Nonverbal intimacy as a benchmark for human–robot interaction*

Billy Lee
University of Edinburgh

Studies of human–human interactions indicate that relational dimensions, which are largely nonverbal, include intimacy/involvement, status/control, and emotional valence. This paper devises codes from a study of couples and strangers which may be behavior-mapped on to next generation android bodies. The codes provide act specifications for a possible benchmark of nonverbal intimacy in human–robot interaction. The appropriateness of emotionally intimate behaviors for androids is considered. The design and utility of the android counselor/psychotherapist is explored, whose body is equipped with semi-autonomous visceral and behavioral capacities for 'doing intimacy.'

Keywords: nonverbal behavior, intimacy, androids, human–robot interaction

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Could androids form intimate relations with people? This question provokes passionate discord among experts and lay people alike. The notion that a synthetic being could form genuine relationships with people taps into perennial questions about morality, consciousness, free will, and authenticity (Turkle, 2007). Human–robot technologies are, nevertheless, beginning to press for answers to these hitherto fictional questions. In so doing we face the challenge not only of a science of humanlikeness, but also of disclosing the ontological nature of our being.

Any number of benchmarks could be derived to guide the agenda for increasing realism in human–robot interaction. Kahn et al. (2007) suggest around thirty should suffice. More importantly they distinguish between ontological versus psychological claims to personhood. Films such as *Blade Runner* capture some of our dilemmas about artificial personhood. Does the android Rachael *really* love? Is it *conscience* that bids the fugitive android Roy to save his would-be captor during his expiring moments? Does his final act transcend our synthetic-authentic dialectic?

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Metzinger (2003) has questioned whether it is even moral to begin an enterprise that ultimately leads to the suffering of its descendants. For what kinds of beings will androids be? Ramey (2006) poses a conundrum based on Heidegger's principle: *being is that for which an object is, and an object is that for a being*. Clearly androids designed by people are *for* people. As such they belong to the category object. In Sartre's terminology the android is categorically not *pour soi* (for itself) unlike all human beings (Sartre, 1943/1957). This leaves uncertain the moral value and moral accountability of even very-humanlike androids, which by having been designed by humans, could not ontologically, be human. To attempt to benchmark personhood, moreover, is to pursue a moving, if not impossible, target. Personhood is not given by performance criteria. A person is a particular kind and a particular way of being (MacDorman & Cowley, 2006). Something that is not a person could not qualify as one by passing a set of benchmarks. And someone who is a person could not be disqualified by failing any particular benchmark. The task is not to personify robots but to design human–robot interactions that leverage on people's ways of being with each other, which they engage in intuitively without instruction.

In this regard the present study addresses how people maintain relationships with each other. This paper presents a study of nonverbal behavior between strangers and romantic partners and proposes 'act specifications' for intimate and non-intimate relational behavior. It explores the feasibility of mapping these behaviors on to android bodies and the possibility of an android counselor. Future incarnations of the person-centered therapist emulator Eliza, and embodied conversational agents, such as Stelarc's prosthetic head (see Suchman, 2006), will doubtlessly continue to raise the bar on Turing-type tests of human emulation. A high benchmark is whether an artificial being of the future could be a psychotherapist — could it form a healing relationship with a person?

Nonverbal behavior has been described as the pathway to intimacy. Signals from the face, voice, posture, gesture, interpersonal distance and positioning have bodily effects on the other person distinct from linguistic effects (Kito & Lee, 2004). They may amplify, attenuate or contradict speakers' ostensive verbal communications. Many nonverbal communications are also involuntary, and are thereby perceived as more faithful to the speaker's true intent, especially when there is a disparity between the body and the spoken word. In the film *Blade Runner*, papillary dilation and involuntary contraction of the iris, so-called blush and pupil dilation responses, were recorded to distinguish replicants from humans. The presence of these involuntary empathetic reflexes in humans, and absence in replicants, when asked about challenging social scenarios reveals what Ramey (2006) calls the 'constitutive sociality' of the latter. We are, to put no finer point on it, inherently social beings: *intersubjects*. We inhere in a social fabric that is our

shared world of which we are already participants, simply by *being in the world* (Merleau-Ponty, 1945/1962).

