Contact Expressions For Touching Technologies

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ABSTRACT
Human-computer interfaces typically involve limited tactile input and audio/visual output, and even when the interface has been enhanced with speech, gesture, and haptics, this is often done to supplement (or compensate for) audio/visual output. Even the most interesting and elaborate work on force-feedback does not seem to be yet envisioning the full expressive potential of physical contact, in particular, the "contact expressions" used routinely by people and animals in different contexts. People use contact expressions when other forms of communication are inappropriate or impossible, to supplement other forms of communication, or because the physical contact itself has significance. As robotic toys and embodied technological devices become smaller, more portable, more durable, and more commonplace, it is our belief that contact expressions will become an important area of interface design and will open up new areas of study for applied semiotics. This paper describes a "contact cushion" we have built and used to explore some of the potential for contact expressive devices – and outlines a preliminary design taxonomy of basic contact expressions.

Keywords
Contact Expressions, Semiotics, Tactile interfaces, Haptics

1. INTRODUCTION
SCENARIO: *Karo moves into the living room to find Janet lounging on the sofa with her infant son, Paul, who is sleeping beside her. Young Paul starts to thrash in his sleep, so Karo crawls up and sprawls next to him. Janet pats Karo affectionately on the head and Paul opens his eyes, so Janet then pats him on the head, too. Paul smiles sleepily at the joke, wraps one arm around Karo, and snuggles into the warmth; the two of them start to breathe deeply and evenly in tandem contact. A little later Karo indicates that Janet's friend John is calling, but Janet can tell from the signal that he is in a chatty mood and so decides not to answer.*

Karo puts his nose under Janet's arm, nudging it up a few times until she gets the idea that he wants to be stroked; he settles his head into her lap. When Karo's head begins to get too heavy, Janet tries to push it off; but Karo notices that at that moment he would disturb the sleeping baby if he moved in the direction she is pushing, so he resists – and when Janet stops pushing, he moves his head in a different direction. After a while, Janet drifts off to sleep – and wakes when the nearly-empty bowl of chips that was beside her slides off the sofa and spills onto the carpet. She reaches out her hand to confirm that Karo is still lying beside her, then pats/pushes him to indicate that he should take care of it; he responds by getting up, licking/eating up the spilled chips, and picking up the bowl in his mouth and taking it into the kitchen.

In this not-too-distant-future scenario, Karo is a robot – and all of this takes place silently in the dark.

The purpose of this scenario is to highlight some of the ways that signifying physical contact is an almost unnoticed part of everyday life – and to suggest ways in which such "contact expressions" may be fruitfully incorporated into future computational devices.

What we mean by "contact expressions" is probably most evident in the range of examples from the scenario, but we can also say that by our view they involve mutual signification, are not simply "parasitic" on natural language (nor entirely subsumed within it), and include both instrumental and experiential touch. In other words, just as "facial expressions" involve significance beyond the control and display of certain muscles, so, too, "contact expressions" involve significance beyond simple properties of touch. And just as there is an emerging vocabulary and set of techniques for designing graphical interfaces (GUIs), we wish to contribute to the emergence of a similar vocabulary and set of techniques for designers of contact expressive interfaces (CUIs). In our view, contact-expressive design can involve anything from simple "massage chairs" to more complex, pro-active feedback devices suggested by the description of Karo. To paraphrase John Austin, we would like to begin addressing the problem of "How to (design computational devices that) Do Things With Contact Expressions."

2. SURVEY
In general, there seems to be very little direct research and development on contact expressive devices. What follows is a short survey of work in three relevant traditions: studies in the behavioral sciences that attempt to show the significance of "touch"; attempts to create taxonomies (or "vocabularies") of physical touch; and the development of technologies that use physical contact as a significant part of the interface.

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2.1 Behavioral Sciences

Although there is a fairly large body of research into what may be called "nonverbal communication", the majority of this work is on visual expression (facial expressions, physical appearance, direction of gaze, physical posture, orientation, movement, proximity and other visible forms of "body language") and paralinguistics (i.e., vocal inflection, pitch, volume, speech rate, etc.). A representative definition of what is meant by non-verbal communication makes this clear: "Nonverbal communication, then, could be defined as that part of a message, which is not words, but which may accompany words or occur separately from words – and includes facial expressions, gestures, posture, spacing, tone of voice, pitch, volume, speed of talking, etc." [22]. Although a typical survey of nonverbal communication will include references to studies of touch, there is usually very little detail; and a survey of the literature on nonverbal communication also reveals that only a small percentage of it is devoted directly to studies of touch.

