Human and Machine in Formation: An Ethnographic Study of Communication and Humanness in a Wearable Technology Laboratory in Japan

by

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A thesis submitted in conformity with the requirements for the degree of Doctor of Philosophy.

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2015

Abstract

This dissertation reports on an ethnographic study of human-centered technology researchers, conducted in Japan between 2010 and 2012. Researchers in this field—a multidisciplinary group mostly of computer engineers, as well as complex systems scientists, biologists, and psychologists—claim that existing "machine-centered" technologies require users to behave like machines, resulting in burdensome and brittle social relations. In contrast, they attempt to create "human-centered technologies" that humans can interact with "naturally," which they believe will facilitate the creation of resilient and comfortable societies. HCT researchers believe that the key to understanding natural human interactions lies in how humans "read ambience." Reading ambience is the process through which a social actor identifies and acts on the aspects of its self and surroundings that inform it of what behaviors are appropriate in a given setting. They work to reverse engineer how humans read ambience to create technologies that humans can interact with naturally.

This dissertation argues that HCT researchers efforts to understand humanness through reverse engineering elucidate dimensions of human relations that have been suppressed in conventional discourses on the human. Anthropological understandings of the human have been predicated on the notion that the human is a form of life. Instead, HCT researchers' work shows that the human is a system of communication. The human is defined by how it interfaces and exchanges messages with other systems of communication. Their perspective shows the human as a system defined by the relations it maintains among its body, its social and material surroundings,

including technologies and other humans. By following HCT researchers' attempts to create human-machine interfaces, this ethnography attempts to offer an approach to the human based in communication that challenges atomistic understandings of the human still latent in anthropology.

Acknowledgments

I want to begin by giving my utmost thanks to the people at the place I call the Wearable Technology Laboratory, and the other labs in the Osaka area that allowed me to join in their activities. Their hospitality, friendship, and co-operation was invaluable. They welcomed my presence and tolerated my questions, and allowed me to become a part of their work and lives in ways for which I will be forever grateful. I reserve special thanks for the person I call Shinagawa, who made it possible for me to conduct my research at the WTL at all. I enjoyed our long conversations, which have shaped this dissertation in so many ways. The professors, whom I call Terada and Nishida, as well as the postdocs, Nishiwaki, Omoto, Kashino, and Kawasaki offered me their help and friendship, and I enjoyed the times we spent together. I am also particularly grateful to the student, Yamanaka, with whom I explored so many interesting ideas and experiments. I hope I have been able to write of the members of the WTL and their work in a way that reflects my admiration for their insight, energy, and kindness.

Though their contributions to my work are not explicitly reflected in this dissertation, I also want to thank those in Toronto, Tokyo, and various places in the U.S., who I interviewed during the first half of my fieldwork for their generosity.

With the exception of those represented in the list of references, the names contained in this dissertation are pseudonyms.

My studies benefited from the financial support of the School of Graduate Studies and Department of Anthropology at the University of Toronto, the Dr. David Chu Scholarship in Asia Pacific Studies, the Ontario Graduate Scholarship, the Sir James Lougheed Award from the Government of Alberta, and the Social Sciences and Humanities Research Council of Canada.

I want to thank the many people in Japan and elsewhere who helped my family and me over the years. Atsuro Morita, Atsufumi Kato, and the staff at the Faculty of Human Sciences at Osaka University made the most valuables of my fieldwork in Osaka possible.

My old friends Ana Maria Constantinescu, Masahiro Enoki, and Felipe Toro helped my family and me feel at home in Japan. My aunts and uncles, Yoichi Otsuki and Hiromi Otsuki, and especially Masayoshi Sahara and Chieko Sahara helped my family and me establish a life during my research, and I cannot fully express my gratitude to them for all they have done for me over the years. Donald and Peggy Burrows sent my family love and words of encouragement.

I have had the privilege of working with scholars who have each pushed me to be better. Atsushi Akera, Mike Fortun, Kim Fortun, Cooper H. Langford, Martha Langford, Margaret J. Osler, and Krystyna Sieciechowicz have helped me find my way during my years in STS and cultural anthropology. Aalok Khandekar, Ali Kenner, Nicole Cook, Jon Cluck, Gareth Edel, Casey O'Donnell, Shailaja Valdiya, Kyoko Motobayashi, and Alejandra González Jimenez have been great friends and wonderful collaborators. I am also thankful for the comments on my work I received from members of the Dissertation Writing Workshop in the Department of Anthropology at the University of Toronto. I also thank Anne Allison, who provided encouragement and helpful advice during the writing process.

My dissertation's examiners, Michelle Murphy, Naisargi Dave, as well as my external referee, John Hartigan, Jr., provided me with wonderful and stimulating feedback. As teachers and as members of my core dissertation committee, Joshua Barker and Michael Lambek have been patient, supportive, and challenged me intellectually since I arrived in Toronto.

I thank Charles Hong and Jeffery Yen, for helping me stay sane. I would not have been able to complete this project without their friendship.