A critical difference between verbal and nonverbal signals is the relation between sign and referent. In speech this relation is arbitrary and learned; however, many nonverbal communications are understood directly because they elicit a physiological response. The physical and physiological impact of the other's body is felt as *presence* (Buber, 1923/1937). Appropriate bodily acts from the android with a very humanlike body will substantiate presence by eliciting a physiological response from the person during interaction. We can imagine compelling interchanges with Thrun's personal service robots, capable of tracking gaze, holding gaze, and mimicking posture and facial expression (Thrun, 2004). Psychological studies show that behavioral synchronization is a powerful communicative experience. It has been used to explain how we 'hit it off' immediately with some people and not others (Bernieri & Rosenthal, 1991).

What behaviors will a relational android require? We may begin to frame this problem by considering Sternberg et al.'s (1981) prototypes of socially intelligent behavior, based on lay people's observations:

Accepts others for who they are;
Admits mistakes;
Displays interest in the world at large;
Is on time for appointments;
Has social conscience;
Thinks before speaking and doing;
Displays curiosity;
Does not make snap judgments;
Makes fair judgments;
Assesses well the relevance of information to a problem at hand;
Is sensitive to other people's needs and desires;
Is frank and honest with self and others;
Displays interest in the immediate environment.

As they stand these present a daunting prospect for the engineer of social intelligence. These competencies must be translated into specific bodily acts that may be mapped onto the android body. Current android bodies are far inferior in behavioral capacity to the socially experienced adult. However, even a newborn infant is equipped with behaviors capable of sustaining 'primary intersubjectivity' with its adult caregiver, for example, holding gaze, tracking gaze, and a level of nonverbal reciprocity which has been called 'protoconversation' (Trevarthen, 1998). Current androids already have a repertoire of facial displays commensurate with that of the human neonate, albeit not yet responsive, but requiring remote control

by a human agent (MacDorman & Ishiguro, 2006). It would not seem beyond the reach of next generation android bodies to implement rudimentary intersubjectivity such as facial and postural mimicry, the precursors of human empathy (Thompson, 1998).

In this paper we examine aspects of social intelligence that are concrete and visible in the human form. For example, *Is on time for appointments* is concrete but it cannot be physically act-specified as an action of the body. *Has* a *social conscience* is clearly linked with trait conscientiousness, though again, no bodily acts that specify this trait have as yet been identified (McCrae & Costa, 1987). *Accepts others for who they are* is clearly linked with the personality dimension *openness*. Openness is associated with increased interaction quality between interaction partners. The association is mediated by visual attention — the acts of *looking at the partner while listening* and *holding gaze* (Berry & Hansen, 2000). *Makes fair judgments*, and *assesses well the relevance of information to a problem at hand*, are both social skills that require deep social embeddedness within a human culture, and therefore lie beyond our scope. However, *displays curiosity* and *displays interest in the immediate environment*, may both be act-specified to some degree. For example, turning the head towards others present, reliably specifies *gregariousness* (Gifford, 1991) and, therefore, could provide a criterion for assessing android–human interaction.

The task is to devise a set of act specifications for relational intimacy that are sufficiently concrete to be behavior-mapped onto androids. We sidestep the challenges of reciprocity and contingency (MacDorman & Cowley, 2006), and propose that even in teleoperation mode, such acts will provoke profound interpersonal experiences in humans. In summary, the study devises behavioral codes for nonverbal intimacy that are based on concrete bodily acts and specified at a level which is psychologically meaningful to an ordinary observer. The usefulness of these codes for the design of an intimate android is explored. Early demonstrations of Eliza revealed that the psychotherapist–client interaction could proceed with minimal intervention from the therapist emulator. The parsimony of this interaction suggests that an embodied android psychotherapist could be an illuminating case from which to examine the possibility of intimate relations between humans and robots.

Coding nonverbal behavior in couples and strangers

A split-screen videotaping procedure was used to record short unstructured interactions between strangers and between partners in established romantic relationships. The aim of the study was to devise a set of act specifications defining intimate and nonintimate interaction behavior.