There does seem to be widespread acknowledgement of this neglect by the researchers who study nonverbal communication, and one suggested explanation [20] is that although this may partly be the result of touch-related inhibitions and taboos, it is almost certainly also related to the methodological difficulties of studying physical contact. These difficulties include the fact that casual contact among strangers is rare; intimate contact between friends or lovers is usually private; and the factors relevant to touch are difficult to isolate from other senses and forms of expression without creating further research challenges. All of these difficulties also help to explain why most of the research on touch is in the form of observational correlation studies. (For a survey of this research, see [19].)

Finally, within the field of psychology there is the concept of "contact gestures" which are "physical commands" used instead of visible gestures. So, for example, a young child who wants an adult to open a container may use a contact gesture to actually place the adult's hands on the container and put them through the motions of opening it. There has been some work comparing the use of contact gestures among autistic and non-autistic children and apes [13], but in general, there does not seem to be an existing descriptive taxonomy of contact gestures.

2.2 The Semiotics of Touch

Although semiotics in the large is concerned with the full range of "signification" (or "meaning"), physical contact is one of the areas that seems least explored by semioticians. To be sure, it is indicated (usually in a cursory manner) as part of the larger field of semiotics, but there seems to be very little detailed study, theory, or discussion about the signifying nature of physical contact.

Introductory texts on semiotics usually devote no more than a line or two to the effect that physical contact involves "body codes" (body contact, proximity, physical orientation, appearance, facial expressions, gaze, head nods, gestures and posture) – and "group-specific codes" (gender, age, race, culture, status, etc.). As indicated above, many of these codes are what behavioral scientists typically consider part of nonverbal communication (rather than physical contact *per se*). Even the most encompassing scholarly discussions or surveys of semiotics [16] do not seem to have included much detailed investigation or analysis of physical contact.

And unlike the behavioral sciences, this does not seem to occasion as much comment among practitioners. We can imagine at least two possible contributing factors: the first is that semioticians tend to come from linguistic or philosophical traditions (rather than, say, physical therapy); the second is that many semioticians may still, in many ways, believe in the validity of abstract taxonomies – in which case the "physical embodiment" of signifying systems may seem irrelevant to the signification processes themselves (and are therefore subsumed under more general semiotic taxonomic categories). There is indeed suggestive evidence for this second hypothesis if we look at the kinds of semiotic descriptions that have been proposed for physical contact. So, for example, there have been some proposals for large taxonomies of types of bodily contact; classifications of bodily contact common in Western Culture; a five-level taxonomy of type/meaning pairings; and proposals for modeling the possible relationships between physical contact and status (see [19] for an overview).

On a related note, although Piaget and his colleagues have done a great deal of research studying "sensori-motor intelligence" – and Piaget himself was deeply interested in integrating semiotics into his model of cognition [24] – the literature on development psychology does not appear to contain studies of what might be called the "physical semiotic function." A contributing factor may be the structure of Piaget's stage model, which proposes that the semiotic (or "symbolic") function arises as part of the transition out of the sensori-motor stage. In other words, the semiotic function is seen largely in terms of the emergence of (referential) language and *thought* – by contrast to the more "primitive" sensori-motor reflexes. By this view, the emergence of language is related to the observation that words (and "thoughts") can "represent" physical actions that need not be taken. The fact that there can be physical "puns" – that some contact expressions can stand for, or reference, *other contact expressions* – does not seem to have been the subject of study.

2.3 Tactile Technologies

Although some aspects of haptic research are as old as any work on human-computer interaction, in many ways touch is still a nascent field of HCI study. There are, of course, a number of efforts to develop technologies that accept tactile (or haptic) input and, to a lesser degree, provide tactile output ("force feedback", etc.). Most of the work to develop "tactile interfaces" has concentrated on simulating different aspects of the physical world (game force-feedback devices, motion simulators, and the like); on providing additional feedback in multimodal systems for complex tasks (force-feedback for molecular docking systems, etc.); or on "mapping" the movement of an on-screen pen over physical contours of a surface to a (force) feedback input device. (For a summary of the history of research on haptic and force-feedback interfaces, see [28].)

One of the earliest projects to use tactile conviviality as part of the interface was in the creation of Noobie, The Furry Computer [10]. It was a computer in the form of an over-sized, plush toy for small children to climb up on, snuggle into, sit (or lay) on, etc. This theme, of using plush toys to make the interface friendly

and familiar, has been elaborated by a number of subsequent researchers [11,12,15,17]; however, very few projects seem to be elaborating the physical contact aspects of the original Noobie project.

