Tactful Interaction: Exploring Interactive Social Touch Through a Collaborative Tangible Installation

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ABSTRACT

How do tangible systems take advantage of our socio-physical embodiment in the world? How can we use tangible interaction to better understand collaboration and intersubjectivity? We present *Parazoan*, an interactive installation where evocative objects collaboratively control a dynamic visual display. Our analysis of interactions with *Parazoan* explores our questions and discusses implications for our understanding of tangible and virtual collaboration.

Keywords

Tangible, Collaboration, Gallery studies, Interactive art.

INTRODUCTION

> *What is this prepossession of the visible, this art of interrogating it according to its own wishes, this inspired exegesis? We would perhaps find the answer in the tactile palpation where the questioner and the questioned are closer, and of which, after all, the palpation of the eye is a remarkable variant.*
>
> Maurice Merleau-Ponty [14]

Though de Certeau once spoke of a "cancerous growth of vision" in modern social life, we believe that one of the brightest promises of interactivity is the possibility of "touching" and transforming the digital information we encounter. A significant contribution of tangible computing research is the integration into human-computer interation of a broader idea of touch for human-computer interaction. Touch in this view is kinetic, active, exploratory, a natural means by which we communicate and inform ourselves. Engaging with the world involves varieties of touch: our moving body makes distant objects reachable, we grasp and manipulate tangible objects, we feel the shape and texture of surfaces of all kinds. Perhaps most importantly, we create meaning through actions visible to others and from others' actions [12, 18]. Our experience of touch, then, is socially and culturally mediated to its core. Constraints, conventions and behaviors – learned in everyday interaction in the world and legibly expressed in everyday bodily comportment – define the way we touch, move, and even experience the capabilities of our own bodies [23].

Tangible interactive systems exploit our socio-physical embodiment [3], allowing us to manipulate information through augmented physical objects and spaces, and also to derive meaning collectively from these physical-digital manipulations. One characteristic of such systems is their explicit use of physical constraints. Gravity causes objects to fall or to rest on surfaces; solid objects cannot occupy the same space. Yet recognizing that the interactive world is made of more than physical constraints, tangible systems harness the understandings that people develop in their everyday engagement with objects and people in socially meaningful spaces. While we understand affordances as deriving from an object's shape or texture, we can also see how accumulated experience guides peoples' interactions: glass affords breaking; wood, graffiti writing [15].

While an integration of specifically situated interactions might be a move away from tangible computing's early goals of creating broadly intuitive interfaces [21], tangible systems are well-suited to explore and exploit the ways that people draw from prior experience, social cues, and situational context to render their interactions meaningful *in their particular situation*. This has implications both for tangible system design, and for methodology. We hope to demonstrate that tangible interaction is a uniquely effective tool for researchers wishing to probe the embodied basis of collaborative practice.

We explore the embodied process of communication, collaboration and understanding through the design and evaluation of a tangible and visual installation called *Parazoan*. The system consists of a small collection of graspable objects that react to touch and proximity, collectively controlling a dynamic graphical display. *Parazoan* was exhibited in a gallery for a week, and we videotaped and observed interactions with the installation.

We will first discuss the influence of related projects both in the field of tangible interaction design and in social analysis of gallery settings. After describing the system, we present our observations of its use and discuss some broader implications indicated by our evaluation.

RELATED WORK

From the early responsive environments of Myron Krueger [13] to "Tangible Bits" [11], artists and designers have sought to explore nascent and well-established relationships between people, objects and the spaces they inhabit.

The approach favored by some tangible systems focuses on readily understood visual representations and tight coupling between physical object and digital data. Following the suggestion that the "coupling of bits and atoms" [11] is one of the key concepts in tangible interfaces, Ullmer and Ishii have asserted that the value of tangible interfaces lies in the "seamless integration of *representation* and *control*" [21]. Drawing from the Model-View-Controller architectural pattern in graphical user interfaces, they propose the *MCRpd* interaction model, in which the "view" component is comprised of physical and digital representations (*Rpd*). The physical representation is embodied in the same physical object as the tangible control component (*C*), while the digital representation may be a projected image or sound, tightly coupled with the tangible component of the interface. Applications typically used clearly representative physical icons, intended to be as easily graspable intellectually as physically.

