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Affective Touch in Social Robots

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ABSTRACT

Social robotics asks people to be physically and psychologically intimate with robots. Of all the senses, touch is most associated with intimacy and the material qualities of contact readily morph into psychological ones. To see how these intricacies of touch are present but not always fully articulated in research into tactility in social robots, this paper firstly considers two sets of research in tactile robotics, one examining touch in an anthropomorphic robot and the other in an innovative, partially zoomorphic robot. While such research can be criticised for functionalising and quantifying touch, this is not an exhaustive understanding of the incorporation of affective touch in social robotics. Alongside functional and quantifying processes (and not necessarily in opposition to them) are novel and rich imaginative ones, often driven by low-tech materials. These dimensions of affective touch are more often articulated in discussions of robotic, cinematic, tactile and media art that consider the perceptual style of touch to be multivalent, imaginative and mobile. This perspective can contribute to articulating the dynamics of affective touch in social robotics, allowing for the recognition of the importance of the low-tech, material features that are a noteworthy part of touching robots. The ambiguities and indeterminacies of affective touch, messy materialism and the interactivity of affect interweave with high-tech computational practices in generating the experience of touching social robots.

KEYWORDS

Robots; touch; affect; haptic creature

The animated film *Big Hero 6* stars an unlikely kind of robot for its hero. Baymix is a large, soft healthcare robot, a futuristic version of the social robots that are now becoming part of the daily lives of people across the developed world. Baymix is reportedly based on the real-life inflatable arm developed by researchers on soft robotics at Carnegie Mellon University (Szondy). Unlike the many threatening metal robots in cinema (*Robocop*, *Transformers* or *Terminator*), Baymix is eminently touchable, designed and programmed to care, compelled to respond to distress calls, only disengaging when its patient declares "I am satisfied with my care." Baymix's starring role in the film aligns with the current reinvention of robots as machines with which we can be intimate, that we can feel comfortable with – and comforted by – touching.

To cultivate people's perception of machines as unthreatening and caring, materials and interactive features are incorporated that encourage people to make physical and psychological contact with social robots. Touch is vital to intimacy, and readily generates emotions. The phrase "affective touch" describes the conjunction of emotion with touch, or "the 'touching' nature of touch" as Mark Paterson expresses it (13). [1] Touch can be conceived not only as a sensory mode, but also as a perceptual style; that is, as a partial and exploratory way of perceiving. Consequently, tactile and haptic experiences are not only triggered by touch but also by other senses, most notably through vision, such as when partial and/or textured images draw a viewer to be proximate to the image (Deleuze 122-34; Marks 160-66). Touch has a strong imaginative dimension and its meanings reach beyond the moment of touch to invoke individual and group histories, cultures and places (Merleau-Ponty 365-70). Considering the ways that the dynamics of affective touch are working in social robotics is thus a complex process.

[1] Touch or hapticity refers to a sensory mode in which the body senses pressure, temperature and pain, as well as itself through proprioceptive, vestibular and kinaesthetic senses (Paterson xi).

To see how these intricacies of touch are present but not always fully articulated in research into tactility in social robots, this paper firstly considers two sets of research in tactile robotics, one examining touch in an anthropomorphic robot and the other in an innovative, partially zoomorphic robot. While such research can be criticised for functionalising and quantifying touch, this is not an exhaustive understanding of the incorporation of affective touch in social robotics. Alongside functional and quantifying processes (and not necessarily in opposition to them) are novel and rich imaginative ones, often driven by low-tech materials. These dimensions of affective touch are more often articulated in robotic, cinematic, tactile and media art. The second part of this paper considers the way these practices consider the perceptual style of touch to be multivalent, imaginative and mobile (Svankmejer; Vasseleu; Paterson 79-102; Deleuze

122-34; Marks 160-66). This perspective can contribute to articulating the dynamics of affective touch in social robotics, allowing for the recognition of the importance of the low-tech, material features that are a noteworthy part of touching robots. Like other digitally driven devices, social robots are comprised of both the analogue and the digital (Hanson, *Bodies in Code* 2-15), and engage with the unpredictability of embodiment and materiality. The ambiguities and indeterminacies of affective touch, messy materialism and the interactivity of affect interweave with high-tech computational practices in generating the experience of touching social robots.

Touching humanoid robots

A three person team including the eminent roboticist Hiroshi Ishiguro, famous for his lifelike androids, has published a research paper reporting on the humanoid device "Kirin" (Cooney, Nishio and Ishiguro). This robot is designed to investigate "how people communicate affection through touching a humanoid robot appearance" (1420). The research aims to uncover how people touch a humanoid robot, the meaning of the touch gestures in a one-way context, and how robotic touch and vision might be used to recognise touch. Specifically designed for the experiment, the robot elides the significance of bodily difference. In effect, the robot becomes a gender and racially neutral figure, the average of male and female human height and "mostly human-shaped" (1422). Hard surfaces are covered with dark cloth to make the robot soft and temptingly touchable. Unusually for a robot the machine has no actuators, so it does not move. During the experiment, participants were asked to touch Kirin and then report to the researchers the meaning of their touch. The touches of the robot were recorded through tactile and visual sensors and attributed affective significance. The research aimed to establish normative affective meanings associated with touching a humanoid robot body, meanings that are mapped on to webs or skins of tactile sensors and fixed in digital form. [2]

