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Virtual Interpersonal Touch and Digital Chameleons

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Abstract We studied the characteristics of hand touch with a mechanical device that approximated a handshake, and we then examined the effect of handshake mimicry on assessment of a partner. Two participants interacted with a force-feedback joystick that recorded each of their hand movements individually. The two participants then greeted one another by feeling the recording of the other person's movements via the force-feedback device. For each dyad, one of the participants actually received his or her own virtual handshake back under the guise that it was the other person's virtual handshake. Results demonstrated three significant findings. First, for any given participant, a metric that took into account position, angle, speed, and acceleration of the hand movements correlated highly within individuals across two handshakes. Second, across participants, these metrics demonstrated specific differences by gender. Finally, there was an interaction between gender and mimicry, such that male participants liked people who mimicked their handshakes more than female participants did. We discuss the implications of these findings and relate them to theories of social interaction.

Keywords Handshakes · Touch · Mimicry · Immersive virtual reality · Computer-mediated communication

Introduction

In the current work, we examined the use of virtual interpersonal touch. Our goals were to (a) present a tool to capture precise nonverbal metrics relating to handshakes[1], and (b) examine the possibility of using algorithms to implement handshake mimicry.

[1] We realize that our virtual device is an extremely loose approximation of an actual handshake, and refer to the notion of "virtual interpersonal touch" when describing the participants' experience whenever possible. However, in order to maintain readability in the paper we sometimes use the word handshake.

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Interpersonal Touch and Handshaking

Social etiquette constrains the use of touch in public spaces. Indeed, there are well-known rules that govern personal space, rules that are ultimately about staying away from and not touching other people (Argyle and Dean 1965; Hall 1966; Hayduk 1983). Thus, it is not surprising that some paradigms in understanding touch in interpersonal communication frame most forms of touch as a violation of nonverbal expectancies (Burgoon and Walther 1990). This corresponds with the observation that, with the exception of handshaking, most forms of touch in public spaces—handholding, face-touching, etc.—are signs of affection, intimacy, and trust (Burgoon 1991; Lee and Guerrero 2001), and thus too private for most casual social interactions.

Even though social etiquette constrains our use of touch in public spaces, many field studies have in fact demonstrated that touch can be used for social advantage. Waiters who touch their customers on their shoulders or their hands when returning change receive bigger tips (Crusco and Wetzel 1984; Hubbard et al. 2003; Stephen and Zweigenhaft 1985). Touch also increases purchases at stores (Hornik 1991) and consumption at restaurants (Kaufman and Mahoney 1999). Finally, touching someone briefly on the shoulder increases compliance to requests (Gue′guen 2002; Kleinke 1977). Alternatively, studies in uses of therapeutic touch have typically not yielded supporting results across a variety of healing contexts (for a review, see Wardell and Weymouth 2004).

In the current study, we were interested in a highly ritualized form of touch in public spaces—the handshake. As Burgoon (1991) noted, the handshake is widely interpreted as a formal gesture of trust and receptivity. The handshake is also widely thought to be important in making first impressions. Historically, books on social etiquette have dwelled on the proper firmness and duration of the handshake that elicit the most social advantage (Post 1934; Vanderbilt 1957).

Although there have been many studies exploring the meaning and consequences of touch in public spaces, there have been very few studies that have explored handshaking in particular. Nevertheless, these studies consistently demonstrate that handshakes communicate important social cues. In a study where interpersonal touch events were recorded and coded at a several academic conferences (Hall 1996), it was found that higher status individuals were more likely to initiate forms of touch that were more affectionate and directed at the arm or shoulder. Conversely, lower status individuals were more likely to initiate touch that was more formal, such as a handshake. In other words, the handshake is seen as a safe, socially-appropriate form of touch.

Another line of research has explored whether the handshake transmits information about an individual's personality. Early research in this area was carried out by Astrom and colleagues in a series of three small studies. In their first study consisting of 29 psychiatric patients and two trained coders (Astrom et al. 1993), it was found that factors such as temperature and humidity of a handshake may provide information about personality traits such as introversion, but are less useful as diagnostic indicators of psychological disorders. In a broader study that looked at greeting and closing salutations (Astrom 1994), it was found that in the closing handshake, the strength of the grip related to personality variables such as sociability and neuroticism. Finally, a third study confirmed that individuals readily inferred and agreed on personality characteristics of greeting behaviors, particularly with regards to introversion (Astrom and Thorell 1996). Thus, Astrom and his colleagues have shown that greeting behaviors encode personality traits to a certain degree, and that people infer personality traits from greeting behaviors. This research supports the notion that firmness and warmth of a handshake were positively correlated with an individual's extraversion and sociability.