Another impulse in tangible interaction design has emphasized the intimacy and communicative power of touch [19]. A prototypical example of such systems, InTouch [1] provides a tangible channel for long-distance communication using devices with wooden rollers, sensors and actuators, connected via Ethernet. Playing with one device causes the other to move. Interactions were interpretable by the users, who might engage in games of resistance, roll the rollers smoothly, or in other ways flexibly interact with the system. Emerging from these designers' considerations of intimacy are tangible systems that support the development of private meanings and messages that are not meant to be widely understood.

Analyzing several deployments of tangible collaborative systems, Eva Hornecker asserts that one of the most salient features of tangible interaction is its embeddedness in physical space. She notes that "in interaction we 'read' and interpret representations, act on, modify and create them. [9]" via observable and legible bodily interaction with physical objects within socially meaningful space. Though Hornecker's work is one of few discussions of collaborative interaction with "tangible interfaces" labeled as such, researchers at Kings College London have carried out detailed studies of collaborative interaction in gallery and exhibit spaces, with similar findings [8]. Detailed studies of video records show the ways in which people attend to each other's interactions with exhibits, which in turn shape aspects of their own encounters. Applying similar techniques to a tangible system, Williams and Kabisch [22] evaluated "an experimental testbed [called *SignalPlay*] for understanding how people explore and understand ubicomp technologies as spatially situated phenomena." Our analysis of *Parazoan* employs similar methods, but differences in interaction between the two systems become evident in our evaluation: *Parazoan* uses centrally located shared visual feedback while *SignalPlay* uses sound, and *Parazoan*'s tangible objects are much less iconic than those utilized in *SignalPlay*, and were thus approached in a different manner by participants.

PARAZOAN

Parazoan is an exploration of the interactive relationships between participants, a set of three biomorphic physical objects (referred to as "parazoans"), and the digital content they are coupled with.

The installation was designed with several goals in mind. First, both the objects and the graphics they controlled were intended to be expressive and interpretable rather than representative. Second, where prior tabletop displays have implemented workbench-like spaces for tightly coupled digital-tangible tools [11, 21], this system was geared towards exploration of reliable but loose coupling of tangible object and digital data, playing in the gray area between tangible interface and game controller (two design trajectories that, with the invention of the Nintendo Wii, seem to be converging). Lastly, it is a collaborative system that is oriented towards exploring social aspects of touch.

The parazoans are coupled with dynamic visual content that reflect how participants manipulate them. Participants' gestures generate painterly graphics on a central display as they tilt, move, shake, and squeeze the parazoans, and give rise to firework-like particles when the parazoans are moved close to one another. The objects do not need to make contact with the screen, they merely need to be moved around. Graphics range from delicate lines when parazoans are handled gently to bold graphics when manipulated intensely. Participants work together to create images from minimal lines to complex intertwined strokes.

Parazoans

The parazoans are made of a custom-built silicone casing, covering an embedded microcontroller and a vibrating motor. The silicone compound was selected for its texture and flexibility. The firm-but-squeezable feel of silicone is not common to everyday objects; sex toys might be the most common example of this material in use.

The unusual curvilinear shape of the parazoans resembles a game controller and facilitates two-handed interaction, yet also evokes the features of a living creature or an anatomical component. The work of different artists has inspired the body of the parazoans; particularly, the cinematography of David Cronenberg and the sculptures of Matthew Barney have had a significant impact. Each parazoan gently glows a different color through a thin, translucent layer of silicone. The parazoans also each have an antenna-like appendage that vibrates gently when a participant picks up and presses the object. It vibrates more frantically when brought close to another parazoan, inviting

Figure 1: A parazoan.

the participant to explore further and engage in a proximate interaction. The object's reaction is intended to be situationally informative, like a dog wagging its tail, in order to engage participants with the unusual shape and material of the parazoans.

A Sun Microsystems Small Programmable Object Technology (SunSPOT), is embedded in each parazoan. Each SunSPOT runs a custom Java application that manages its sensors, actuators and wireless communication. At short intervals, the SunSPOT reads the values of the 3-axis accelerometer and sends the data to the host computer. Furthermore, the SunSPOT establishes connections with the other active SunSPOTs and sends ping queries to determine the signal strength to and from each device, which it then sends to the host computer. The appendage's vibration is based on the values returned by different sensors; a change in acceleration after a period of rest triggers a light vibration, whereas sensing a strong signal from nearby parazoans creates a strong vibration, coupled with a graphical reaction to be detailed in the next section.