One aspect of this process is that it functionalises touch, a notion developed by Cathryn Vasseleu out of the Czech animator Jan Svankmejer's work on the contrast between utilitarian (as occurs in manual work, surgical procedures, body washing) and poetic touch (employed in tactile art). In contrast to poetic touch, which allows for the formation of idiosyncratic imaginative associations, Vasseleu notes that the machine haptics used by touchscreens are directed at "the normalizing of its [touch's] functionally motivated forms" (143). Touch in such instances is reduced to pressure, as Claudia Casteñada writes, it is "represented as an 'information packet' such

[2] Sophisticated tactile skins have been developed that extend over a variety of forms. See Silvera-Tawil, Rye and Velonaki for an excellent overview ("Artificial Skin"). There is limited research regarding human touching of android robots.

that variations in touch are quantitatively rather than qualitatively different from one another" (232). Functional touch is used to exchange data for pragmatic purposes, and in Kirin's instance the function of touch is to communicate affect (with therapeutic or communicative purposes in future applications).

Otniel Dror terms the translation of affect into data as the "quantification of affect," tracing it to practices emerging in the nineteenth century that enabled affect to be represented in the emotion free space of the laboratory (367-69). Among other things, Dror notes that the neutrality and universality of numbers releases emotion "from its particular contexts of production" and conceals its viscerality (373). This abstraction is seen in the mapping of data onto Kirin's supposedly neutral universal body, in which the body's specificity and significance is removed (as is its interactivity). From this perspective, the research with Kirin is continuous with research in Artificial Intelligence, cybernetics and robotics that has overlooked the significance of embodiment, focussing on the importance of immaterial data that is only incidentally embodied in devices – machinic or biological (Hayles 1-83). In a variation of a familiar conflation occurring between Artificial Intelligence/robots, and understandings of the human, the research with Kirin seeks to determine the meaning of human touch of a robot by deriving these meanings from human touching of another human. Such robotic practices partially acknowledge the importance of the bodily in human-machine relationships, but struggle to integrate and articulate the indeterminacy and diversity of corporeality as well as its historical and social locatedness (for example, see Suchman on situated robotics, 230-31).

The mapping of set disembodied data onto a universal human body only incompletely engages with the significance of embodiment. The researchers recognise the limits of their approach, noting that "problematic to the current endeavor is that a countless number of touch gestures and associated meanings may exist, possibly complex" (Cooney, Nishio and Ishiguro 1420). Multiple, intricate meanings are present in the way Kirin engages touch, although they are not articulated or investigated. Kirin also calls upon an embodied tactile imagination, in its "safe, soft and flexible" humanoid shape (1420). These decidedly low-tech features play a vital role in provoking the imagination and generating an invitation to touch. Reducing affect to quantity is present here, but it exists alongside other dynamics concerning touch, albeit ones that remain implicit.

Touching machinic creatures

The importance of the low-tech material dimensions and imaginary processes in the touching of social robots is further apparent in the Haptic Creature. Designed to investigate the dynamics of affective touch in detail, the Haptic Creature is an imaginative and nuanced device inspired by the affective dynamics circulated by touch in the relationship between a woman and her cat (Yohanan and MacLean 2011; 2012). Indeed, the Haptic Creature is reminiscent of one of Svankmejer's animated composite beings, one that has wandered into the unlikely context of a scientific research laboratory and normative meaning. Impossibly a cross between a cat, rabbit and mouse, the machinic lap pet has movable pointy ears, a purr box, expanding lungs, a tail and brown fur. Its description as zoomorphic is contestable, because the device can also be conceived to be an abstraction from animal form. It recognises touch and movement, and expresses emotions in ways that can be sensed by touch through different combinations of ear stiffness, purring and breathing. These expressive characteristics are derived from observations about animals' emotional expression, with the researchers following Darwin's recognition of ear stiffness as expressing emotion in animals and deriving the breathing rates from those of domestic cats, dogs and rabbits (Yohanan and MacLean "Design and Assessment").

The research discussed here uses the Haptic Creature in two ways. Firstly, it examines the way humans touch the robot and the meanings that these gestures are believed by participants to have (Yohanan and MacLean "Role of Affective Touch"). Secondly, it explores the affective meanings participants attribute to the robot's affective expressions (Yohanan and MacLean "Design and Assessment"). This is a more ingenious device for examining touch and affectivity than Kirin, although it too participates in practices of quantifying affect and functionalising touch.

Research into the meaning of people's touches of the device calls on a "Touch dictionary" of gestures, and aims to align specific affective meanings with these gestures. Participants were asked to imagine that the device was their pet to which they were asked to communicate an emotion. They were then asked which touch gesture they would most likely use to communicate the emotion (Yohanan and MacLean "Role of Affective Touch"). Although patterns emerged, the ascription of set gestures to emotion encountered limits, with touch gestures overwhelmingly likely to communicate multiple affects. Crucially though, this multivalence of gesture was countered by the second part of the experiment, which asked participants to perform the touch gesture. After the participants performed the gestures selected for an affect,

each gesture was articulated in terms of mean pressure and mean duration of participants' gestures, and the mean ascribed to the affect itself. [3] Thus each gesture was further distinguished into multiple gestures defined by pressure and duration, each of which was assigned to a different affect. This removed the multivalence of gesture, and so the process of quantification removed the ambiguity and multiplicity of the meaning of touch.