A sampling of current projects gives an indication of both utilitarian and experiential applications of touch-oriented computational research. There are projects to develop telephones with various haptic qualities [4,21]; to develop various kinds of "musical objects" that respond to touch [27,31]; to develop physically embodied interface objects ("tangible bits") that can be manipulated in various ways [14]; to develop contact-responsive plush electronic toys (Furby, Barney, Tickle Me Elmo) [7,18,29]; and to develop hand-held devices with "ambient touch" interfaces [25] that can support different physical interactions such as tilting, dropping, spinning, rubbing the device against something else, and so on. There is also related work in the field of textile design, where online shopping is motivating research into methods for simulating tactile aspects of different materials [8]; and in recent years, there have been semi-serious proposals for combining VR and force-feedback for "virtual sex" [3].

3. PROBLEM STATEMENT

As indicated in the survey, there does not seem to be much in the way of either semiotic analysis of – or applied research into – the extended possibilities of what we are here calling contact expressive devices. In some cases the absence of research is simply curious. For example, most human-computer interaction already involves what could be considered contact expressive input: we type at keyboards, move mice, draw with pens on tablets, and use pressure-sensitive screens. And although this is obviously a very limited subset of the full potential of contact expressive interfaces, it is almost inevitable that haptic interaction will be extended in various ways (not the least of which will be to make more expressive use of haptic *output*.)

In other cases, the absence of an explicit emphasis on contact expressions is actually startling. There are, for example, many robotics projects around the world with the stated intention of improving life for the elderly, the autistic, and the allergic; however, it is rare for these projects to include physical contact with the robots as an explicit goal (for some important exceptions, see [5,9]). Even project reports devoted to robotics and "social interaction" tend to ignore almost all aspects of physical contact. So, for example, in the otherwise excellent survey article on the many dimensions of "embodied social interaction" [11], there is literally no mention of physical contact.

Beyond these limitations, there is also the almost total absence of any semiotic study of contact expressions – and virtually no work of which we are aware that attempts to leverage such analyses in the service of designing and implementing useful and experientially interesting contact expressive devices.

We feel, therefore, that there is still major work to be done studying, understanding, and making use of contact expressions. Our particular focus in this paper is to contribute to the development of this area of study by sketching an initial design taxonomy and an example contact-expressive design Pattern.

4. METHOD

Since the application of semiotics to computational interfaces is still in its infancy, a brief description of our orientation may help the reader contextualize the work we report here. Our work can be understood as part of the larger effort on the "syntonic design" [23] of empowering computational devices, applications, and services. Briefly, this consists of a cycle of implementation, study, and revision. The implementations are based on cognitive insights from the intersection of developmental ("constructivist") psychology and semiotics [24,2]; the studies are largely qualitative in which insights about *the activities of participants using particular implementations* form the basis for cognitive hypotheses, the development of design vocabularies and guidelines [1], iterative modifications of the implementations, and further study.

In order to begin elaborating a vocabulary for contact expressions for computational devices, two small, exploratory studies with a contact expressive cushion (the PillO'Mate) were conducted. The first study explored the use of the cushion as a therapeutic presence, and illustrates a number of issues relevant to understanding the *experiential* (or "self-fulfilling") potential of contact expressive devices. The second study explored people's reactions to using the cushion as a telephone "pager", and illustrates some issues relevant to their *instrumental* potential.

These studies involved qualitative explorations of contact expressions and some of their significance ("what do different kinds of contact expressions mean to you?" and "why do you associate a specific contact expression with a specific type of person?", "if we changed the device so that it was contact expressive in this other way, what kind of person would you assume is trying to contact you?" etc.). These discussions are the basis for formulating some initial descriptions of human contact acts – and for then incorporating them into an evolving "design Pattern Language" for contact expressive devices.

In the work reported here our goal was to complete an initial cycle of implementation, study, and analysis. In other words, we felt that there was very little known about contact expressions and which aspects might be relevant to the design of contact expressive devices. Therefore, in order to get some idea of which areas are promising for further, sustained investigation, we chose to focus on a quick implementation and a series of short exploratory studies to get some initial indications of how people used them and what significance was ascribed to them. Although it will be important later to do more rigorous studies, it simply felt premature to develop testable hypotheses, do extensive studies with control groups, or gather quantitative results. The cushion, the studies, Speech Act Theory, and Pattern Languages are now described in more detail.