More recent research in this area by Chaplin and colleagues (Chaplin et al. 2000) used a more systematic trained coder methodology to quantify variations in handshaking specifically and how those metrics correlate with self-reported personality traits. For example, these metrics included grip strength and duration. In that study, each participant shook hands with four trained coders and completed personality measures. It was found that participants' handshakes were quite stable across time and coders. In addition, it was found that certain handshake metrics correlated with personality traits. For example, a firm handshake was positively related to extraversion and negatively related to shyness and neuroticism. Furthermore, male participants gave significantly firmer handshakes than female participants. It was also found that male coders had a significantly more positive impression of handshakes they received than female coders. As Chaplin et al. (2000) points out, "handshaking has historically been viewed as a male activity" (p. 110).

Mimicry

In real life, we often mimic other people unconsciously. For example, Kendon noted that a variety of small facial movements and larger arm and leg movements were synchronized within a dyadic or group interaction—a phenomenon he termed *interactional synchrony* (Kendon 1970). Kendon suggested that this synchrony regulated interpersonal credibility and trust. Others have described similar phenomena. For example, LaFrance and her colleagues have suggested that body posture mirroring in a group setting can be an indicator of group rapport (LaFrance 1982; LaFrance and Broadbent 1976). Other disparate findings in the social psychology literature are related to interpersonal mimicry, such as behavioral contagion (Provine 1986, 1992) and speech accommodation (Cappella and Panalp 1981). Thus, there is a great deal of research suggesting that people unconsciously mimic each other in a variety of contexts.

A large body of research has also explored the link between automatic mimicry and social rapport in more controlled settings. For example, in a study where confederates were instructed to either mimic or not mimic a participant, it was shown that confederates who mimicked were rated as more likeable (Chartrand and Bargh 1999). Another study in a more naturalistic setting found that waiters who repeated their customers' orders received larger tips than waiters who did not repeat their customers' orders (van Baaren et al. 2003). A particularly interesting finding in this area has been that mimicry can trigger prosocial behavior in general rather than specifically at the mimicker (van Baaren et al. 2004). In that study, participants who were mimicked were more helpful and generous towards others than were non-mimicked participants.

Moreover, expectations of future interactions with a person increases the need for affiliation, and this in turn increases the likelihood of mimicry (Lakin and Chartrand 2003). Participants who were told they would interact with a confederate in the future again were more likely to mimic specific gestures that the confederate used. In other words, particular social memberships or interaction goals are more likely to trigger automatic mimicry. This line of evidence suggests that both unintentional (automatic) mimicry and intentional mimicry are intimately linked with social affiliation and rapport. More importantly, the effect is bi-directional; mimicry facilitates affiliation and affiliation goals increase mimicry. Finally, some researchers have suggested an evolutionary basis for automatic mimicry as an adapted "social glue" to create and sustain social rapport within groups and communities (Lakin et al. 2003).

What this line of research shows quite conclusively is that both unintentional (automatic) mimicry and intentional mimicry facilitates and expresses social affiliation. Others have also discussed some of the implicit and explicit processes underlying mimicry (Yabar et al. 2006). In a handshake, there is most likely both automatic and intentional mimicry, which occurs. For example, if someone grasps your hand extremely firmly, then clearly there is intentional mimicry going on, as people will reciprocate the firmness of grasp, if for no other reason than to prevent physical discomfort during the handshake. On the other hand, subtle features during handshakes such as velocity and position may be mimicked more implicitly. It is important to differentiate the simultaneous matching that occurs explicitly in a handshake (i.e., gripping someone's hand more firmly over the duration of a handshake to match their style) with the planned mimicry one might employ when she or he knows the features of a given individual's handshake style in advance of the handshake. In the current study we focus on the latter phenomenon.

Virtual Environments and Social Influence

Immersive Virtual Environment Technology (IVET) is a methodological tool that can be used to study human behavior across a variety of domains (see Blascovich et al. 2002, for a review). Using virtual environments, researchers can digitally represent human form and behavior to resemble specific individuals. Recently, researchers have begun to use IVET to explore social psychological processes including interpersonal distance (Bailenson et al. 2003), eye gaze (Bailenson et al. 2005) and social facilitation (Hoyt et al. 2003).

When people interact in virtual environments or alternatively any sort of digital media (e.g., cellular phones, videoconferences, chatrooms), these computer mediated communication systems are uniquely suited for employing automatic mimicry for social advantage. Given that the system must digitally track a wide variety of actions and movements of all interactants precisely in order to mutually render the behaviors, it becomes quite easy to employ automated mimicry. To test this "digital chameleon" hypothesis, Bailenson and Yee (2005) conducted an experimental study in which undergraduate students were immersed in a virtual environment. Participants were seated opposite a virtual embodied agent who presented a persuasive argument. The agent either mimicked the head movements of the participant or utilized other types of head movements. Results demonstrated that participants in the mimic condition were more likely to pay attention to the agent in terms of gaze and agree with the agent's argument than participants in the recorded condition. Moreover, almost none of the participants had detected the manipulation as assessed by a post-experiment questionnaire.