[3] For example, a stroke defining aroused has a duration of 1.02 seconds and pressure of 2.30 while a stroke designating depressed has a duration of 1.60 seconds and pressure of 2.10 (Yohanan and MacLean "Role of Affective Touch" 173).

Research examining how the Haptic Creature's affective expressions are interpreted by human touch found it more difficult to eliminate polyvalence and ambiguity. Using its ears (stiffness), lungs (breathing patterns) and purr box (patterns of vibrotactile purring) the Haptic Creature displayed nine affects. Participants were asked to tactilely interact with the creature and ascribe emotion categories to its displays (Yohanan and MacLean, "Design and Assessment"). For five of the displays the most frequently attributed emotion was not the expected one, and all of the displays were attributed different affects, with participants sometimes ascribing opposite feelings (477). [4] The researchers conclude that the device was better at communicating arousal rather than valence (positive or negative), with the expression of the lungs and vibrotactile purr box particularly open to ambiguity and misinterpretation. In a fascinating proposal, the authors suggest that these features could be further refined to make the emotions expressed more determinate, in accordance with the novel nature of the mechanical device (479). So, for example, the purr could be used to express negative valence and breathing modified to communicate valence as well as arousal levels. The "expressive range" of breathing could be broadened by making the faster exhalation than inhalation (the approach to modelling breathing in robotics is usually the reverse). This would shift the emotionally expressive features of the Haptic Creature further away from mimicking animal behaviour, toward expressive directions particular to this mechanical device.

[4] The display of pleasant, recognised by 44 per cent of participants as pleased was interpreted as distressed by 26 per cent of participants. The display of unpleasant, recognised by 23 per cent of participants as distressed was interpreted as pleased by 18 per cent of participants. Interestingly, subsequent research with the Haptic Creature interpreted the results via a dimensional model of emotions and concluded that many misattributions were of related emotions (Altun and MacLean 39).

Although not directly conflating the robot with the human body, such animal inspired (and even abstract) devices are constructed to complement a universal human body that performs standardised gestures linked to set affective meanings. This understanding of affective touch is present in more or less complex forms in a range of zoomorphic haptic devices, such as MIT's Huggable (a bear) that has a web of sensors measuring force, temperature and proximity from which data is combined to determine affective content and assign response (Stiehl et al). The tactile sensors covering the therapeutic companion Probo (a caricatured green elephant) provide the location and force of touch, which is then classified into painful, annoying or pleasant (Saldien et al.). The best known commercial device is the therapeutic robotic

seal Paro. A skin of tactile sensors under its furry coat registers the force and pressure of its interlocutor's touch and interprets it as hurtful or pleasurable, adjusting its cries accordingly (Wada and Shibata).

Suchman writes of the connections between laboratory robots and model organisms, observing that "The model organism is haunted … by … its 'circular trajectory', as models become apparently independent test beds for assessing the very theories that they materialize in the first place" (322). This circularity is complicated in research with the Haptic Creature by the dynamics between the constraints of computational technology and exploratory desires of the researchers. Although affective computing frequently depends on models of basic, discrete emotions (Suchman 233; Boehner et al. "How Emotion Is Made"), the touch dictionary and expressive design employed in research with the Haptic Creature draws on James Russell's circumflex schema of emotional dimensions (valence and arousal). Dimensional descriptions of human affect suggest affective states are not independent from one another but continuous and related in a systematic manner. Given current constraints of computational technology, models depicting emotions along a continuum end up being divided up in practice (Gunes and Pantic 84; Gunes and Schuller 322) and the Haptic Creature research is no exception to this. Yet despite this, it is notable that the researchers incorporate a dimensional model of model into various stages of their analysis in an attempt to move beyond discrete models of emotion (see also later research on the device, Altun and MacLean "Recognising Affect"). Further, the fur, breath and vibration of the device, and the request that the participants engage in an imaginative process associating the device with a pet, all point to an implicit awareness of the complexities of touch beyond that of reductive quantification.

The entwinement of quantification with low-tech and imaginative processes in social robotics reconfigures the intimacies of affective touch in new ways. On the one hand, human interlocutors communicating with such devices might be corporeally different, but contact between them is interpreted and transmitted by the robot in a standardised fashion with the assumption that the communicating bodies are similar and the meaning of gestures is known. In this sense such an interaction invites the criticism of affective computing that it does not "acknowledge the ambivalence and mixed feelings involved in any emotional experience" (Lasén 90). Communicators standardise their gestures to attempt to use the device successfully, incorporating machinic norms into their expression (Alac). Nevertheless, this standardisation, which justifiably emerges out of the need of these devices to function normatively as educational, therapeutic and communicative devices, is not the full extent of

the tactile interactive experience. Also operating are imaginary and material aspects of touch that allow for an ambiguity and ambivalence of affective touch and diversity of response. The soft and/or fuzzy covers that inevitably cover tactile robots are testament to this. These textures and densities constitute a large part of the invitation to touch and engage with the device. [5] They are a notable feature of Kirin, the Hug (DiSalvo et al.), Paro (Wada) and Huggable (Stielhl et al.), which would cease to function without their provocation of affect and imagination. Interaction between a social robot and its interlocutor draws on the abundant expressive resources of all sorts of materials and bodies that provoke rich, imaginative and sometimes unpredictable experiences.

