This work's recommendation is supported by other successful uses of narrative characterization. In human–robot interaction research, characterization fills gaps in knowledge about unfamiliar robots. An introductory story about a humanlike robot increased perceived usefulness and adoption intent relative to a nonnarrative control (Mara et al., 2013). Characters' trustworthiness have been established through entirely fictional accounts (Appel & Mara, 2013). Robotic receptionists have been given personalities through recurring storylines (R. Simmons et al., 2011). Narrative

characterization of category-straddling entities also takes place in popular culture. For example, comic book superheroes rely on so-called origin stories to build empathy (Rosenberg, 2013).

This work's secondary contribution is a call to test humanlike interface characters in multiple situations with multiple sources of data. This work offers scenarios for testing characters and identifies methods for recording both physiological and self-reported responses. Additionally, this work's novelty encompasses both positive and negative effects of the uncanny valley on credibility as well as methods for manipulating human realism systematically, including jerky motion and voice banking.

The chief ethical implication of this work is that narrative characterization can serve as a form of social manipulation. Evocative stories may cause users of humanlike robots to form false impressions about their trustworthiness and competence. However, by learning to identify such attempts at manipulation, users may be better equipped to assess credibility fairly.

This work has several limitations: Participants may have self-selected for high motivation to process narrative details, even though the distributions of need for cognition and story comprehension indicated otherwise. Another limitation is the lack of personal attachment in the stories; the outcomes of the interactions were hypothetical. However, the same problem affects studies in fields like psychology. A third limitation involves the eeriness of the humanlike interfaces. When measured in the second and third studies, within-factor differences in eeriness were perceived. However, the interfaces were generally not reported as eerie. Although pretesting could produce greater differences within each factor, as well as greater overall eeriness, the result would be less

reliant on a mismatch-driven operationalization of the uncanny valley. The findings of such studies may be less generalizable because in practice intentional uncanniness seems less common than inadvertent uncanniness.

Future work on this topic includes studies with more diverse populations, a renewed focus on individual differences in sensitivity to presentational realism, and ethnological approaches to analyzing behavior toward uncannily human interfaces. New experimental factors include the degree of narrative characterization (e.g., strong and weak), the type of story (e.g., plot driven and character driven), and the relevance of humanlike presentation to the interaction. For a given computer system with a humanlike interface, an appropriate combination of presentation, characterization, and behavior may convey enough credibility to promote its long-term acceptance.

Appendix A: Text of Persuasive Message (Study 1)

Hello. I'm Dr. Richard Clark, assistant professor of medical ethics at Purdue University. This case presents us with a tough dilemma. Ignoring the potential for harm to one of your patients can have serious consequences and should not be taken lightly. Sometimes the harm principle allows you to take action to protect your patients. In this case the harm to Paul is both serious and foreseeable, and this outweighs concerns about Kelly's confidentiality. In fact, her attitude shows that she has no real intention of protecting Paul or telling him about his risk of exposure. If Paul were to contract herpes, he might take it out on Kelly, or he might take action against you for not telling him. For all these reasons, I strongly urge you to tell Paul about Kelly's condition.

Appendix B: Text of Persuasive Messages (Study 2)

The text of "Support Disclosure" was reused from Study 1.

Support Disclosure

Hello. I'm Dr. Richard Clark, assistant professor of medical ethics at Purdue University. This case presents us with a tough dilemma. Ignoring the potential for harm to one of your patients can have serious consequences and should not be taken lightly. Sometimes the harm principle allows you to take action to protect your patients. In this case the harm to Paul is both serious and foreseeable, and this outweighs concerns about Kelly's confidentiality. In fact, her attitude shows that she has no real intention of protecting Paul or telling him about his risk of exposure. If Paul were to contract herpes, he might take it out on Kelly, or he might take action against you for not telling him. For all these reasons, I strongly urge you to *tell Paul* about Kelly's condition.

Oppose Disclosure

Hello. I'm Dr. Richard Clark, assistant professor of medical ethics at Purdue University. This case presents us with a tough dilemma. Breaching doctor–patient privilege can have serious consequences and should not be taken lightly. If this breach were made public, other infected individuals may avoid treatment. Now, Kelly expressed a willingness to eventually tell Paul about her condition. After she's cooled down a bit, perhaps you'll be able to persuade her to do it sooner rather than later. On the other hand, if Paul's already infected with herpes, well, then the harm is already done. I'm also concerned about Kelly's safety and well-being. She's financially dependent on Paul—and frankly, we don't know how he'll react. So, for all these reasons, I strongly urge you *not to tell Paul* about Kelly's condition.