Participants. The 56 participants of the study were students of the University of Edinburgh or their acquaintances who participated voluntarily. The 28 participants comprising the 14 strangers dyads had not met before the experiment. The

Table 1. Nonverbal behavior codes with operational definitions

Nonverbal Behavior	Code Description
Intimacy (close involvement)	
1. Direct gaze	Looking directly at partner
2. Touching partner	Body contact with partner
3. Engaging the common space	Placing a part of the body within table perimeter
4. Lean forward	Head forward of the vertical line with hips
5. Body orientation	Degree to which upper body faces the partner
Altercentrism (centering on the other)	
6. Back-channeling	Vocal utterances or head nods supporting partner
7. Attentiveness	Visual attention, listening, general attentiveness
8. Matching and mirroring	Reciprocating action, movement or posture
Creating meaning and sharing interest	
9. Drawing attention to object	Remarking on or pointing to object in the room
10. Drawing attention to own body	Remarking on or showing own body
11. Focus attention on partner's body	Remarking or attending to partner's body
Adaptors (adapting body to circumstance)	
12. Touching self	Touching or rubbing the face, limbs, body
13. Preening	Preening of hair
14. Head and trunk shifts	Adjusting head or body position
Animation and affect (level of bodily excitement)	
15. Hand gestures	Gesturing to support speech, smiling
16. Smiling	Mouth raised at edges
17. Relaxed laughing	Natural laughter that is not anxious
18. Facial pleasantness	Cheerful or positive facial expression
Social anxiety (signs of tension and nervousness)	
19. Body posture	Open and relaxed versus closed and blocked
20. Fidgeting	Stereotyped head or limb movements
21. Nervous utterance	Nervous laughter, vocalization or utterance
Physical security (signs of security)	
22. Being quiet	Intentional silence
23. Talking without looking	Not holding gaze with partner when talking
24. Complete open body	Lean back, legs relaxed, arms behind body
Interaction management	
25. Loquaciousness	Degree to which locution flows
26. Turn taking	Degree of hesitation before talking
27. Disengaging	Breaking contact, proximity or conversation

28 participants comprising the 14 couple dyads were established partners in a romantic relationship.

Videotaping procedure. The participants were greeted by separate experimenters who took them to separate doors and explained that the door led to a small room where they would meet a stranger or their partner. They were to converse for four minutes on any topic. The two doors were on opposite sides of the experimental room. Entry by both participants was timed to be simultaneous, so that they met face to face on entering the room and the initial greeting was recorded. In the room was a table placed centrally with two opposing swivel chairs and recording equipment. Two cameras on stands were set at 45 degrees from each other to capture the head and body of each participant. The cameras fed a mixer which split the image vertically into two half-screens, one allocated to each camera, before being record by a standard video cassette recorder. The cameras were placed at an unintrusive distance and zoomed in; all recording equipment was visible to the participants. A small clip microphone on the table recorded sound.

Behavioral coding. Two judges independently coded 27 behaviors from each four minute interaction. Specific behaviors which seemed especially likely to distinguish between couples and strangers were identified. The codes were devised after a detailed examination of a sample of the video footage, and in consultation with previous coding schemes designed to assess personality and attachment behaviors during short interactions (Berry & Hansen, 2000; Guerrero, 1996).

Results

The 27 nonverbal behavior codes derived by the present study are shown in Table 1. Two independent judges rated the behaviors on 7-point Likert scales which ranged from 0 (very little) to 6 (almost always). Inter-rater reliability was assessed by computing intra-class correlation coefficients for each set of ratings. Coefficients for the 27 behaviors ranged from 0.63 (for *direct gaze*) to 0.96 (for *touching partner*). Behaviors with coefficients below 0.75 were considered unreliable and excluded from further analysis. In total 8 behaviors were excluded: direct gaze, attentiveness, matching and mirroring, smiling, facial pleasantness, body posture, being quiet, and turn taking. For the remaining 19 behaviors, the average of the two judges scores for each behavior was used in subsequent analyses.

Stranger versus couple behavior

Differences between strangers and couples were assessed by means of *t*-tests between the mean scores of the 19 behaviors for the two groups. Couples touched

their partners more than strangers, $t(54) = 4.94$, $p < .01$, engaged the common space more, $t(54) = 5.05$, $p < .01$, leaned forwards, $t(54) = 4.69$, $p < .01$, oriented their bodies towards their partner, $t(54) = 4.39$, $p < .01$, drew attention to objects in the room, $t(54) = 1.59$, $p < .01$, drew attention to their own body, $t(54) = 2.44$, $p < .05$, focused attention on their partner's body, $t(54) = 2.92$, $p < .05$, and showed the complete open body posture, more than strangers, $t(54) = 2.77$, $p < .05$. Strangers made comparatively more back-channeling responses, $t(54) = 1.52$, $p < .05$, fidgeted more, $t(54) = 1.66$, $p < .05$, and made more nervous utterances, $t(54) = 1.96$, $p < .05$.