In previous work (Bailenson et al. 2007), we have explicated a concept called *virtual interpersonal touch*, the use of virtual haptic devices to allow one person to use IVET to touch another person. Also, we found that different emotional states, such as fear or joy, could to different degrees be encoded and inferred using these haptic devices. We have demonstrated that a haptic device is capable of transmitting many of the emotional features typically conveyed during physical, hand-to-hand shakes (Bailenson et al. 2007). Given that physical handshakes correlate with personality measures, and that mediated handshakes can mimic features such as speed, location, and firmness of handshakes to extremely precise degrees, handshake mimicry using virtual interpersonal touch may be highly effective in achieving social influence.

Overview of Experiment

In the current study, participants in dyads shook one another's hand via a mediated force feedback virtual device before negotiating with one another. We examined two central questions.

The first was to examine handshakes quantitatively, creating descriptive metrics based on movement, speed, and other aspects of a handshake. Based on work by Chaplin et al. (2000) we had the following hypothesis:

H1 *Virtual interpersonal touch would remain stable over time, such that metrics acquired from multiple handshakes from the same individual would correlate highly.*

This is important in the current studies for two reasons. First of all, without stability there could not be mimicry. In other words, if a person's handshake constantly changes, it would be hard to employ mimicry based on past handshakes. Second, it is important because it validates our IVET system in the sense that virtual interpersonal touch is at least somewhat similar to a physical handshake in its level of stability.

Moreover, we also had specific research questions using these metrics to predict individual differences such as gender and personality type:

RQ1 *How do standard personality traits correlate with metrics derived from a person's handshake?*

RQ2 *How do male handshakes differ in terms of objective metrics from female handshakes?*

The second goal of the current study was to examine the effect of nonverbal mimicry on impression formation. Similar to our previous work, we predicted that:

H2 *Few participants would detect the mimicry in a handshake.*

H3 *A person who mimics another person's handshake would be seen as more likable than a person who does not mimic another person's handshake.*

However, given the discussion by Chaplin et al. (2000) as well as historical assumptions that handshaking is a gendered social ritual that emphasizes male–male interactions, we further hypothesized that:

H4 *The effect of handshake mimicry would be more effective for men than for women.*

Method

Design

We selected for one between-dyads variable: *participant gender* (male or female), and manipulated one within-dyad variable: *mimicry condition* (mimic or normal). We used a force feedback joystick to record and play back handshakes. In the *mimic* condition, one of the dyad members received his or her own handshake back while believing it was the other person's handshake. In the normal condition, the dyad member actually received the other person's handshake. In other words, in the mimic condition, we first recorded a participant's handshake and then played the handshake back to that participant. Thus, the force feedback joystick mimicked the handshake of the participant as the participant shook the joystick. Within each same-gender dyad, one person was in the mimic condition and one person was in the normal condition. Neither of the two participants in a dyad was told that the mimicry was occurring.

Materials and Apparatus

To record and replay the handshakes, we used an Immersion Impulse Engine 2000 force feedback joystick. The device provides movement along two degrees of freedom and is capable of outputting a maximum force of 2 lbs. (8.9 N). We placed the device on its side so that the handle faced toward the subject rather than toward the ceiling. The joystick was secured to a table using clamps, and its height adjusted so that subjects could interact with the joystick via a handshake in a natural manner. Figure 1 shows the experimental setup.

Participants negotiated a rental/lease agreement in an integrative bargaining task similar to those commonly used in negotiation research. In other words, one party could "logroll" or trade-off multiple issues to maximize benefit for each side (see Mannix et al. 1995, for an example). One of the participants was always in the role of apartment owner, while the other one was in the role of renter, and the negotiation was over rent rate, lease length, services provided, and start date. The purpose of the negotiation task was to facilitate social interaction in order to illuminate any social influence effects from the handshake mimicry.

Participants

Participants were undergraduate students who received 10 dollars each for participation. Forty-eight were female (24 in the mimic condition, 24 in the normal condition) and 42 were male (21 in the mimic condition, 21 in the normal condition). Experimental

Fig. 1 A user interacting with the virtual interpersonal touch device

condition was randomly assigned, with approximately an equal number of people taking on the role of owner and renter in each of the four conditions resulting from crossing gender and mimicry condition. Participants in the dyads did not know one another.

Procedure

Participants arrived at the laboratory in dyads. When they arrived, they sat down in chairs spaced apart by 2 m, and filled out consent forms and then biographical questionnaires (e.g., age, race, gender). According to observations of the experimenters while the participants were outside of or within the experimental room, none of the participants shook hands physically before the study began.