4.1 PillO'Mate Device

The PillO'Mate is an oversized cushion, inside of which is the following technology: a fine wire-mesh proximity-sensor, a GSR (Galvanic Skin Resistance) sensor, a vibration motor, a heating pad, and a speaker. The electronics inside the cushion are surrounded with "granular" Tempur™, which was chosen so that the cushion would to be not too heavy, it would be pleasant to hold and hug, and yet it would still protect the electronics inside. The back of the cushion is covered in fleece (to conduct heat),

and the front is covered in imitation leopard-skin to encourage stroking, cuddling, and nuzzling. (For the studies reported here, it was not possible to completely integrate all the necessary components directly into the cushion. The resulting solution has a "tail" which consists of cords that connect the heating pad to an external transformer for the heating pad, an amplifier for the speaker, and a PC for the audio clips. Although this tethered solution made certain kinds of studies impractical, it also made some users explicitly aware of and interested in the potential of more mobile contact expressive devices.)

People use the PillO'Mate in much the same way they do an ordinary large cushion – they pick it up, put it on their laps (or hug it to their chests), fiddle with it, and lean, lay, or put their heads on it. The cushion switches to an active state when it detects an approaching object (such as a hand) within 5cm, but only by being stroked or touched in specific ways will it react with sound, vibrations, and/or changes of temperature. (For more detail, see [6].)

4.2 PillO'Mate Studies

Study 1: Warming Up to Contact Expressions. The original impetus behind the PillO'Mate was to develop a device that helped people relax. Using a pet (cat) as an initial source of inspiration, the device was developed as a way to explore certain qualities that people find relaxing about having a cat sleeping on their laps. It is important to emphasize that the goal was not to simulate a real cat, but rather to explore and support different aspects of touching, feeling and listening. The first study, then, is based on observations of people (many of them attendees at Comdex 2003 in Gothenburg) sitting with the PillO'Mate and talking about it in terms of its soothing qualities.

Study 2: Contact Expressive Pager. In order to explore some of the instrumental potential of contact expressions, we did a very small study of people's concerns by discussing scenarios involving the PillO'Mate as a "contact expressive pager." This consisted of some exploratory meetings with six people in which they were asked to sit with the cushion on their laps, close their eyes, and imagine that when the cushion started vibrating it was an indication that someone was calling. They were then asked to describe characteristics of the imagined caller based on the characteristics of the contact expression. The study was divided into two parts: in the first part, participants discussed the significance of the current PillO'Mate for different categories of people calling, types of call, etc.; in the second part, they discussed how they felt the contact expressions of the PillO'Mate could or should be changed in order to better match the their experience and expectations of different callers, phone calls, and so on.

4.3 Applied Semiotic Analysis of Contact Expressions

There are a number of possible semiotic models that could be used as the basis for enriching our understanding and application of contact expressions. Since we are interested in exploring the co-adaptation and co-evolution of cognition and mediating technology, we pursued an analysis of *activity* inspired by the earlier phenomenological work of Winograd and Flores [32]. That is, we are trying to understand *contact acts* – the first-person "how and why" of contact expression signification.

As a further elaboration of Speech Acts, we are also in the initial stages of trying to build a design vocabulary for contact expressive devices.

4.3.1 Speech Act Theory

In order to frame the results and insights of our work, we now provide a brief overview of (a slightly generalized version of) Speech Act Theory (for a more detailed overview, see [32,26,30]). Speech Act theory emphasizes what people want to *do* with language (as opposed to trying to establish the truth-value of what any particular statement signifies), and proposes three major types of "acts": locutory, illocutory, and perlocutory. (In order to provide relevant examples below, we reference "contact acts" which we will more fully elaborate later in the paper.)

The locutory dimension of a communication act has to do with its material generation – locutory differences in a contact act includes whether the contact expression is soft or hard, whether it vibrates or not, the rate of vibration, and so on. The illocutory dimension of a communication act has to do with the *intention* of the act – illocutory differences in a contact act include whether the physical contact *asserts* ("someone is calling"), whether it *expresses* ("I am happy"), whether it *directs* ("move over there"), whether it *interrogates* ("what is this thing?"), and so on. The perlocutory dimension of a communication act has to do with the effects it can have on the receiver's actions, beliefs, or judgments – perlocutory differences in a contact act include whether *the person being touched* calms down, has a change of mind, is physically displaced by the contact, leans into it, and so on.

In addition, an important aspect of the Speech Act model is the emphasis on the *felicity* conditions of an act – that is, on the conditions that make such acts appropriate. For this study, we consider this to be largely synonymous with Alexander's notion of "context" (see below).