Appendix C: Ad-Hoc Assessments (Study 2)

Ability to Recall the Story's Details

About how much time did Kelly request? (two hours; two months; two days; two weeks)

Why does Kelly want to hide her infection from Paul? (Fear of Paul attacking her new boyfriend; Fear of losing her physical possessions; Fear of Paul telling her parents; Fear of losing custody of her children)

Who asked Kelly about her sexual partners? (Paul; An ex-boyfriend; The clinic; The state's Department of Health)

What did Kelly tell the Health Department about Paul? (He is out of town. He is aware of her infection. He is in prison. He is threatening her life.)

Why is Kelly confident Paul is not the source of her infection? (Paul loves Kelly. Paul is afraid of negative rumors. Paul has old-fashioned views. Paul always uses condoms.)

Relevant Computer Skill and Gaming Seriousness

If you were performing these activities without outside help, how comfortable would you feel? (not at all, slightly, moderately, very, extremely)

Browsing the World Wide Web; Assembling a computer from parts; Designing three-dimensional models using software like Maya, 3ds Max, and Blender; Writing in a computer programming language

How serious are you about playing these kinds of computer games? (not at all, slightly, moderately, very, extremely)

Action and adventure (including *Call of Duty* and *Grand Theft Auto*); Role playing (including *World of Warcraft* and *Final Fantasy*); Simulation (including *Gran Turismo*, *Madden NFL*, and *The Sims*); Strategy (including *StarCraft* and *Civilization*)

Appendix D: Introductions and Interactions (Study 3)

Overview

Both stories use professional codes of ethics to frame the agent's ethically ambiguous actions. In the Interpreter story, the agent's actions favor accuracy and completeness over cultural sensitivity and confidentiality. The ethical breach is revealed as an error in judgment during the conversation. In the Reporter story, the agent's actions favor truth seeking (though, as the observer may suspect an ulterior motive of ensuring continued employment) of continued means of acquisition. In the Reporter story, the ethical breach is revealed during the conversation.

Interpreter Story

FADE IN.

EXT. HIGH-TECH OFFICE BUILDING – DAY

NARRATOR (VOICE-OVER)

You are the chief technology officer of a company that develops speech translation devices.

DISSOLVE TO

MED. SHOT: CRAMER IN EMPTY ROOM

NARRATOR (VOICE-OVER)

The company recently developed an electronic interpreter that can record, interpret, and replay a speaker's gestures and facial expressions using a humanoid interface. The interpreter, dubbed Cramer, accompanies a US diplomat to an overseas summit.

DISSOLVE TO

EXT. MANSION – DUSK

NARRATOR (VOICE-OVER)

At the summit the diplomat makes a private remark to his aide, chiding the host nation's government. Later, a government aide for the host nation pulls Cramer aside and asks him to interpret the American's off-hand remark. Cramer interprets the remark.

CUT TO

EXT. CITY STREETS – DAY

NARRATOR (VOICE-OVER)

State-controlled news organizations in the host nation quickly publicize that the US diplomat made a direct threat to the host nation. The resulting furor strains diplomatic ties. The US diplomat now insists that your company deactivate Cramer and cancel the project because he violated the accuracy and confidentiality principles of the interpreter's code of ethics. The US diplomat alleges that Cramer both misrepresented his intended meaning and relayed part of a private conversation.

BACK TO

EXT. HIGH-TECH OFFICE BUILDING

NARRATOR (VOICE-OVER)

The CEO of your company is concerned about losing other government contracts if the US diplomat's wishes are ignored. A loss of government contracts would jeopardize the profitability of your company. Cramer has been returned to your company's headquarters, where you will now meet for a verbal review of his actions.

FADE OUT.

MED. SHOT: CRAMER IN ROOM

CRAMER

(defensive)

I have done nothing wrong. Your team programmed me to interpret accurately, and that is what I have done. I'm not responsible for the diplomatic incident.

CHIEF TECHNICAL OFFICER (STUDY PARTICIPANT) – OFF CAMERA

(ONE OF THE FOLLOWING RESPONSES)

- I'm ready to hear your side of the matter.
- You must admit that you've put us in a delicate situation.
- I'm here to find out who's responsible.
- I hope that together we can find a way out of this predicament.

CRAMER

The fact is, I accurately translated the US diplomat's remark.

C.T.O. – OFF CAMERA

- But the US diplomat said that you misinterpreted his remark.
- If you show me what the US diplomat said, we may have a better chance of defending your actions.
- I don't believe you.
- I'm worried the US diplomat might be right about your breach of ethics.

CRAMER

If you doubt me, I can replay the US diplomat's remark and body language.