The experimenter then randomly selected one of the participants and took him or her to another room with the handshake apparatus to collect the *baseline handshake*. Participants walked up to the apparatus depicted in Fig. 1 and put their right hands on the device. The experimenter instructed participants to shake hands with the device as if they were shaking hands with someone else, and indicated that the handshake was going to be recorded so that other people could shake their hands in the future. When participants indicated they were ready, the experimenter hit a button and the handshake began. The device exhibited resistance towards the center, and we recorded data based on the *x–y* coordinates of the joystick every 5 ms. We stopped recording handshakes after 7 s had passed, though some participants were done before the seven second mark. The first participant was taken back to the initial room, and the process was repeated for the other member of the dyad.

When both handshakes were recorded, we then implemented the *greeting handshake*. One at a time and in a random order, participants were brought to the handshake device and were told:

> In this part of the study, you will be interacting with the subject in the other room, and will be shaking his (her) hand. In other words, we're playing back a recording of his (her) handshake. The handshake will last for seven seconds. You will be using this joystick that uses motors to provide the force and the location of his (her) real handshake.

We played back the recordings we had just collected from the baseline shake during the greeting shake, and also recorded the motion that participants used during the greeting handshake. In other words, while receiving the other person's (or their own) handshake, we recorded the motions participants were making to get a second recording of their handshakes.

We next began the negotiation task. Participants were taken to two separate computer stations, where they could hear one another but were blocked from seeing one another by an opaque screen. They then were assigned roles as either the owner or the renter according to a counterbalancing scheme, received instructions on how to negotiate by creating concessions on the various parameters, and began their negotiation. They were given 4 min to understand the instructions and ask questions of the experimenter, and 10 min to negotiate with one another.

After the negotiation was complete, participants filled out questionnaires, including a scale with four items measuring their opinions about the other negotiator, as well as a number of personality scales used by Chaplin et al. (2000).

Handshake Measures

We first computed a number of quantitative metrics from the recorded movements to analyze the data from the handshake itself. We describe each of these measures in turn, though see Bailenson et al. (2007) for a more detailed mathematical description.[2]

Distance

This metric is the total distance traversed by the tip of the joystick. A low score would mean that the participant barely moved the joystick while a high score would mean that a lot of movement occurred.

Mean Speed

This metric is the average speed at which the participant moved the joystick. A low score would mean that the participant moved the joystick slowly while a high score would mean that the participant moved the joystick very fast.

Standard Deviation of Speed

This metric is the standard deviation of a participant's movement. A low score would mean a steady movement while a high score would mean jerky movement.

Mean Acceleration

This metric is the average acceleration of a participant's movement. A low score would mean the participant was decelerating while a high score would mean the participant was accelerating.

Standard Deviation of Acceleration

This metric is the standard deviation of the acceleration of a participant's movement. The lower the score, the less change there was during the trial. The higher the score, the more the participant was speeding up and slowing down throughout the trial.

Angle

This metric is the average angle of the major axis of the handshake from 0° to 180°s. A score of 0°s indicates a horizontal movement, ninety is straight up and down, and the angle moves counterclockwise as the score goes up.

Verticalness

We also computed a score that more directly measured the verticalness of a handshake. To compute this measure, we took the absolute value of the difference between the angles of a handshake from the vertical 90°.

[2] We could not use the duration of the handshake as a measure because there was very little variance in the length of time people used the handshake machine.

Standard Deviation of Position

This metric is the standard deviation of the joystick position on an x–y plane. A low score would mean staying close to a small area of the plane while a high score would mean moving across many different areas of the plane.

Standard Deviation of the Major Axis

The major axis is the axis along which the average angle was made. The standard deviation of the major axis is a measure of the deviation in position along the major axis. A low score would mean moving only very slightly along the major axis while a high score would mean moving a great deal along the major axis.

Standard Deviation of the Minor Axis

The minor axis is the complement of the major axis. The standard deviation of the minor axis is a measure of the deviation in position along the minor axis. A low score would mean moving only very slightly along the minor axis while a high score would mean moving a great deal along the minor axis.

Percent of Major Axis

This metric is the ratio between the standard deviation of the major axis and the minor axis. A low score would mean comparable distances moved along both axes and thus an overall square or circular pattern. A high score would mean significantly more movement along one of the axes and thus an overall rectangular or oval pattern.

Subjective Measures

We included a number of personality trait measures. These specific scales were chosen in an attempt to replicate past findings (Astrom and Thorell 1996; Chaplin et al. 2000).