Some limitations of this model will become clear as we start to apply it to the analysis of instrumental and experiential contact expressions. Here we briefly highlight two of them: first, it is not clear whether all illocutory dimensions of speech acts are present in contact expressions (nor whether the illocutory categories of speech acts account for all aspects of contact expressions); and second, it is not clear how the current instrumental emphasis of the model can account for such acts as jokes, play, altruism, creative expression (singing, poetry), and other self-fulfilling forms of expression.

4.3.2 Pattern Languages

Christopher Alexander developed Pattern Languages as a way to effectively identify and describe "good" architectural solutions – solutions that satisfy both structural and experiential requirements.

For our purposes, Patterns are important because they describe an effective (architectural) *feature* that resolves certain conflicting *forces* in some *context* – and they do so in a way that helps a designer "know what to do." So, a classic example is Alexander's proposal for (natural) "Light on Two Sides" as a pattern that needs to be addressed in order for a room to be "good." This example illustrates that Patterns are specific, flexible, sharable, testable, and pragmatic. This particular

Pattern is specific enough for anyone to be able to determine whether or not it is satisfied for a particular room; it is flexible enough that it may be satisfied many different ways; it is sharable in that it can clearly be described for someone else; it is testable in that people can determine whether or not the proposed feature does, in fact, improve the quality of rooms where it is present; and it is pragmatic because the description of the pattern helps a design know what to do, under which conditions, and why.

5. PILLO'MATE STUDIES

Below we highlight some of the insights from the two PillO'Mate studies. For each study, we were interested in which aspects of the cushion people found meaningful – both as *instigators* and as *recipients* of contact expressions. We frame these in terms of any locutory, illocutory, and perlocutory acts that seem present; additionally, we note if there are contact expressive acts that do not seem to fit the existing framework; finally, we highlight the difference between *instigator* and *recipient* contact acts.

5.1 Warming Up to Contact Expressions

The first study was in the form of informal feedback about the PillO'Mate from a large number of users (consisting mostly of male attendees at a trade show). In this study we were exploring whether and how people would "warm up" to a contact expressive device that was "warming up" (literally and metaphorically) to them.

5.1.1 Warming Up: Contact Acts

Locutory contact acts

Instigator. The locutory dimension of human contact acts in this study involved different parts of the human body (hands, faces, etc.)

Recipient. In general, the locutory contact acts of the cushion remained fairly constant: physical vibrations, heat, and surface texture. Although we did not specifically ask for suggestions about how the cushion might be changed or improved, there were a number of spontaneous proposals for changing some locutory aspects. Many people commented on the "purring", wishing that it were different in various ways (faster, slower, stronger, softer, more varied, etc.). For many, this seemed related to their model of it as a substitute cat – which itself also occasioned suggestions for making another, more "dog-like" cushion. (Note that they didn't want it to have the *form* of a dog, but rather the contact expressivity of one.) There were very few spontaneous suggestions about other locutory contact acts (weight, size, shape, heat, etc.) It was also possible to reduce or increase the vibrations, and this was done a few times at the request of a few people.

Illocutory contact acts.

Instigator. Most of the observed human illocutory contact acts were either interrogative or directive. The interrogative acts involved various kinds of explorations of the cushion's surface texture and grain; its heat, softness and weight; and its reaction to different kinds of stroking, squeezing, patting, and so on. Examples of the directive acts included attempts to restart the purring of the cushion if it stopped

Recipient. Although this is the most well-developed aspect of Speech Act theory, for obvious reasons we are cautious about what it means to apply this classification to the PillO'Mate. To be sure, people did use intentional language when they described the pillow's activity ("it is stopping – it must want me to keep stroking it"). (The question of whether truly intentional contact acts ever *could* be part of some mechanical device raises many of the standard philosophical controversies of artificial intelligence. In particular, it raises questions about whether a designed device is illocutory in its own right – or whether it is expressing the illocution of the designer. We leave it to the reader to consider whether or not it is reasonable to describe the PillO'Mate's ability to stop purring under certain conditions as an "excercitive" attempt to demand stroking.)

Perlocutory contact acts.

Instigator. Examples include: whether or not individuals were actually successful at restarting the purring.

Recipient. As in the case of receiving illocutory acts, people did use language ascribing intentional behavior to the cushion ("see? It got me to keep stroking it."). As before, we leave open the question about whether the PillO'Mate actually achieved its goal. For our purposes, the philosophical debates are less interesting than the design implications that people seem willing to invoke intentional explanations, intentions, and interaction frameworks.