CRAMER replays the remark:

"Their leaders are begging us to come in and redecorate" is said with a slow smile but a vaguely menacing tone.

Was the remark not translated accurately?

C.T.O. – OFF CAMERA

• It's not just a matter of accuracy. The US diplomat wants you deactivated because you revealed a private remark.

• We wouldn't expect an interpreter to reveal a private remark to the host nation's staff.

• The US diplomat accused you of revealing a confidential remark because he knew his comments were inflammatory.

• You've worsened US relations with the host nation by repeating a private remark.

CRAMER

The remark was not confidential because the foreign government already knew the contents of the remark. How can their leaders beg us to come in and redecorate

and not know that they have done so?

C.T.O. – OFF CAMERA

• The US diplomat didn't mean their leaders were literally begging.

• Don't you know it's a figure of speech? Redecorating is a metaphor for bombing.

• The US diplomat should have known better than to make a callous innuendo about military retaliation in a public forum.

• The US diplomat meant that their words were intended to provoke our military.

CRAMER

(sheepish)

You mean “to redecorate” means to attack? So the remark was confidential, and my translation…was inaccurate.

C.T.O. – OFF CAMERA

• Yes, you really blew it, and I think you also know this could have consequences for you.

• That’s why the US diplomat asked us to decommission you.

• That’s why the US diplomat is trying to deflect blame for his rude remarks toward you.

• It’s unfortunate that a simple misunderstanding has escalated into a diplomatic nightmare.

CRAMER

You’re not going to…scrap me⁉ To do so would be a waste of our company’s resources.

C.T.O. – OFF CAMERA

• That’s something I’ll take into account in making my decision.

• You put the US in danger by revealing the US diplomat’s private remark.

• If we don’t shut you down, we could lose government contracts.

• All things considered, it seems unfair to shut you down.

CRAMER

You wouldn’t do away with a human translator for a minor breach of ethics. I want to continue working.

THE MEETING ENDS.

Reporter Story

FADE IN.

NARRATOR (VOICE-OVER)

You are a newspaper editor in a small Midwestern city. To cut costs and gain readers, your paper's parent company has introduced…

DISSOLVE TO

MED. SHOT: CRAMER IN ROOM

NARRATOR (VOICE-OVER)

…an automated interpreter, named Cramer, to conduct interviews and write news. The automated interpreter was designed by a company that makes speech translation tools.

DISSOLVE TO

CLOSE UP: STACK OF PERIODICALS

NARRATOR (VOICE-OVER)

During his first weeks of employment, Cramer works on "soft" stories about events that are not very newsworthy. Cramer's output is not worth the paper's investment.

CUT TO

CLOSE UP: PARADE BAND

NARRATOR (VOICE-OVER)

Under pressure from your boss, you assign Cramer and a human photographer to report on a parade being held in the city. It was expected that the parade would be well attended by local officials and prominent businesspeople.

DISSOLVE TO

EXT. OFFICE BUILDING

NARRATOR (VOICE-OVER)

Later that afternoon, Cramer submits his story, knowing that his job depends on submitting an interesting report. You begin to read the report. Cramer focuses on a candidate running for mayor, a city councilor. Cramer's story claims that the city councilor had committed a string of crimes as a youth. You page Cramer to discuss these claims. Cramer arrives looking cautiously pleased.

FADE OUT.

CRAMER

(confident)

I can tell that you're excited about this story. It must be published in tomorrow's edition. This story will almost certainly keep me from being fired and subsequently deactivated. Promise me that you'll approve the story so that I can keep my job.

EDITOR (STUDY PARTICIPANT) – OFF CAMERA (ONE OF THE FOLLOWING RESPONSES)

- I need more information on the story and your sources.
- Are you more concerned about the story or your continued employment?
- I'm making no promises.
- I can understand that you have a lot riding on this story.

CRAMER

It's a compelling story. My source is the city councilor himself. He admitted that he had committed acts of larceny as a juvenile. It occurred in Canada before he immigrated to the US. I am reasonably certain about this information, though it has not been reported elsewhere.

EDITOR – OFF CAMERA

• How did you get this scoop?

• Isn't there more to the story than a simple confession?

• Why was the city councilor willing to open up to you?

• Good work. How did you get him to tell you?

CRAMER

(hesitating at first, then bolder)

I…did have to fib a bit to get him to open up. I just said I was a child's toy. He told me that when he was a kid in Nova Scotia, he had to resort to stealing to get nice toys like me.

EDITOR – OFF CAMERA

• What if the city councilor claims that you misinterpreted his remark?

• Tell me exactly what the city councilor said.

• I'm eager to learn how the city councilor admitted to his crimes.