Table Display

A custom-built wood table provides the inner space (15" x 23" x 3.5') necessary to host a projector and a front-face mirror to create a sizable projection. The soft fabric screen is surrounded by a six-inch-wide wooden frame bordering the visuals. This frame, on which drinks and plates shared space with the parazoans, facilitated participants' transition from casual observation to active manipulation. The table served as a shareable display for collaborative interaction, yet created a space that was not available to the whole gallery at once, thus allowing for fairly intimate gatherings around the display and avoiding performance anxiety. Gathered *around* the table, participants viewing the screen could easily look straight at each other, a configuration which would not often occur facing a vertical screen.

The projector and a SunSPOT base station are connected to the host computer residing under the table. The computer runs a custom Java application that parses the data received from the parazoans, and generates real-time visuals based on how participants tilt, shake, move and manipulate them.

To produce the visuals, the application controls three tracing agents (one for each parazoan), particles that move

Figure 2: Two parazoans rest on the edge of the exhibit table.

in a virtual 3D space. Each parazoan's tracing agent matches the color emitting from its parazoan. The tilt and acceleration of the parazoan control the direction, speed, and thickness of the colored line that is coupled with it. When a parazoan is held within two inches of another parazoan, its tracing agent generates colorful particles that are pulled toward the tracing agent of the proximate parazoan. These moving particles leave fine traces behind, which slowly fade away. Participants' interaction with the graphical display, then, is an interplay between close control and the use of broad gestures. Traces created by participants' interactions slowly fade away, while new ones are drawn over them. In addition, the system records participants' gestures – motions taking place between short moments of rest – and replays them when the parazoan is immobile. This allows participants to generate interesting patterns deliberately, and, in the absence of interaction, creates continuous dynamic visuals for people to watch, which might entice them to interact (see Figure 2).

OBSERVATIONS

Though designed to be fun and engaging, *Parazoan* was also intended to address questions about how user interactions might play out. How do people move and feel these biomorphic silicone objects? How does the interaction unroll in a public setting? How do participants cooperate to explore the details of the interactive space? Will the aesthetically pleasing visuals be interpretable as traces of a history of tactual interactions?

Parazoan was deployed for one week in June 2008 at the Beall Center for Art and Technology at UC Irvine. Using a handheld camera, we recorded video of visitors' interactions with the installation and received informal feedback. Observations presented in this paper are based on close analysis of video footage, along with consideration of what participants told us about their experiences interacting with *Parazoan*. Video was transcribed with time markers, and then coded in a manner consistent with ethnographic grounded theory [20]. Transcripts were first open-coded, with a wide variety of gestures and actions tagged, such as "hard shake" or "touching antennae". These tags were then clustered during the axial coding phase into broader and more meaningful categories of action, such as "attending to the object" or "engaging with others". Based on these categories, we articulate a few principle themes that organize participants' observed actions into a coherent framework.

Modes of Interaction

Entering a gallery setting to attend an interactive arts show, participants expected some unfamiliar objects to be augmented and reactive, and understood that they were free to touch and interact with all the exhibits. We observed that participants typically progressed through phases of interaction with *Parazoan* that could be broadly characterized as *exploratory* and *instrumental.*

Exploratory Interaction

While exploring, participants might attend primarily to the parazoan itself (occasionally ignoring the screen altogether), to the graphics on-screen, or to the coupling between the two. In prior work examining performance and spectatorship in similarly public installations, Reeves et al. discussed the public availability of manipulations and effects [17]; but while both physical manipulation and digital effects of *Parazoan* were publicly visible, the coupling between the two tended to remain mysterious until users actively manipulated a parazoan for some moments.