Other issues. One of the major observations was the number of "non-acts" – namely, the number of people who saw the cushion and by various means indicated that they didn't want to touch or hold it. In this regard, there is probably a significant correlation between the (predominantly) male attendees at Comdex, and the "affordances" (texture, pattern, size, etc.) of the particular cushion. (However, the resistance was fairly general – women were also reluctant.) We did see, however, a significant change in attitude over the course of the trade show. This seems partly the result of word of mouth ("it looks weird, but try it"). In fact, once people tried the cushion, it was quite common for them to try and persuade their companions – and some even went running to get friends to try it. (Indeed, many people were reluctant to stop using it once they started, although this could have had as much to do with trade-show exhaustion as anything else.)

5.2 Contact Expressive Pager

In the second study, we conducted informal discussions in two stages to learn more about what, if any, "caller expectations" people associated with different kinds of contact expressions.

Note that for this study most of the participants shifted their attention entirely from the cushion as an expressive device to the *person calling* as the expressive agent.

5.2.1 Current PillO'Mate: Caller Contact Acts

In the first part, people sat with the current implementation as we explored what they assumed about the callers based on the way the pillow "rang" (vibrated). Here we summarize the different contact expressive acts that people used in their "pager" interaction with the cushion.

Locutory contact acts. For these scenarios, the cushion is purring/vibrating. One interesting phenomenon here is that people became interested in the locutory qualities of the cushion

itself (and their relationship to the caller). So, for example, people were able to make definition assertions about the possible caller based on the purring/vibrations ("definitely not someone from work," "possibly my mother," etc.).

One set of discussions involved issues related to whether the existing PillO'Mate vibrations felt like a phone ringing. This brought out some aspects of what the participants find important about phone signals. The current PillO'Mate, for example, was built with design goal to be *comforting* – that is, to vibrate and sound "content." So, one thing about the cushion that ran counter to people's expectations about a phone ringing: it does not "pulse" or "change" in some way that they have come to expect from a ringing phone. This raises a number of interesting questions about conventions of phone expectations (that the phone is a device that is aggressive and interrupts).

Illocutory contact acts. When asked why they thought a person was paging them, most people felt it was "for just a small chat, no special reason, maybe guidance in a problem that I may have."

Perlocutory contact acts. Interestingly enough, several people raised the issue of whether they were inclined to answer based on who they thought was calling (and why). Typically, people said that the purring was so calm that they actually felt unusually relaxed about the thought of talking on the phone. Indeed, some said that it was hard for them to imagine a situation where they would not answer the phone, but the fact that the ringing was a gentle vibration might mean that they felt more relaxed and positive about answering and talking. As one person said, "the telephone signal can often be very disturbing. By making it softer and more subtle it would be less stressful and leave it up to me if I want to answer it or not. I would probably still always answer the phone, but I would be calmer doing it!"

Other issues. We also had people explore putting the cushion against different parts of their bodies (back, face, etc.) to see whether it made any difference to who they thought was calling, why, and whether they were inclined to answer. In general, people found it difficult to engage in these activities, and in order to understand this better, in future studies we will explore a larger number of variations on this particular experiment.

5.2.2 Future PillO'Mate: Caller Contact Acts

In the second part, we asked people to sit with the pillow and imagine different scenarios of callers, and then to talk about how the pillow vibrations related to their expectations. We also asked people how they might change the contact expressivity of the cushion to bring it into line with their expectations.

Locutory contact acts: Mostly people found it easy to imagine how to change the locutory dimension to express the mood of the caller ("if it is an angry caller the vibration should be very aggravating, uneven, and have wild swings of intensity"). There is also some indication that some of the people in the study were able to imagine contexts when "vibrating gently" is exactly the way they would prefer to have a phone "ring." So, for example, one person said, "It's perfect as it is! The reason why is that I find telephones to be disturbing and I easily get stressed by ringing signal on the phones, they are always so loud!"

Illocutory contact acts: Similarly, it was easy to imagine the appropriate contact expression for certain kinds of calls ("if the caller is from work and it is important it would have been a pulsating vibration; an important vibration that is hard to ignore").

Perlocutory contact acts. We also explored various "manual" versions of different contact expressions and asked people to talk about how they felt about answering these calls. One example involved "pressing" (with a hand from inside the pillow) against the person; this struck people as annoying and they said they might answer, but only because it would otherwise become unbearable. We also experimented with having the inside of the pillow "roll/move" against its covering (and the body of the person); people indicated that they would answer because they were intrigued – and suggested various ways of transforming the contact expression to suit different kinds of calls. Heat and cold were interesting expressive variations; people felt they would have a difficult time noticing unless the transition was clear, and preferably from one extreme to the other.