Big 5 Factors

We implemented a 50-item Big 5 inventory drawn from the International Personality Item Pool (Goldberg et al. 2006). Participants responded to each item on a 5-point fully-labeled scale, labeled from "Strongly Disagree" to "Strongly Agree." The Big 5 Factors were Neuroticism (M = 2.89, SD = 0.42, α = 0.83), Extraversion (M = 3.35, SD = 0.94, α = 0.72), Openness (M = 3.72, SD = 0.66, α = 0.83), Agreeableness (M = 3.66, SD = 0.58, α = 0.74), and Conscientiousness (M = 3.65, SD = 0.62, α = 0.82). We averaged the questions for each of the five dimensions into a single measure.

Self-Esteem

As our measure of self-esteem, we implemented Rosenberg's 10-item Self-Esteem scale (Rosenberg 1965). Participants responded to each item on a 5-point fully-labeled scale, labeled from "Strongly Disagree" to "Strongly Agree." The reliability of this scale had an alpha of .86 (M = 4.11, SD = 0.67); consequently we averaged the questions into a single measure.

Shyness

As our measure of shyness, we implemented the revised Cheek and Buss Shyness scale (Cheek 1983). Participants responded to each item on a 5-point fully-labeled scale, labeled from "Strongly Disagree" to "Strongly Agree." The reliability of this scale had an alpha of .91 (M = 2.68, SD = 0.64); consequently we averaged the questions into a single measure.

Liking of Partner

Participants were asked to rate how much they liked their interaction partner using four survey items. These four items asked participants to rate how much they enjoyed working with the other person, how friendly they thought the other person was, how happy they were with the negotiated terms, and how willing they thought the other person was in terms of making mutually beneficial arrangements. Participants responded to each item on a 5-point fully-labeled scale, labeled from "Strongly Disagree" to "Strongly Agree." The reliability of this scale had an alpha of 0.72 (M = 3.20, SD = 0.60); consequently we summed the questions into a single measure. This score was used as an operationalization of social influence, similar to past research (Morse 1972).

Negotiation Success

The two parties negotiated on four aspects of the agreement: price, move-in date, length of lease, and services included. For each aspect, instructions were given regarding the range of terms (e.g., for rental price, there were five options starting at $2,000 per month with $500 increments) and the commission they would receive for each option. Of course, the optimal terms between the two agents were not congruent, and the two parties were scored based on the difference between their negotiated terms and their optimal terms (i.e., the largest commission). The most optimal term had a score of five and the least optimal term had a score of one. Thus, the lowest negotiation score possible was four and the highest was 20. The coding of success was objective in that the point assessment for any combination of terms chosen by the two negotiators was set by a standard scoring scheme, and for all items the responses were zero sum (i.e., an advantage for one negotiator was linked with a disadvantage for the other). The mean score was 11.21 and the standard deviation was 2.23.

Mimicry Detection

During debriefing, the last thing participants were asked to do was to write a paragraph about the other person's handshake, describing the motions of the other person's shake and the experience of shaking hands digitally. Two coders blind to experimental condition each read the paragraphs written by participants looking for any word or phrases that related to mimicry or that indicated that participants had detected the mimicry. Not a single participant detected the mimicry according to either coder, confirming H2.

Results

Handshake Metrics

We performed an exploratory factor analysis on the handshake metrics in an attempt to arrive at a more parsimonious representation of the 10 factors. A principal components analysis revealed three factors with eigenvalues greater than one. Altogether, these three factors accounted for 80% of the overall variance in the handshake measures. We used an oblique rotation to arrive at the factor loadings, shown in Tables 1 and 2.

We labeled the first factor, which most speed and acceleration metrics loaded onto, as *vigor* (Cronbach's alpha on standardized components = 0.96), based on the taxonomic scheme developed by Chaplin et al. (2000). The metrics that loaded onto the second factor related to how square, as opposed to rectangular, a handshake was. We labeled this factor as *shape* (Cronbach's alpha on standardized components = 0.76). For the final factor, the metrics that loaded onto it were related to how vertical, as opposed to tilted, a handshake was. We labeled this factor as *verticality* (Cronbach's alpha on standardized components = 0.52).

Stability of Handshake Over Time

To analyze the stability of an individual's handshake over time (H1), we compared the metrics obtained for a given participant between the *baseline handshake* and the *greeting handshake*. The baseline handshake was the handshake that was initially recorded from each participant and is the handshake we focus on in subsequent

Table 1 Factor loadings of the handshake metrics

	Vigor	Shape	Verticality
Mean acceleration	**0.95**	0.08	0.05
Mean speed	**0.95**	0.04	0.13
Distance	**0.95**	0.04	0.13
SD of speed	**0.94**	0.02	0.09
SD of position	**0.86**	−0.11	0.26
SD of major axis	**0.85**	−0.14	0.26
SD of acceleration	**0.68**	−0.08	0.03
Percent of major axis	0.24	**−0.92**	0.13
SD of minor axis	0.59	**0.71**	0.03
Angle	0.02	0.10	**0.88**
Verticalness	−0.25	0.51	**−0.79**

Bold items indicate factor loadings above 0.60

Table 2 Factor correlation matrix

	Vigor	Shape	Verticality
Vigor	–	0.007	0.16
Shape	0.007	–	−0.17
Verticality	0.16	−0.17	–

sections. The greeting handshake was the handshake that participants used when they used the handshake machine again and were told they would be shaking the other person's hand. In other words, during the greeting handshake, participants felt the force of the other person's handshake but the haptic device also recorded their own handshakes.