[5] The importance of fur to tactile robotics has led to the development of a fur based sensor that recognises touch gesture in later development of ideas from the Haptic Creature in 'Cuddlebot' (Flagg et al.; Allen et al.).

Novel and surprising responses are found in embodied responses to the most practical of haptic devices, such as the surgical robot Da Vinci. Reportedly, surgeons respond and adapt to different machine configurations, experiencing phenomenal shifts (incorporating instruments into their bodies and reunifying fragmented images of patients) that vary with their history and the technology with which they have worked (Suchman 265-66). More broadly, unexpected affective response to robots is apparent in the frequency with which people attribute emotional expression to devices that were never intended to be emotionally expressive, such William Grey Walter's tortoises (Riskin 11), electronic ordinance devices, and robotic floor cleaners (Sandry 103-10). Novelty and unpredictability is inevitably part of the dynamics of our embodied engagement with social robots, and may be more or less acknowledged and incorporated into their therapeutic, educational and entertainment purposes. Discourses in aesthetics, on the other hand, are better known for their articulating these values.

Tactility and affectivity in cinematic, tactile and new media art

Less constrained by normative demands than social robotics, reflections on touch as a perceptual style in cinematic, tactile and new media art frequently engage with its polyvalent, imaginative and mobile dimensions (Svankmejer; Vasseleu; Paterson 79-102; Deleuze 122-34; Marks 160-66). The practice of and reflection on such artworks call attention to the notion that touch does not simply refer to making physical contact, but to styles of perception and imagination. The ambiguity of the tactile imagination may be related to indeterminate perceptions. Examining the writings and artwork of Svankmejer, Cathryn Vasseleu explains that "Tactile mediation" does not necessarily refer to the direct engagement of touch and is not achieved by simply incorporating touch technologies into the machines we use. She

relates tactility to the unintentional, associative relationships of a certain style of imagining (155). This style is described in Svankmejer's writings and explored in his "tactile experiments", which include practices like constructing a series of tactile tablets through which to explore people's associations between touch and colour (6-10). Svankmejer, she notes, experiments with "tactility as a sensory modality in which objects of all sorts can kindle affect by analogy" (143), leading to an understanding of "tactile experience in terms of poetic metamorphosis rather than phenomenal dexterity" (144).

For Svankmejer the analogies of the tactile imagination rekindle childhood memories and enable access to a universal unconscious. He observed that the tactile imagination was best stimulated by ambiguous objects, writing "to facilitate free associations, analogies and imaginative thinking, it is best to choose items which are vague, difficult to define or parts of objects which, precisely because they defy identification, excite with their strangeness, stimulate elemental, structural, warm and colourful sensations" (21). Functional touch, in which a hand performs a clear and familiar task is unlikely to provoke such imagining. According to Svankmejer, and to cinematic theorists such as Laura Marks, part of what makes an encounter with any object or subject tactile and so a matter of ambiguity, mobility and proximity, is that it is unknown. The eye may roam a textured image trying to work out what it is, or a hand feel around an object in a drawer, not recognising what it is touching. As such, the tactile imaginary is not bound to the sense of touch, but is a style of perception employable by other sensory modes, most frequently vision, as evident in Svankmejer's extraordinary tactile animations.

Crucially, touch occurs in the *relationship* between subjects and objects. One influential formulation of this relationship is the phenomenologist Merleau-Ponty's, in which the touching of hands in a chiasmic relationship exemplifies the indistinguishability of subject and object (*Invisible* 146-49). This continuity between parties touching means that the experience of touch, including its affective dimensions, is generated by both parties when they touch. "The quality of the encounter, its 'feeling'" writes Casteñada, "is not established by the toucher or the touched alone" (234). Svankmejer develops his own formulation of how the affective significance of touch arises each time anew in the context of two entities. He points out that tactile affectivity is mobile and endlessly reworked according to each moment and configuration of contact. Observing tactile art, he writes:

> With every touch the [tactile] object changes, it enriches the emotions of everyone who touches it. Not only visibly (with covered objects), where after a while the fingers leave on the object, or on some parts of it, visible traces (dirt, grease, surface wear and so on) but also on an emotional level. Every sensory touch necessary "charges" the object emotionally. A tactile object acts as an accumulator into which those perceiving invest their emotions at the moment of touching. Of course, they reciprocally drain off the emotions that have been invested into it, firstly by the maker and secondly by all the others who have touched the object since then. I venture to say that the emotional content of a tactile object constantly changes; that we touch the same, yet at the same time an altogether different, object. It is this emotional and permanent metamorphosis that is one of the fundamental characteristics of tactile art. (116)

Here we see that the affective experience of touch in a piece of tactile art is constantly changing, relating not only to the emotion of the creator of an object but also to others who have touched it. Affective experience is reinvented with each, fundamentally creative, touch. The tactile imaginary is not invoked by self-sufficient subjects and objects and the touching of digitally driven devices, such as sociable robots, is no exception to this. Touch occurs in the junction between parties, in their commingling, and affect experience is generated anew with each contact. Generalisation and the assumption that individual's touch-affect connections remain stable into the future overlooks this process. No matter how carefully digitally mapped a bond between touch and affect is, they are inevitably decoupled with each touch.