Other issues. We can summarize this study by saying that there were a number of "standard" interface insights. It became clear, for example, that the response to the usefulness of such a phone was very much connected to the person's individual experience with, and expectations of, mobile phones. On the other hand, there were also insights directly relevant to understanding contact expressive devices. Most of the participants liked the idea of a phone that could be calmer, and that would inform them when someone was calling but in a more "casual" way.

6. CONTACT EXPRESSION ACTS

We now sketch an initial Contact Act taxonomy and a brief example of a Contact Expression Pattern. The difference between contact acts and a contact expression Pattern is, in some ways, like the difference between descriptions of building materials for a house – and a design Pattern that satisfies some important concern of the occupant of that house. In other words, although it is important to have a detailed understanding of contact acts, it is the creation of an appropriate contact-expressive Pattern language that may be the most useful to the designer.

6.1 Contact Expression Acts

Consider again the three main speech act components:

Locutory contact acts. As already noted, the illocutory speech acts are the ones most frequently studied and analyzed. However, in the future, innovative new sensors, actuators, and materials will allow designers to exploit the potential of a wider range of locutory contact acts. To indicate some of this range, we here list some of the possible sensors that can currently be included in computational devices: acceleration, altitude, chemical, displacement, electrical, fluidity, force of impact, frequency (of contact), friction, height/level, moisture, momentum (angular and rotational), movement, odor, orientation/angle, position, pressure, proximity, resistance, roughness, shape, size, spatial distribution, squishiness, stiffness, taste, temperature, tensile strength, texture, thickness, tilt, torque, turbidity, velocity, viscosity, wavelength, and weight.

Illocutory contact acts. The most elaborated aspects of this model are the illocutory acts, these have been further classified as: assertives, declaratives, directives (interrogatives and exercitives), expressives, and promissives. These seem clearly

relevant for contact expressions initiated by people in their interactions with contact expressive devices. However, as noted earlier, it is a controversial question whether computational devices can (or ever will) be able to perform truly illocutory contact acts in any meaningful sense of the word. Nonetheless, it does seem reasonable to us that people will be willing to take the "intentional stance" on this question for many kinds of contact expressions initiated by computational devices – we therefore consider it worth including these as relevant to the description of them.

Perlocutory contact acts. The status of many perlocutory contact acts seems relatively uncontroversial. If, for example, one pushes a robot out of the way and it actively resists, it seems reasonable to say that the perlocutory component of the contact act has not been satisfied. However, the development of new sensors, actuators, materials, and other kinds of computational mechanisms may also start to challenge some of the existing notions about the boundaries of perlocutory contact acts initiated by computational devices – and the degree to which individuals may be willing to do more than simply take the intentional stance with regard to them.

6.2 A Contact Expression Patterns

Within the confines of this short paper, we cannot do justice to the potential of contact-expressive Pattern Languages. However, we do feel it is important to at least indicate how contact acts can be used as the basis of a more expressive and usable design language of Patterns – and how that design language can be helpful in the design of contact expressive devices.

The key link between Contact Acts and a Contact Expression Pattern Language is to look at the specific locutory, illocutory, and perlocutory aspects of good contact acts and answer the Pattern questions: *what* is the precise feature of a particular, successful contact act; *why* is this feature helping to make the contact act successful ("what forces does it resolve?"); and *when* (or *where*) will this feature work ("context")? Said another way, *features* of contact expressions are those locutory embodiments that resolve some set of *forces* (including the illocutory and perlocutory dimensions of both parties interacting through contact acts), for some *context* (the felicity conditions for those acts).

In the tradition of work on design Patterns, the following is offered as an initial attempt to solicit feedback and suggestions for improvement.

Pattern: A Private Contact Signal

Feature. For situations where it is not possible, appropriate, or desired that other people become aware that a person is being paged, use contact expressions that cannot be seen, heard, or felt by others.

Forces. Someone needs or wants to receive a phone call, but auditory or visual signaling isn't possible or appropriate; similarly, the movement of the person being called may also be restricted.

Example. One possibility is a body-suit that could act as a telephone pager, using various contact expressions (such as constriction, change of temperature, movement of "grain" of body-suit, "tilting" the wearer, making the person's movement more "viscous," etc.) to let the person know many aspects about a phone call.

7. FUTURE WORK

Our work with the PillO'Mate thus far suggests a number of studies that can help further our understanding of the cognitive semiosis of contact expressions, elaborate design vocabularies and guidelines, and implement empowering contact-expressive devices.