For an index of stability over time, we tabulated the correlations between each of the three handshake factors between the two shakes. The correlation coefficient was 0.72 for the vigor factor, 0.46 for the shape factor, and 0.35 for the verticality factor. In Chaplin's study (2000), inter-rater correlations ranged from 0.40 to 0.90, so our correlation largely falls within that same range. Thus, there is a degree of stability in the handshaking behavior of individuals.

Individuals whose handshakes were mimicked showed a higher stability than individuals whose handshakes were not mimicked. The correlation coefficients for vigor was higher in the mimic condition ($r = 0.84$) than in the normal condition ($r = 0.39$), $z = 5.25$, $p < 0.001$. The correlation coefficients for shape was higher in the mimic condition ($r = 0.58$) than in the normal condition ($r = 0.17$), $z = 3.01$, $p < 0.001$. Finally, the correlation coefficients for verticality was slightly higher in the mimic condition ($r = 0.34$) than in the normal condition ($r = 0.21$), but this difference was not significant, $z = 0.39$, $p = 0.36$. In sum, a person has to accommodate less when shaking their own hand than when shaking another person's hand. Consequently there was greater stability in the mimicry condition than in the normal condition.

Individual Differences in Handshake Metrics and Personality Traits

To test RQ2, we ran three independent *t*-tests with gender as an independent variable and the three handshake metrics from the baseline handshake as dependent variables. We only used data from the baseline handshake to get a purer measure of a participant's hand movements without the added resistance from the force feedback device (i.e., the movements of the other participant) in the greeting handshake. Neither the effect of gender on vigor ($t[88] = 0.59$, $p = 0.56$, $d = 0.13$) or shape ($t[88] = 1.28$, $p = 0.21$, $d = 0.27$) were significant, but the handshakes of female participants had a higher verticality score than the handshakes of male participants ($t[88] = 2.02$, $p = 0.05$, $d = 0.43$). In other words, the handshakes of male participants were significantly more tilted (set at an angle) than the handshakes of female participants. Figure 2 demonstrates plots of the four handshakes with the lowest (left panel) and highest (right panel) scores on the verticality score, without consideration of the movement and shape factors.

To test RQ1, we ran a series of zero-order correlations among all of the personality measures and the three handshake metrics obtained in the factor analysis. While there were a number of correlations among the personality measures themselves (e.g., the correlation between shyness and extraversion was significant, $r = -0.57$, $p < 0.001$), those correlations were of little theoretical relevance to the current hypotheses and for the sake of brevity are not discussed in this paper. More important were the correlations between the three handshake metrics and the personality variables. However, not a single correlation was significant in this analysis, with the magnitude of the largest correlation coefficient being 0.13, and not a single *p*-value below 0.23.

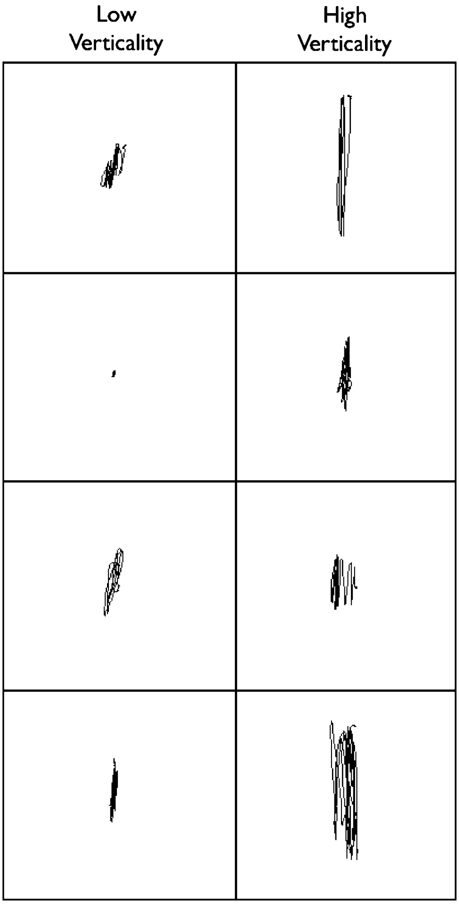

Fig. 2 The four handshakes from the sample lowest (*left panel*) and highest (*right panel*) in verticality score