The differences suggest distinct interpersonal goals underpin the behavior of the two groups. Strangers appear to attempt to progress and to regulate the conversation, through the use of support and tension-reducing mechanisms. Couples showed more physical security and external interest, making meaning and sharing experience, and going beyond the immediate concern of managing the conversation.

Sex differences

T-tests revealed 4 behaviors that tended to distinguish between men and women: women smiled more, $t(54) = 2.27$, $p < .05$, made more nervous utterances, $t(54) = 2.14$, $p < .05$, and of marginal significance they to tended laugh more, $t(54) = 1.94$, $p < .05$, and to fidget more, $t(54) = 1.83$, $p < .07$. These findings are consistent with research on sex differences in expressivity (Brody & Hall, 2000). The results are also consistent with the view that women's interpersonal motives are affiliative: they work harder to manage the interaction, while men's interpersonal motives revolve around status and control (Cross & Madson, 1997).

General discussion

The intimate android

Social robots of today already elicit anthropomorphic responses from humans. Aibo and Paro, for example, have elicited caring, companionate and sentimental behaviors from children and the elderly (Kahn, Friedman, Perez-Granados, & Freier, 2006; Turkle, Taggart, Kidd, & Daste, 2006). If the android can elicit, even temporarily, a sympathetic or empathetic response from a human, an interpersonal transaction has been emulated. Such a response might include, for example, empathetic facial mimicry or sympathetic gaze towards the android, the social purposes of which are established (Sonnby-Borgstrom & Jonsson, 2004; Ishiguro, 2006). Such transactions could be further elaborated within constrained environments. For example, consider the embodied android counselor/psychotherapist

capable of simulating sympathetic presence through facial and bodily gestures coordinated with the speaker's emotional state. A rudimentary sympathetic interaction might resemble, for example, the orchestrated affect-attunement sequences seen in mother–infant protoconversations (Trevarthen, 1998).

How appropriate are the act specifications from strangers and couples for relational androids? In the present study couples touched their partners more than strangers did. This was often accompanied by the forward lean, and drawing attention to their own or their partner's body, for example, the hands or hair. Physical touch is a powerful communicative act used to signify sexual desire, warmth/love, playfulness, and friendliness (Heslin, Nguyen, & Nguyen, 1983). Touching the partner is therefore unlikely to be an appropriate act for next generation androids. On the other hand, psychotherapists sometimes describe the act of "holding without touching". This is achieved through sympathetic presence and inclusion (awareness on behalf of the other). We found strangers engaged in back-channeling (vocal utterances and head nods supporting the other's speech) more than couples did. These sympathetic acts towards the stranger probably create the sense of reassurance, closeness, and being *held*, that is crucial for the navigation of an uncertain and potentially harmful interpersonal situation. The increased fidgeting and nervous laughter of strangers may indicate their greater unease. But these may instead have been expressed to show a solidarity with the other person and recognition of the predicament which is their common, if temporary, interpersonal ground. We can imagine feeling some degree of comfort and reassurance from the embodied android counselor who back-channels our utterances skillfully. At worst this might feel awkward, but unlike physical touch, it is unlikely ever to seem invasive.

The observed gender differences likely reflect culture and socialization. Women tended to laugh, smile and fidget more and made more nervous utterances. Men appeared to withhold behavior. The reification of these differences in "male" and "female" androids would be tantamount to a naturalistic design fallacy, because it has not been determined whether these differences are task relevant. Specifically male or female behavioral codes were not identified in the present study. The android psychotherapist of the future is likely, however, to be a gendered being since the therapeutic process relies somewhat on the analysis of the transference relationship, for example, the projection of a father figure. Further work is required to identify behavior codes for "doing maleness" and "doing femaleness" and their relational significance in human–robot interaction.

Android psychotherapist

The android therapist of the future whose body can mirror the client's pain and strife the way a human body can, will begin to simulate the presence of an "other"

that is the foundation of therapy. Two conditions will have to be met: First, a very humanlike appearance that has circumvented the challenges posed by the *uncanny valley* (MacDorman & Ishiguro, 2006); Second, very humanlike behavior that reciprocates that of the interaction partner. The fledgling technology of anthropomimetic robots is noteworthy — robots with polymer bone skeletons and series-elastic actuators that mimic the properties of the human frame and musculature (Holland & Knight, 2006). When powered up the Cronos robot moves strikingly like a person because its movements propagate biomimetically through muscles, bones, and tendons throughout its structure, just like the human body. It represents the first step towards conjoint symbol grounding by human and robot — the robot must be able to do more than say "I am sad," it must be able demonstrate it — be able to cry with its body the way a person does.