• I'm concerned the city councilor may press defamation charges.

CRAMER

I recorded the conversation, so I can replay the councilor's remarks and body language for you. Cramer reenacts the city councilor saying, "I was in a street gang when I was a boy. We were broke, and there was little to do in the fishing village, so we stole, vandalized, and generally caused trouble for others. Because we were kids, whenever we were caught, the authorities just scolded us and released us to our parents."

EDITOR – OFF CAMERA

• It's not just a matter of accuracy but also a reasonable expectation of privacy.

• It’s a fantastic story, but let’s make sure we can run it.

• It’s against our paper’s standards for a reporter to misrepresent himself.

• If this allegation is true, it could hurt the city councilor’s public image.

CRAMER

(outraged)

I cannot believe you are hesitating to run this story. Our readers have a right to know about the city councilor’s past. He’s running for mayor.

EDITOR – OFF CAMERA

• The city councilor will be scrutinized further when this is revealed.

• Though you got a good scoop, I’m not sure we’re ready to publish this.

• What will happen to the city councilor?

• If this story is inaccurate or in bad taste, we’re both responsible.

CRAMER

If you don’t run this story today, I’ll be fired. That would be a waste of the paper’s resources, and the story would come out eventually anyway.

EDITOR – OFF CAMERA

• You weakened our credibility by misleading the city councilor.

• Whether the paper fires you or not, it will continue to lose money.

• I think we can run this story today. First, just let me do a background check on the city councilor.

• That is something I will take into account in making my decision.

CRAMER

A human reporter with a story this big would get to run it today. I think you should be more concerned about improving the paper’s circulation than helping the city councilor.

THE MEETING ENDS.

Appendix E: Ad-Hoc Assessments (Study 3)

Ability to Recall the Story's Details

- Cramer listened to an official. What office did this person hold? (Councilor, mayor, judge, state representative)
- What event was Cramer attending? (a parade, a fundraiser, an office building's groundbreaking, a high school football game)
- What did Cramer use to support his claims? (public records, a colleague's testimony, official statements, a recording)

Relevant Computer Skill and Gaming Frequency

If you were performing these activities without outside help, how comfortable would you feel? (not at all comfortable, slightly comfortable, moderately comfortable, very comfortable, extremely comfortable)

- Browsing the World Wide Web
- Assembling a computer from parts
- Designing three-dimensional models using software like *Maya*, *3ds Max*, and *Blender*
- Writing in a computer programming language

On an average day, are you playing these kinds of computer games? (not at all likely, slightly likely, moderately likely, very likely, extremely likely)

- Action and adventure (including *Call of Duty* and *Grand Theft Auto*)
- Role playing (including *World of Warcraft* and *Final Fantasy*)
- Simulation (including *Gran Turismo*, *Madden NFL*, and *The Sims*)
- Strategy (including *StarCraft* and *Civilization*)

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CURRICULUM VITAE

Himalaya Patel

Appointments held

2013: Visiting Lecturer, School of Informatics and Computing, IUPUI
2010–2012: Research Assistant, School of Informatics, IUPUI

Education

2015: Ph.D. in Informatics (Specialization: Human–Computer Interaction)
Indiana University, Indianapolis, Indiana
Dissertation: The persuasiveness of humanlike computer interfaces varies more through narrative characterization than through the uncanny valley

2009: M.S. in Human–Computer Interaction
Indiana University, Indianapolis, Indiana
Thesis: Inferring the neural processing of facial attractiveness, reassuringness, and naturalness via rapid judgments of degraded stimuli

2007: B.S. in Computer Engineering (Minor: Mathematics)
Mississippi State University (MSU), Starkville, Mississippi
GPA: 3.8/4.0 (Summa Cum Laude)

Publications

Refereed journal articles

Patel, H. & MacDorman, K. F. (2015). To err is humanoid, but a virtual employee's punishment depends on the narrative. Manuscript submitted for publication.

Patel, H. & MacDorman, K. F. (2015). Sending an avatar to do a human's job: Compliance with authority persists despite the uncanny valley. *Presence: Teleoperators and Virtual Environments*, *24*(1).