For Svankmejer, the tactile imagination is provoked when touch is freed from domination by external visual perception, and instead initiates a process of inner visualisation and its associated affectivity. He articulates the liberation of imagination and feeling in surrealist terms, calling upon the idea of the repression of the unconscious and the stimulation of the imagination. Svankmejer's association of a tactile imagination with indeterminate and unknown objects is continued by thinkers working with Deleuzian ideas on the haptic, although they are not articulated in terms of the imagination and the unconscious. The importance of poetic analogy gives way to that of continuous material – analogue – relationships. Laura Marks explains that haptic vision in cinema is a kind of seeing based on a contiguity between viewer and object. It appeals to "tactile connections on the surface of the object" (Marks 162) that make it difficult for the viewers to discern what they are looking at and their participation is required to constitute the image

(183). Haptic vision contrasts with optic vision, which sees things at a distance and establishes clear knowledge of a scene. Haptic vision is not so much about representing touch in visual images (although this can be the case), but about bringing the viewer into material contact with images, allowing them to touch the viewer.

Mark Hansen writes of haptic vision that engages tactility and proprioception as a mode of vision (*New Philosophy* 1-12). Of particular relevance to questions of perception and affectivity is his articulation of an inner affectivity produced through the experience of haptic space within the body. This affectivity is distinct from external perceptual experience, and so from its expression. Through examining experimental and exploratory digital artworks, his work generates a sense of the possibilities for human-machine interaction, providing reference points by which to consider the limits and strengths of strategies to cultivate human and machine intimacy. While Hansen's work focuses on vision and the digitalisation of the image, its ideas can be extended to other modes of perception, the limitations of which I will consider below.

In close, critical conversation with Deleuze's views on affect and perception, Hansen examines the way digitally produced art produces an autonomous, internal affective response. The quantification of affect is always supplemented by the processes of the human body. He writes:

> Affectivity, accordingly, is more than simply a supplement to perception (as Deleuze maintains) and it is more than a correlate to perception (as Bergson holds). Not only is it a modality of experience in its own right, but it is that modality – in contrast to perception – through which we open ourselves to the new. In short, affectivity is the privileged modality for confronting technologies that are fundamentally heterogeneous to our already constituted embodiment, our contracted habits and rhythms. (*New Philosophy* 133)

Unlike Svankmejer's, Hansen's discussion of the way that affect emerges from the interplay between art object and the body is not focussed on kindling a repressed universal imagination but on the encounter with the technologically new and different. One example he discusses is the artwork *Dream of Beauty 2.0*, a digital facial image that, in contrast to our usually expectation of expressive faces, ultimately asserts its own foreignness. The viewer's inability to make contact with the digitally generated image instigates the realisation that it "does not need us, will continue to exist in total indifference to our efforts to engage it, and can have meaning only to

the extent that it foregrounds the source of our affective response – our constitutive embodiment, which is to say, the profound divide between its materiality and our own" (*New Philosophy* 143). The affective experience of the face, that is, does not lie in it as an affection image (as Hanson claims Deleuze would have it), but in our bodily experience of the image.

The artworks examined by Hanson defy regular perception's expectation and capacity, going beyond, in the case of Robert Lazzarini's *Skulls* sculpture, "the ratios of our embodied experience" (*New Philosophy* 143). The irreconcilability of the space and time of digital realm with embodied human perception produces an inner haptic experience analogical to perception. This self-affecting is a "sensory experience" of the "body itself" (*New Philosophy* 11). It is this capacity for affectivity that allows "the capacity of the body to experience itself as 'more than itself' and thus to deploy its sensorimotor power to create the unpredictable, the experimental, the new" (*New Philosophy* 7). Independent, affective experience is thrust to the fore when perceptual connection and contact cannot be made due to radical difference. This inner experience is, like Svankmejer's tactile imagination, a creative process.

Despite resonance between Svankmejer and Hansen on matters of perception and affect, they diverge in that Hansen's account of the experience of digital art characterises it as an encounter with an unreachable otherness. The human body makes restricted perceptual contact with the spatiality and temporality of the digital, which is remote and alien to the human body. In contrast, Svankmejer's tactile artworks, are unsettlingly intimate. His animations rearrange everyday objects and often employ a domestic setting, producing cloyingly proximate spaces that fold into themselves and bamboozle perception, as exemplified by the animation *Alice* (1988). Arguably this divergence is an effect of emphasising different sensory modes, with Hansen only discussing the visual processing of images in *New Philosophy for New Media*. His focus on a sensory mode often associated with remoteness can be thought to emphasise encounters with distance. When he later examines the embodied experience of virtual reality, Hansen notes that "any *purely visual account of perception must fail*" (*Bodies in Code* 120) and turns to touch's contribution, which he suggests stems from the "implicit conjunction with movement" (*Bodies in Code* 121) inherent in its nature as a double sensation (*Bodies in Code* 120-21). This means he articulates the self-affection of Merleau-Ponty's notion of the bodily schema (in contrast to body image) in terms of "primordial tactility" (*Bodies in Code* 67-81).