The illusion of contact experienced with the person-centered therapist emulator, Eliza, breaks down the moment we realize there is no "other." The momentary therapeutic benefit one gets as Eliza appears to track our expressions of woe is dispelled when we notice a lack of illocutionary force in her conversation. When Eliza says "tell me more about your sadness," and I do, she fails to ground my sadness in her own experience, and thereby to disclose a new world to me. She is not an "other," but a shadow, but even a shadow can give some confirmation. Stelarc's prosthetic head program, a large screen projection of an emotionally animated speaking head is much more compelling than Eliza (see Suchman, 2006). The head's voice-synthesized responses to our questions are accompanied by exaggerated emotional expressions which enchant and lull us into a state of suspended disbelief, allowing us to accept at an emotional level that he really is talking to us. The social immersion is so engaging that a conversational content blindness sets in, obscuring linguistic disparities that would otherwise kill the illusion. The phenomenon is not altogether new. A student surmised that the head "works just like a politician." Psychotherapists have long been aware that underneath ostensive verbal communications, interpersonal contact at a more basic level is often being sought.

The full-bodied android with very humanlike appearance, movement and gesture will be the next level of therapist emulators. The sense of otherness can come from a body that is able to ground feelings talk in somatic experience that is like our own. Koizumi et al.'s (2006) semi-autonomous communication robot offers the beginning of a design principle. The robot has three levels of behavior: reactive, behavioral, and reflective. Reactive and behavioral levels are partially automated (e.g., head nods), while reflective behavior is controlled by a human teleoperator (e.g., speech). A teleoperated semi-autonomous android therapist co-located with the client could provide a degree of presence not experienced in current telephone counseling. A remote psychotherapist could relay verbal reflection on the client's

situation (e.g., paraphrasing and problem formulation). Eliza demonstrates that simple reflecting-back of 'handle words' can elicit feelings talk in the user and a powerful, albeit temporary, sense of interpersonal contact. Autonomous visceral behavior such as breathing, blinking, and micro-movements and sympathetic responses such as back-channeling, matching and mirroring should heighten the sense of presence and contact. In a future application a single operator might manage a number of semi-autonomous android therapists working simultaneously. Advanced androids might track the client's emotion and affect from physiological parameters such as cardiac, electrodermal, and electromyographic activity.

Liu, Rani and Sarkar (2006) show how affect sensing can be used to assist socially intelligent human–robot interactions. Biosensors could be used to measure micro-frowning from activity in the corrugator supercilii, micro-smiling from the zygomaticus major, and anxiety related tension, invisible to the eye, from electromyographic activity in the upper trapezius. Current human therapists use visual cues such as a client's breathing, hunched shoulders, and gaze to assess how the client blocks experience. Affect sensing technologies for human–robot interactions offer the possibility in the future of super-psychotherapists, whose affect monitoring capabilities exceed those of human psychotherapists.

Conclusion

Nonverbal intimacy is proposed as a benchmark for human–robot interaction. Act specifications derived from human–human interactions are proposed to guide the design of intimate robots. The behavioral parsimony of the psychotherapist offers the opportunity to explore an application of intimate human–robot interaction. Semi-autonomous teleoperated androids with built in visceral and behavioral reactivity may enable remote counseling, coaching or psychotherapy. According to Sartre the presence of the other establishes one in a new type of being in a way that a two-dimensional image cannot. Another person affects my situation directly such that there is a comparison between *what I am for myself* and *what I am for the other*. I am changed both ontologically and psychologically by the actual presence of another.

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Author's address

Billy Lee
University of Edinburgh
School of Philosophy, Psychology, and Language Sciences
7 George Square
Edinburgh EH8 9JZ UK

b.lee@ed.ac.uk

About the author

Billy Lee is Lecturer in Psychology at the University of Edinburgh. He received an MA in Philosophy, Physiology, and Psychology, and a D.Phil in Psychology from the University of Oxford in 1988 and 1994, respectively. His research interests include verbal and nonverbal communication in relationships, especially the therapeutic (counseling) relationship, video-mediated communication, and communication technologies.