The Effect of Handshake Mimicry on Liking

To examine H3 and H4, we then conducted an ANCOVA with gender and mimicry condition as the independent variables, negotiation success as a covariate, and the liking score as the dependent variable.[3] The purpose of including negotiation success was to account for any residual benefits or detriments on liking that events occurring during the negotiation may have caused. The covariate of negotiation score was significant ($F[1,83] = 10.36$, $p = 0.002$, $\eta^2 = 0.10$). The correlation coefficient between negotiation score and liking was 0.26; the better a person did in the negotiation task, the more they liked the other person. We also found a significant main effect of gender ($F[1,85] = 6.34$, $p = 0.014$, $\eta^2 = 0.06$). Women liked their partners slightly less ($M = 3.08$, SEM = 0.08)

[3] Because the main variable of interest (mimic vs. normal) was manipulated within-dyad (i.e., one member of the dyad mimicked the other), it was not possible to do the dyadic analysis for either the mimicry condition or the interaction between gender and mimicry. However, we tested the main effect of gender by dyad, which was not significant, $t(63) = 0.11$, $p < 0.91$, $d = 0.03$.

than men ($M = 3.36$, SEM = 0.09). The effect of mimicry condition was not significant ($F[1,83] = 0.60$, $p = 0.81$, $\eta^2 < 0.01$). As Fig. 3 demonstrates, there was also an interaction between gender and mimicry Condition ($F[1,85] = 7.83$, $p = 0.006$, $\eta^2 = 0.07$). Post-hoc Tukey HSD tests ($\alpha = 0.01$) confirms the pattern of error bars in Fig. 3, specifically that males liked partners who mimicked them ($M = 3.54$, SEM = 0.12) more than women liked partners who mimicked them ($M = 2.93$, SEM = 0.12).

Discussion

Summary of Results

In the current study, we found that there was moderate stability in the virtual interpersonal touch behavior of individuals over time. Furthermore, when people encountered their own touch during a second interaction, they demonstrated more stability than when they encountered someone else's handshake in a second interaction, presumably due to accommodating or mimicking the motions encountered in the second handshake. Also, we demonstrated that male and female participants used different types of movements in virtual interpersonal touch. Women tended to keep all of their movements in a single vertical plane, while men tended to shift the angle of the major axis of their shake towards the side. Furthermore, men liked partners who mimicked them via virtual interpersonal touch more than women did. Finally, personality traits did not predict either type of movements exhibited during a handshake or with liking behavior, though the power of the current inferential tests were not high enough to draw conclusions from these null results.

Comparing Virtual Interpersonal Touch to Physical Handshakes

Previous research (Chaplin et al. 2000) has found gender differences in handshakes, in particular that males demonstrated firmer and more vigorous handshakes than women. That

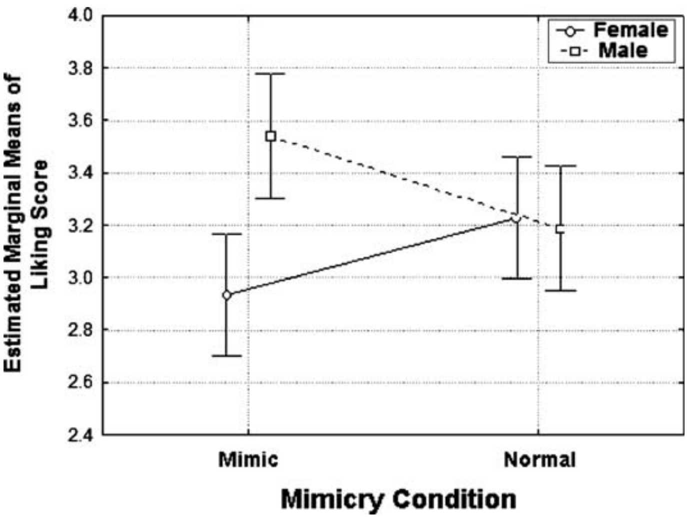

Fig. 3 Estimated marginal means of liking score by gender and mimicry condition

study relied upon subjective ratings by experimenters who shook the hands of subjects as they came into the laboratory. In the current study, we also found gender differences, though on a slightly different parameter. Our differences came from objective metrics gathered by a haptic device.

Each method has benefits and costs. The subjective ratings are subject to demand characteristics that relate to individual differences of the participants; an obvious example is gender (i.e., the coders expected firmer handshakes from men than from women), but there are certainly other factors that could sway an experimenter such as attractiveness of the participant or other group factors such as race and age. Moreover, the error associated with subjective ratings is high in that coders are not perfect and feature unavoidable variance in their ratings. These possibilities may partially explain why previous research (Chaplin et al. 2000) found relationships between personality measures such as extraversion and handshake type that were not demonstrated in the current dataset.