Touch as a double sensation, as articulated by Merleau-Ponty in his portrayal of the chiasmic nature of touch (*Visible* 146-49), demands a material closeness that even haptic vision does not insist on. Touch does not occur between two discrete entities but in their entwining so that the affectivity that occurs with touch is not ascribable to one or the other participant. This extends to tactile meanings provoked by social robots, which are subject to the idiosyncrasies and relationality of perception and its affectivity (Kerruish). For Merleau-Ponty, each perception is embedded in an embodied imagination that includes memories, ideals, cultural norms and values, among other things (*Phenomenology* 235-82). Tactile meanings emerge from this human embodied perception and the messy materialism of the device in which the discrete units of the digital are instantiated. The functionalising of touch to provoke affect is never a completely precise affair.

Robotic configurations of the analogue and the digital

The soft and/or fuzzy covers that inevitably cover tactile robots are testament to the importance of their sometimes ambivalent and unpredictable materiality. Although soft in this instance, tactilely expressive qualities encompass a range of densities and textures, including the sharp and the jagged. These materially expressive features are termed here "analogue" in its adjectival sense, and following Deleuze, considered to be continuously variable physical quantities that can be contrasted with the digital features of devices (111-21). These expressions are defined by the idea of modulation, that is, "they establish an immediate connection between heterogeneous elements; they introduce a literally unlimited possibility of connection between those elements, on a field of presence whose moments are all actual and sensible" (116). The messiness of the analogue means that the unpredictable and idiosyncratic may emerge with tactile experience. This includes experiences of the digital, which are inevitably instantiated in material devices and experienced by bodies. It is this flop, bounce and wobble of manual messiness that we see ironically rendered in digital animation in the scene in *Big Hero 6* when Baymix's battery is running down and it is lurching around as if drunk. This intoxicated robot with impaired functionality slides from the grasp of Hiro Hamada, no longer creating a feeling of comfort or care. Its analogue aspects have spun out of control and disrupted the digital programming with which they usually work to contribute to the robot's purpose. The digital is embedded in analogue experience; so often hard and metallic, in this instance it is caught by the floppy and squidgy.

The analogue dimensions of tactility suggest that the affective effects of technological devices only emerge in interaction. Like human use of other tools, following Don Ihde we can say that "the skills learned in developing and using instruments parallels quite precisely the same interactive pattern noted in becoming bodily self-aware. One is neither directly aware of the possibilities or constraints of the instrument, nor does one derive this set of capacities from simple material properties, rather it is in use that one reflexively becomes aware of such capacities" (51). This extends to affect, in that the "possibilities and constraints" of the affective significance of tactile interaction cannot be decided on before interaction. Kirste Boehner et al. research affect as interaction in Human Computer Interaction, contrasting it with the informational model of affect and noting that affect as interaction entails a "shift from designing systems to model and transmit emotion to designing systems that support humans in producing, experiencing and interpreting emotions" ("Affect" 65). From this perspective, examining affectivity in tactile robotics includes articulating the open-ended and sometimes less predictable dimensions of interaction. This includes examining the relationship between the high-tech computational and low-tech imaginative aspects, which together kindle affective response. Touch weaves together quantified norms, algorithmic processes, memories, feelings, ideas and so on in deeply culturally and historically inflected ways.

The capacity for tactile digital devices to establish new configurations of the digital, material and affective is striking in a device such as the Haptic Creature. The researchers explicitly engage participants' imaginings of pets and consider the affective potential for greater abstraction of its expressive breath. As discussed above, the dynamics of the embodied imagination and experiences of affective novelty are more commonly discussed in the context of artworks. Digitally driven artworks engaging in hapticity are especially relevant here. One exemplary work is the interactive haptic artwork by Char Davies, *Osmose*, in which "the felt boundaries of the body are blurred into a semitransparent environment, providing the sense of a thickness to space, and of an altered sensory orientation to the world" (Paterson 125). Also of relevance are works by Thecla Shiphorst, for example, the interactive installation *soft(n)* that explores the somaesthetics of tactile interaction with a focus on intimacy, imagination, sensuality and play (Schiphorst). While relating the novelty and exploratory nature of such works to the often normative functions of social robotics may be a long-term project, other artworks are of more immediate relevance. *The Blind Robot* by Louis Phillipe-Demers, which aims to explore the "degrees of engagement, whether it be intellectual, emotional or physical, that are generated when a social robot intimately touches a person." It consists of two robotic arms and hands that

explores the face of a visitor before rendering a portrait on a nearby screen (Kroos, Herath and Stelarc). This experience of intimacy with a robot is firmly focussed not on making the robot palatable to human touch (the robot is an undisguised, skeletal machine, uncovered by soft materials), but on the novelty of the cultural and individually embedded experience of being intimately touched by a social robot. It thus enables the individual to feel and reflect on the significance of haptic and social interaction with a machine, a process that may emerge when people are interacting with social robots simply for functional purposes (Turkle 23 -147). Likewise, Petra Gemeinboeck and Rob Saunders's design of "curious" robots that get "bored" for the piece *Curious Whispers* is directly relevant to affective concerns in social robotics. It moves well beyond reductive quantification of affect, encouraging people to bring human cultural context into a socially creative process with a community of robots. They point out that "embodiment provides opportunities for agents [robots] to experience the emergence of effects beyond the computational limits that they must work within" (2).