7.1 Studying Contact Expressions

One of the most important aspects of future research on contact expressions will be to conduct thorough observational and qualitative studies to understand better the relevant issues. In our quick studies so far, we have not had the chance to engage deeply enough with either the human needs and concerns, nor with the relatively unexplored potential of contact expressions to facilitate and participate in self-fulfilling activities.

As our understanding improves and we create more sophisticated contact expressive devices, it will be important later to do more formal studies, using control groups to study statistic significance, and so on. Our initial work already indicates a number of aspects of gender and culture that will be interesting to study in more detail. It will also be important to explore and understand better the way other forms of sensory experience interact with and complement contact – and also to explore the potential of other types of semiotic analysis of contact expressions. For example, there is currently some debate about the relationship between Speech Acts and "conversations"; theorists such as Searle [26] feel that conversations can be modeled entirely from the units of Speech Act theory, while others [30] feel that there are qualitatively different dimensions to dialogue. We feel it will be important to explore both Speech Acts more deeply – but also

7.2 Implementing Contact Expressive Devices

There are three obvious areas in which it will be interesting to develop future contact expressive implementations: variations on the PillO'Mate, adding computational intelligence, and developing other types of contact expressive devices (for other domains and user-types).

As indicated in our preliminary taxonomy, it will be interesting to imbue the PillO'Mate with more contact expressions: it should be able to move, distribute its contact (multiple "fingers"), embrace, constrict, react to changes in heart rate, perspiration, heart-rate, and so on. We also believe that in order for contact expressive devices to be truly convivial, they will need various means of adapting to the individual characteristics of different people. And, as noted, an important aspect of being contact expressive is responding appropriately to the contact expressions initiated by others; it will be important to begin exploring which aspects of perlocutory contact acts people will accept in computational devices. Finally, it will be important to model contact expressions across a wider range of devices, domains, and user-types.

The Karo scenario also suggested a plausible model whereby the embodiment "needs" of the device can be related to aspects of its

contact abilities. Thus, it seems reasonable and practical to suggest that an embodied contact device might meet some of its power needs ("power is low") with different contact expressions ("stroke me"). It will be interesting to explore the viability of these and similar proposals.

Finally, there is another dimension of contact expressions that is not evident in the examples above, but which may, eventually, be just as significant for the design of contact expressive computational technologies. All of the examples above illustrate some aspect of "surface" contact. However, there are a number of physical signs that we experience from inside our bodies (bladder pressure, inhaled smoke, something caught in the throat, etc.). It is not difficult to generalize the notion of contact expressive devices to include those that could be ingested, and which, for a variety of reasons, will engage in contact expressive interaction with us – from within.

7.3 Design Vocabularies for Contact Expressions

The example contact design Pattern only gives the slightest hint of how to elaborate insights about contact expressions in a form that is useful for designers. Obviously, this is a major area of future work. In particular, we expect this to involve the elaboration, discussion, and revision of additional Patterns – and the development of the larger contact Pattern Language in which the individual Patterns are related to each other.

8. CLOSING

We began by considering various human benefits, but in our discussion of sign systems and technology it may seem as if we have lost touch with the original concerns. Therefore, in closing, we would like to once again return to the human importance of contact expressions.

We were originally made aware of the significance of contact expressions when one of us had a student with Tourette's Syndrome, which in her case manifested itself in mild autism and occasional debilitating depressions. She was interested in doing a project involving robot pets, but it was clear that she found most of the existing personal robots frustrating, indeed offensive. It took a number of conversations before we were able to articulate together what it was that horrified her about them: it was the fact that most of them neither supported nor encouraged contact expressions. Based on her own life-experience and needs, she began to formulate a goal of developing robots that were more contact expressive for others like her who she feels could benefit from them. It is one of the sad paradoxes of her condition that it actually prevents her from making sustained progress on this kind of effort – or even working with us on this paper.

We continue to be surprised that there seems to be so little work as yet on what we here call contact expressions. Our own initial blindness to them makes this plausible, but no less disturbing. Our most optimistic hope for this paper is that it will play some role in changing the current state of affairs – whether by inspiring more research and development where there currently seems to be so little, or by encouraging others to make more readily available any relevant work of which we are currently unaware.

We believe there is enormous future potential for contact expressive computational devices that help with different kinds of tasks, that facilitate and enrich artistic, creative, and entertaining experiences – and for improving the life of those who are autistic, blind, deaf, allergic, elderly, or infirm. There are many people in the world who could seriously benefit from further contact expressions of effort and interest.

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