The parazoans did not prescribe any one obvious manipulation. Small enough to be held in one hand, but shaped to be ergonomic in two, the objects were evocative due to a combination of look, texture, shape and heft. Participants bent, pressed, poked, squeezed, rotated, tilted, flipped, and twirled the parazoans. They shook them up and down, side to side, or even like a drink mixer. Appendages were pointed up, down, at the table, at the body, and at each other. Some people tried to feel the contours of the SunSPOT through the soft silicone casing. Yet while almost anything *could* be tried, and while participants *as a whole* did try almost everything (including knocking the SunSPOTs out of their casings and trying to stuff them back in), individuals approached the objects differently, dependent in part on prior experience. Some participants held the parazoans like game controllers from the beginning: one curve nestled into the palm of the hand, thumbs on top, and index fingers on the front (where triggers would be on most game controllers). Others began by flipping it from one hand to another, or rolling and tilting the controller one-handed. Some used the parazoan's appendage to touch other participants' parazoans. We are reminded of how the idea of affordances [6] has taken hold in HCI [15]: sometimes construed a property of an object, and hence straightforwardly designable, affordances were originally characterized as emerging from a subject's interaction with object and environment, influenced by memory and culture. This distinction is crucial, because it puts the emphasis on inter*action*, rather than static designed features of an object or system.

Attending to the on-screen graphics, one participant said aloud: *"It's a puzzle… it's about dominating color,"* then soon after, *"I can read it."* While the graphics reliably reacted to tangible manipulation, two factors rendered the coupling somewhat ambiguous. First, *Parazoan* generates graphics based on recent gestures when the parazoans are at rest; a participant's tracer will never be the only moving element on the screen. Second, with multiple participants playing at the same time, simultaneous actions could make causality unclear. Participants typically discerned their parazoan's coupling with the display after a few minutes, but this required action and sometimes conversation:

Figure 3: The "game controller hold".

Amy: [picking up third parazoan] Is this the orange one?
Will: I think I'm…
Melinda: Yeah… [pointing first to Will's] oh no you're orange, sorry. [then points to Amy's parazoan].
Will: I'm the other one?
Melinda: Yeah I think so.

Unlike the *SignalPlay* installation [22], interaction was not easily broken down into *iconic* and *intrinsic* modes. Objects were evocative rather than iconic, and our observations indicated that the parazoans' affordances stemmed as much from participants' inclinations as from the physical characteristics of the objects. Exploratory interaction with *Parazoan*, then, was characterized by a trial-and-error approach, watching for the system's reaction to manipulation, and shifting attention between object and screen to ascertain the relationship between the two. The ambiguity of this coupling proved to be engaging to users [5], who spent time exploring and adding their own interpretations to the system's actions. Inviting participants to interpret the graphics and their causes fostered the sorts of interactions discussed in the next section.

Instrumental Interaction and Games

With several minutes of use, participants were typically comfortable manipulating the parazoans and could interact with the onscreen graphics in predictable ways. This sort of use is similar to what Williams and Kabisch [22] refer to as "instrumental interaction", in which users act *through* an object to influence the aesthetic output of the interactive system. Unlike *Signalplay*, whose objects exhibited a range of couplings from tight to loose, *Parazoan*'s objects acted equivalently. This aspect of the system lent itself to the improvised invention of games based not on the appearance of the objects, but on capabilities of the interactive system.

One demonstration of skill, attempted by several participants and easily performed solo, was to try to write ones name on screen by tilting and rolling the parazoan. This required speed as well as accuracy, due to the rate at which the colored traces faded. Cooperative games included tracing each other's paths, "piercing" each other's tracers by arriving at the same spot simultaneously so that neither is drawn clearly on top of the other, and working together to draw multi-colored circles and knots.

A more competitive game involved colliding with other participants' tracers and then attempting to "swallow" them by shaking ones parazoan to widen its on-screen tracer and cover the other player's. A variant on this game also involved "hiding" by covering a portion of the screen in ones own color and keeping the tracer within that area to render it harder for others to locate. This could only be accomplished for a few seconds at a time due to the colors' fading, so players had to keep moving and improvising.

While we speak of participants progressing through "phases" of interaction, these phases did not necessarily follow a strict sequence. "Exploratory" and "instrumental" modes can be correlated with the concept of objects being *present-at-hand* and *ready-to-hand*, respectively – either making the user aware of its existence and otherness, or transparently allowing the user to act through it [7]. Even in skilled interactions, an object will sometimes appear as present-at-hand, as when a carpenter shifts the weight of a hammer in her hand. In the case of *Parazoan*, one woman discovered that the vigorous shaking technique she had been using to swallow other people's tracers was vigorous enough to knock the SunSPOT right out of its casing. Though certainly experienced enough to use her parazoan instrumentally, here she found herself once again exploring the object's physical configuration.