The dialogue between robotics and arts currently underway in robotic art demonstrates the contribution that aesthetic discourses and methods can make to social robotics, including to examining affective dimensions of hapticity. This is apparent in volumes such as *What Do Collaborations with the Arts Have to Say About Human-Robot Interaction*? (Smart et al., 2010) and *Robots and Art: Exploring an Unlikely Symbiosis* (Herath and Kroos, 2016) that speak to the common interests of art and robots, and the contribution that robotic art can make to robotics in general. The dialogue is also seen in the inclusion of robotic artists in research collaborations in tactile robots, such as that conducted into tactile sensing and social touch which included the robotic artist Mari Velonaki (Silvera-Tawil, Rye and Velonaki, "Interpretation of Social Touch," "Artificial Skin").

Conclusion

The complexity and potential unpredictability of affective touch sits alongside the normative demands of many social robots that strategically deploy affective touch. After all, any device offering a therapeutic and communicative tactile experience cannot be guaranteed to be successful when each encounter generates the meaning of the touch anew and with reference to the individual's own messy embodiment and imagination. But in a comment that refers to two common functions of tactile robotic devices, Svankmejer suggests that tactile communication and tactile therapy blur the distinction between utilitarian and poetic touch (4). The idiosyncrasies of the

poetic dimensions of touch are both unavoidable and vital to the affective dimensions of those practices. This point extends to robotics devices and indeed to all tactile devices in which the messiness of the analogue – of the human body and the things it touches – are tangled up with the digital. These complexities of touching of robotic devices may be analysed in various ways, by considering the aesthetic understandings of affect discussed above, through drawing on Merleau-Ponty's ideas regarding the embodied imagination and the reversibility of perception (Kerruish), by employing ideas of affective mimesis and entrainment (Gibbs), or through other conceptual frameworks that examine gesture, imagination, meaning and affect.

Affective tactile robotics are an instance of how, according to Sarah Kember and Joanna Zylinska, "our relationality and our entanglement with nonhuman entities continues to intensify with the ever more corporeal, ever more intimate dispersal of media and technologies into our biological and social lives" (xv). Part of Kember and Zylinska's impetus to adopt the term mediation (instead of new media) is to capture how our lives emerge within technology, for articulating "our being in, and becoming with, the technological world, our emergence and ways of interacting with it" (xv). Thinking of social robots as mediation in this sense highlights how they participate in the regulation of bodies at sociocultural and biological levels that link to broader social and political processes. Contemporary tactile social robots rework intimacy and its associated feelings in this context, incorporating quantification into and extending embodied affective experience. Translation into data enables the networking of physical contact, connecting it to distant and extensive events that a person's touch might inform or be informed by. As Hansen writes, "With the ubiquitous infiltration of digital technologies into daily life, embodied agency becomes conditioned (necessarily so) by a certain (technical) disembodiment" (*Bodies in Code* 93). Attention to the material, affective and social experiences of physical intimacy with robots requires examining the way they incorporate this disembodiment.

As the softness, vulnerability and flop of Baymix the robotic carer suggests, the ingenious devices used in research into tactile social robotics calls for an articulation of its material and imaginative dimensions. These are entwined with digital processes and provoke affect in interaction with people using the device. Each machine and human touch is a contact embedded in a complex embodied imagination. In this process, affective meaning emerges from quantification and materiality, and intimate experience is connected to

distant events both digitally and imaginatively. The remote is present with each messy, close contact, providing new comforts and discomforts.

Works Cited

Allen, Jeff et al. “Introducing the Cuddlebot: A Robot That Responds to Touch Gestures.” In *Proceedings of the Tenth Annual ACM/IEEE International Conference on Human-Robot Interaction Extended Abstracts*, 295-295: ACM, 2015.

Altun, Kerem and Karon E. MacLean. “Recognizing Affect in Human Touch of a Robot.” *Pattern Recognition Letters* 66 (2015): 31-40.

Boehner, Kirsten et al. “Affect: From Information to Interaction.” In *Proceedings of the 4th decennial conference on Critical computing: between sense and sensibility*, 59-68. Aarhus, Denmark: ACM, 2005.

--- . “How Emotion Is Made and Measured.” *International Journal of Human-Computer Studies* 65.4 (2007): 275-291.

Casteñada, Claudia “The Future of Touch.” In Ahmed, Sara and Jackie Stacey. *Thinking through the Skin.* New York: Routledge, 2003.

Christian Kroos, Damith Herath and Stelarc, ed. *Robots and Art: Exploring an Unlikely Symbiosis*. Singapore: Springer, 2016.

Cooney, Martin D., Shuichi Nishio, and Hiroshi Ishiguro. "Recognizing affection for a touch-based interaction with a humanoid robot." *2012 IEEE/RSJ International Conference on Intelligent Robots and Systems*. IEEE, 2012.

Deleuze, Gilles. *Francis Bacon: The Logic of Sensation*. Trans. Daniel W. Smith. Minneapolis: University of Minnesota Press, 2002.

DiSalvo, Carl, et al. “The Hug: An Exploration of Robotic Form for Intimate Communication.” In *Robot and Human Interactive Communication, 2003. Proceedings. ROMAN 2003. The 12th IEEE International Workshop on*, 403-408, 2003.

Dror, Otniel E. “Counting the Affects: Discoursing in Numbers.” *Social Research*, 68 (2001): 357-378.

Flagg, Anna, et al “Conductive Fur Sensing for a Gesture-Aware Furry Robot.” In *Proceedings of IEEE Haptic Symposium (HAPTICS '12)*, Vancouver, Canada, March 2012, pp. 99-104.