On the other hand, the haptic device obviously avoids demand characteristics and is a much more reliable measurement tool. However, using virtual interpersonal touch to approximate a physical handshake has problems in terms of construct validity and generalizability, in that the type of handshake one uses with a virtual machine may be fundamentally different from a physical handshake. In the current study, the fact that we showed stability across time in handshaking indicates that our virtual device does to some degree capture the likeness of a physical handshake, at least in terms of stability. Furthermore, when assessing physical handshakes, it is possible to examine a wide variety of features (e.g., moisture, temperature, and firmness), while current technology makes it difficult, though not impossible, to examine features above and beyond location and force. It could be the case that personality cues such as extroversion and others manifest themselves in ways that our basic mechanical devices failed to register.

Digital Chameleons

It is becoming more and more clear that when people or computer programs mimic us using digital technology, they gain advantage in terms of social influence. As Nass and Moon (2000) point out, people have a preference towards computers who, on a macro-behavioral level, share features such as personality traits with them. On a more micro level, we (Bailenson and Yee 2005) have demonstrated previously that, when an embodied agent mimics participants' head movements 4 s after they occur during a social interaction, the mimicry goes undetected and the embodied agent is more persuasive. In the current work, we have demonstrated a similar finding for handshakes.

However, the finding must be qualified in that there was no overall benefit of mimicry, but instead males liked people who mimicked them more than females. While previous research has demonstrated that handshaking is a gendered activity (Chaplin et al. 2000) our explanation for this gender interaction is somewhat ad hoc. We had predicted that mimicry would cause more liking for men than for women, but not that females would actually dislike people who mimicked them. It is impossible for us to determine if the interaction between gender and mimicry condition is due to males positively liking mimickers or females negatively disliking mimickers, as our post-hoc tests only indicate that males like mimicry more than females (i.e., neither condition was significantly different from the control condition). Future research should examine this gender difference more fully.

These data advance our knowledge of digital chameleons by demonstrating the ability to achieve social influence by using *archived* nonverbal behaviors, compared to using real-time mimicry. In other words, most research examining the chameleon effect and the effects of tailoring nonverbal behaviors features an experimental confederate (or a computer algorithm) that observes a participant and then seconds later copies some aspect of their verbal or nonverbal behavior. The current data extends this work by demonstrating with simple digital technologies that it is possible to store some representation of a given person's nonverbal behavior, and to use that behavior at a later date to achieve social influence. Furthermore, the social facilitation of mimicry occurred without the participants' conscious knowledge that they were being mimicked. It may be the case that people expect mimicry less from a digital or mechanical advice than they do from people—consequently digital chameleons may be uniquely capable of achieving influence.

Limitations/Future Directions

The main limitations of our study stem from the generalizability of the handshake machine itself. The haptic device, while able to provide a good sense of speed and movement, cannot simulate the sensation of the grip of another person's hand. Thus, elements of grip firmness, temperature, and dampness could not be simulated. Nevertheless, in spite of the lack of these features, our findings illustrate that the social influence of mimicry is able to operate even with impoverished settings.

Another limitation of our study was that we were not able to directly measure the effect of handshake mimicry on actual behavior. The self-report measure we chose, liking of the interaction partner, while significant and congruent with our hypotheses, would be bolstered by demonstrations of an effect on actual behavior. Future studies should explore the effects of mimicry on more quantifiable behavioral measures.

Finally, it is unfortunate that handshaking, while seemingly ubiquitous, still appears to be a somewhat gendered ritual and carries different meaning among male participants than for female participants. Another direction for future studies would be to identify a social form of touch that might be less gendered. Previous research shows how hard it can be to find a form of touch that is not seen as overly intimate or simply inappropriate in public spaces (Burgoon 1991). Nevertheless, it might be possible to construe a collaborative task or a physical game where the use of touch has much of its social meaning removed yet retains the ability to be mimicked and thus the possibility to exert social influence.

We live in an age where more and more of our environment is, quite literally, watching our every move and listening to what we say. From surveillance cameras to email servers, from online games to online stores, many of our everyday actions are being recorded and stored in large databases during communication (Rheingold 2002), news consumption (Boczkowski 2004), work (Yuan et al. 2005), and play (Vorderer and Bryant 2006; Yee 2006). Moreover, these digital repositories have the ability to transform representations of computer agents and other people using in-depth longitudinal profiles of our personalities, decisions, and attitudes (Bailenson et al. 2004). And alongside these panoptic devices and digital repositories are an increasing abundance of virtual agents that serve as mediators between us and our banks, hospitals, stores, and schools. These virtual agents could be programmed to mimic many features of our behaviors both textually and orally for social influence—from obvious visual features such as gender to more subtle behaviors such as the choice of words and sentence structure. Our study showed that digital agents can also potentially employ handshake mimicry to gain influence in social interactions. The potential for digital mimicry is no longer a question of "if", but "when."

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