Publicly Accountable Action

Participants did not become skilled manipulators of *Parazoan* by acting alone. As our description of user-invented games indicates, the installation was more engaging when encountered as part of a group, and much of people's emerging understandings occurred in a context where they could observe, be observed by, and converse with other participants. *Modes of interaction* and *publicly accountable action* are not, therefore, independent themes, but deeply intertwined in practice. Just as mutually observable body-actions helped participants develop an understanding of *Parazoan*, their ability to interact instrumentally with the system enabled and was reinforced by others' interpretable actions *on-screen*.

Physical Interactions

Peripheral, and sometimes focused, awareness of others' actions has previously been shown to be a crucial component of understanding interactive installations [8, 22]; these prior findings hold true for *Parazoan*. Some participants, particularly during crowded periods, watched others play before touching a parazoan themselves. While people did bring their personal inclinations to the table, many also echoed the actions of others, especially if those people appeared to be confidently in control.

Situated around a table, typical manipulations of the parazoans were visible to all, if they chose to attend. Some, like violent shaking, deliberate speaking out loud, reaching across the table, or some participants' tendency to tilt their entire body along with their parazoans, actively drew attention. Occasionally we might see a participant touch another participant's object, either with their parazoan's appendage, or more rarely with their hand. We also observed participants explicitly asking for explanations, and demonstrating how the system worked.

Accountable Action On-screen

The ability to account for and attribute the actions of on-screen elements to the physical actions of other players was crucial to participants' abilities to invent and play games as described in the previous section. In "game mode", players are focused on the central screen, and, in conversation, identify with the tracer that they control, saying things like *"You're running away from me!"* or (whispering) *"I'm hiding"*. Implicit in these statements is that they also identify other tracers with other players and their actions.

These accountabilities are bridged by simultaneous embodied and onscreen actions; for example when two parazoans come together and cause a noticeable onscreen event, a participant may point at the screen explicitly to draw others' attention to that coupling. More implicitly, the embodied action of tilting or moving a parazoan is just as available to observers around the table as the movement of the colored tracers on the display. It is the simultaneous occurrence of visible human actions and visible on-screen events, accumulated over time, that allow the development of meaningful social understandings of *Parazoan's* visual component, allowing it to be observed as the locus of participants' intentional actions.

IMPLICATIONS FOR THEORY AND METHODS

In describing passive awareness in the field of Computer Supported Cooperative Work, Toni Robertson draws on Merleau-Ponty's theories of embodied perception [14, 18]. The dual nature of our bodies as both sensing and sense-able enables us to "recognise and understand others' actions by the same process that we shape our own actions for their interpretation by others." Individuals act in relation to physical objects, to other bodies (observing and deliberately being observed), and to physical space (moving, shifting direction of gaze). These individual actions are not isolated, but constitute group activities like conversation, creation of shared representations, or observing the same thing at the same time.

In this study we observe many of the same sorts of embodied actions: visibly moving objects, observing others, moving or speaking in ways that are meant to be observed. We add to this the gradual development of similar expressive, accountable actions on screen, based on the same processes of mutual observability that we engage in as physically and socially embodied beings. The "virtual", digital component of this system takes on its own sort of embodiment, allowing a kind of virtual/visual touch.

Tangible interfaces are already well recognized as objects for users to think with, but they are also objects for researchers to think with. Objects-to-research-with are not new to HCI; cultural [4], technology [10] and urban [16] probes are all used to inspire design by defamiliarizing what we would otherwise take for granted. As engaging artifacts, they not only gather information about people's practices; they can perturb those practices, and the settings into which they are deployed, in informative ways. We believe that there is a clear value in probing collaboration that is manifest simultaneously as atoms and bits. Collaboration in the physical world employs space, bodies, actions, language, and meanings, making these practices more easily available for evaluation [12]. Collaborating through an interactive system can allow for modes of action and engagement that are not normally possible. A "tangible probe" plays in both those spaces, but is more than the sum of these parts. In deliberately targeting the *coupling* between material and bits, we can uncover methods by which users extend meaningfully embodied action into the screens and data-mediated spaces that we encounter daily.

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