Gibbs, Anna. "After Affect: Sympathy, Synchrony and Mimetic Communication." In Melissa Gregg and Gregory J. Seigworth (eds). *The Affect Theory Reader*. Durham: Duke University Press, 2010.

Gunes, Hatice and Maja Pantic. "Automatic, Dimensional and Continuous Emotion Recognition." *International Journal of Synthetic Emotions (IJSE)* 1.1 (2010): 68-99.

Gunes, Hatice and Björn Schuller. "Categorical and Dimensional Affect Analysis in Continuous Input: Current Trends and Future Directions." *Image and Vision Computing* 31.2 (2013): 120-136.

Hansen, Mark B. *Bodies in Code: Interfaces with Digital Media*, New York: Routledge, 2012.

--- . *New Philosophy for New Media.* Cambridge, Massachusetts: MIT Press, 2006.

Hayles, N. Katherine. *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*. Chicago and London: University of Chicago Press, 2008.

Ihde, Don. *Embodied Technics*. Copenhagen: Automatic Press/VIP, 2010.

Kember, Sarah and Joanna Zylinska. *Life after New Media: Mediation as a Vital Process*. Cambridge, Massachusetts: MIT Press, 2012.

Kerruish, Erika. "Perception, Imagination and Affect in Human - Robot Relationships." *Cultural Studies Review* 22.2 (2016): 4-20.

Lasén, Amparo. "Digital Inscriptions and Loss of Embarrassment: Some Thoughts about the Technological Mediations of Affectivity." *Intervalla* 1 (2013): 85-100.

Marks, Laura U. *The Skin of the Film: Intercultural Cinema, Embodiment, and the Senses*. Durham and London: Duke University Press, 2000.

Merleau-Ponty, Maurice. *Phenomenology of Perception*. Trans. Colin Smith. London, New York: Routledge, 2002.

--- . *The Visible and the Invisible: Followed by Working Notes*. Ed. Claude Lefort. Trans. Alphonso Lingis. Evinston, Illinois: Northwestern University Press, 1968.

Paterson, Mark. *The Senses of Touch: Haptics, Affects and Technologies*. London and New York: Bloomsbury, 2007.

Riskin, Jessica (ed). *Genesis Redux: Essays in the History and Philosophy of Artificial Life*. New York: University of Chicago Press, 2010.

Russell, James A. "A circumplex model of emotion." *Journal of Personality and Social Psychology* 39.6 (1980): 1161-78.

Saldien, Jelle et al. "Expressing Emotions with the Social Robot Probo." *International Journal of Social Robotics* 2.4 (2010): 377-89.

Sandry, Eleanor. *Robots and Communication*. Hampshire, UK: Palgrave MacMillan, 2015.

Saunders, Rob, et al. "Curious whispers: An embodied artificial creative system." *International Conference on Computational Creativity*, 2010.

Silvera-Tawil, David, David Rye and Mari Velonaki. "Artificial Skin and Tactile Sensing for Socially Interactive Robots: A Review." *Robotics and Autonomous Systems* 63 (2015): 230-43.

--- . "Interpretation of Social Touch on an Artificial Arm Covered with an Eit-Based Sensitive Skin." *International Journal of Social Robotics* 6.4 (2014): 489-505.

Schiphorst, Thecla. "Soft (n): Toward a somaesthetics of touch." *CHI'09 Extended Abstracts on Human Factors in Computing Systems*. ACM, 2009.

Smart WD, Pileggi A and Takayama, L. "What do collaborations with the arts have to say about human-robot interaction?" Report no: WUCSE-2010-15, All Computer Science and Engineering Research. 2010.

Stiehl, Walter et al. "The Huggable: A Therapeutic Robotic Companion for Relational, Affective Touch." In *ACM SIGGRAPH 2006 Emerging Technologies*, 15: 2006.

Suchman, L. *Human-Machine Reconfigurations: Plans and Situated Actions*. New York, Cambridge University Press, 2007.

Švankmajer, J., S. Dalby and C. Vasseleu. *Touching and Imagining: An Introduction to Tactile Art*. London: I. B. Tauris, 2014.

Szondy, David, "Building a real-life Baymax." *Gizmag*. 22 Feb. 2015. Accessed 15 March 2016. < http://www.gizmag.com/big-hero-6/36122/>
Turkle, Sherry. *Alone Together: Why We Expect More from Technology and Less from Each Other*. New York: Basic Books, 2011.

Vasseleu, Cathryn. "Tactile Animation: Haptic Devices and the Švankmajer Touch." *Senses and Society* 4.2 (2009): 141-62.

Wada, Kazuyoshi and Takanori Shibata. "Living with Seal Robots: Its Sociopsychological and Physiological Influences on the Elderly at a Care House." *Robotics, IEEE Transactions on* 23.5 (2007): 972–80.

Yohanan, Steve and Karon E MacLean. "Design and Assessment of the Haptic Creature's Affect Display." In *Proceedings of the 6th international conference on Human-robot interaction*, 473-480: ACM, 2011.

--- . "The Role of Affective Touch in Human-Robot Interaction: Human Intent and Expectations in Touching the Haptic Creature." *International Journal of Social Robotics* 4.2 (2012): 163-80.