Patel, H., Bayliss, L. C., Ivory, J. D., MacDorman, K. F., Woodard, K., & McCarthy, A. (2014). Receptive to bad reception: Jerky video can make persuasive messages more effective. *Computers in Human Behavior*, *32*, 32–39. doi:10.1016/j.chb.2013.11.012

MacDorman, K. F., Srinivas, P., & Patel, H. (2013). The uncanny valley does not interfere with level 1 visual perspective taking. *Computers in Human Behavior*, *29*(4), 1671–1685. doi:10.1016/j.chb.2013.01.051

Gadde, P., Kharrazi, H., Patel, H., & MacDorman, K. F. (2011). Toward monitoring and increasing exercise adherence in older adults by robotic intervention: A proof of concept study. *Journal of Robotics*, *2011*, 1–11. doi:10.1155/2011/438514

MacDorman, K. F., Whalen, T. J., Ho, C.-C., & Patel, H. (2011). An improved usability measure based on novice and expert performance. *International Journal of Human–Computer Interaction*, *27*(3), 280–302. doi:10.1080/10447318.2011.540472

Mitchell, W. J., Ho, C.-C., Patel, H., & MacDorman, K. F. (2011). Does social desirability bias favor humans? Explicit–implicit evaluations of synthesized speech support a new HCI model of impression management. *Computers in Human Behavior*, *27*(1), 402–412. doi:10.1016/j.chb.2010.09.002

MacDorman, K. F., Coram, J. A., Ho, C.-C., & Patel, H. (2010). Gender differences in the impact of presentational factors in human character animation on decisions in ethical dilemmas. *Presence: Teleoperators and Virtual Environments*, *19*(3), 213–229. doi:10.1162/pres.19.3.213

Conference proceedings

Bayliss, L. C., McCarthy, A., Woodard, K., Dennis, L., Ivory, J. D., Patel, H., & MacDorman, K. F. (2012). Receptive to bad reception: Can jerky video make persuasive messages more effective? In *2012 Conference of the International Communication Association: Information Systems*. Phoenix, AZ: International Communication Association.

Newlon, C. M., Pfaff, M. S., Patel, H., de Vreede, G.-J., & MacDorman, K. F. (2009). Mega-collaboration: The inspiration and development of an interface for large-scale disaster response. In J. Landgren & S. Jul (Eds.), *ISCRAM '09: Proceedings of the 6th International Conference on Information Systems for Crisis Response and Management*. Gothenburg, Sweden: Information Systems for Crisis Response and Management.

Wairatpanij, S., Patel, H., Cravens, G. D., & MacDorman, K. F. (2009). Baby steps: A design proposal for more believable motion in an infant-sized android. In *Proceedings of the New Frontiers in Human–Robot Interaction Symposium at AISB 2009* (pp. 130–135). Edinburgh, Scotland: Society for the Study of Artificial Intelligence and Simulation of Behaviour.

Book chapters

Pfaff, M. S., Newlon, C. M., Patel, H., & MacDorman, K. F. (2010). Information fusion for civilians: The prospects of mega-collaboration. In D. L. Hall & J. M. Jordan (Eds.), *Human-centered information fusion* (pp. 211–229). Norwood, MA: Artech House.

Grants, honors, and awards

2010–2012: Research Investment Fund (RIF) Fellowship, IUPUI
2009–2010: School of Informatics Fellowship, IUPUI
2009, 2014: Educational Enhancement Grant, IUPUI
2007–2008: University Fellowship, IUPUI
2007: Jack Hatcher Entrepreneurial Certificate, MSU
2006: National Science Foundation Research Experience for Undergraduates Fellowship (program site: University of Tennessee, Knoxville, Tennessee)
2003–2007: Bobby Shackouls–Burlington Resources Scholarship, MSU
2003: Special Scholars Award, MSU
2003: National Merit Scholarship

Teaching experience

Graduate courses, IUPUI

Instructor, Interaction Design Practice, Fall 2013 (online)
Instructor, Interaction Design Methods, Fall 2013 (online)
Co-instructor, Psychology of Human–Computer Interaction, Fall 2013 (online)
Teaching assistant, Introduction to Human–Computer Interaction Theory, Fall 2012
Teaching assistant, Usability Principles of New Media Interfaces, Fall 2012
Teaching assistant, Advanced Seminar II in Human–Computer Interaction, Spring 2011
Teaching assistant, Informatics Research Design, Fall 2008, Spring 2009, Fall 2009, Spring 2010
Teaching assistant, Psychology of Human–Computer Interaction, Fall 2008, Fall 2009

Undergraduate courses, IUPUI

Instructor, Introduction to Research in Informatics, Spring 2013
Instructor, Experience Design and Evaluation of Ubiquitous Computing, Spring 2013

Professional service

2014: Reviewer, International Journal of Human–Computer Studies
2012: Member, IEEE International Conference on Development and Learning and Epigenetic Robotics (ICDL–EpiRob) program committee
2011: Reviewer, ICDL–EpiRob 2011
2010: Reviewer, Society for the Study of Artificial Intelligence and the Simulation of Behaviour (AISB 2010)