In March 2011, my family and I were in Tokyo at the Mitaka Reversible Destiny Lofts for fieldwork when the earthquake hit northeastern Japan. I am incredibly grateful to Momoyo Honma, Takayoshi Matsuda, Madeline Gins, and all of the residents of the Reversible Destiny Lofts for their care and concern for us during that uncertain time.

I first met Shiho Satsuka in 2007 at the AAA meeting in Washington, D.C. At the time, I could not have imagined the extraordinary series of discussions, collaborations, and opportunities that would follow. The time I have spent working with her has incalculaby enriched my intellectual life. Shiho has been an exemplary mentor, and I owe what I have had in the eight years since and much of what will come to her.

My parents, Keiko and Koichi Otsuki, and my brother, Sam Otsuki, have watched and supported me in the many years during which this work slowly took shape. Their support has been unwavering. They each have my eternal gratitude and thanks, and I will never be able to repay my debts to them.

Finally, my wife Emma Otsuki and my son, Elliott. I uprooted their lives many times during the years I worked on this dissertation. They both have sacrificed so much for me. There are no words adequate to express the love and gratitude that I feel for them.

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Introduction

1 The Robot's Sacrifice

The defining moment of the play "Sayonara," takes place in its final scene, when a courier faces the Geminoid-F,[1] a robot made to look like a woman, and asks her to sacrifice herself. With paper waybill in hand, he tells her that she will be sent to a beach in the radioactive exclusion zone surrounding the ruined Fukushima Daiichi nuclear power plant. No human can go to the beach to mourn the people washed away by the tsunami of March 11, 2011. The courier relays the message he has received through his mobile phone: she has been assigned to sit on the beach and read poems for the dead. "Will you do this for us?" the courier asks, as he bows toward her in a gesture of deep respect. "Yes," she says, "if I can still be of any use. It would make me happy."

If the courier believed that she was simply a machine, then her reaction to any question would have been pre-programmed, and there would have been no need to ask her consent. The robot had been purchased by an unseen father to provide companionship and comfort to his sickly daughter in the final days of her life. During the first half of the play, the woman asked the robot to recite poems to her, which she did diligently. They discussed these poems, the robot occasionally finishing the weak woman's thoughts. Eventually, the woman's remaining life left her. When the courier appeared, the robot was locked in an unresponsive loop, endlessly repeating the last poem she had been asked to recite. He turned her off and then on again, breaking the loop, and performed a quick check to ensure that she could indeed work normally and was ready for a new task. Treating her as a machine, his question would have been part of a diagnostic process, her response to which, if it came as expected, would certify her as functional and ready for a new job. Had she refused his request, or otherwise acted in a way that he did not expect, her response would have been identified as a malfunction, resulting in the robot's re-programming or disassembly.

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[1] The Geminoid-F is one of four "Geminoid" robots created in the lab of Ishiguro Hiroshi, an engineering professor at Osaka University, who have been designed to closely resemble actual human beings. The most famous of these robots was modelled on Ishiguro himself. See Chapters 4 and 5 for discussions of the Geminoids and Ishiguro's research. "Sayonara" is one of several plays that Ishiguro and Hirata have collaborated on, which use human and robot actors. Hirata Oriza is a renowned playwright, director, and academic, whose works have been translated and

However, the courier had to ask her because he needed her to accept the responsibility for robots' failed response to the disaster. Following a performance I attended in Osaka at the beginning of 2012, the playwright Hirata Oriza hosted a Q&A session for the audience. For nearly five years since 2010, the play has toured Japan, North America, Europe, but this performance was the first since the triple disasters of March 11, 2011. Hirata explained that he had added this final scene following the disasters to show the value that robots could have. He explained how even though robots were supposed to be the pride of Japan, they turned out to be of little use in responding to the nuclear accident. Instead, robots shipped from the US did the initial work.[2] Hirata told the audience that he wrote the scene to show how robots' value could be in doing something other than clearing rubble or cleaning radiation. The robot redeemed technology in humanity's eyes by accepting the responsibility to read poems on the beach for the dead.

If the Geminoid were a human, her act would be considered a blood sacrifice. A blood sacrifice is a positive renunciation of life that produces a *meta-value* or cultural foundation upon which people recognize and accept their obligations to one another, and understand themselves and their positions in the cosmos (Rappaport 1999). Sacrifices initiate states of affairs "opening moral vectors, introducing specific commitments, [and] establishing the seriousness of the ensuing values and acts—the ends and the means—that are at stake" (Lambek 2008, 150). Cross-cultural examples of blood sacrifices, anthropologist Michael Lambek speculates, suggest that what grounds these states of affairs is life: "life itself is the absolute or primary meta-value" (2008, 150).

However, the Geminoid-F is neither alive nor dead. She has no blood to spill. She seems to have a vitality, but it comes from pneumatic actuators and electronic pulses. Her power switch may be turned off, but this is not death, because it is reversible and even restorative, much to the courier's relief. She may be destroyed beyond all possibility of repair, but she was purchased, meaning that there is another similar model on the shelf to replace her.

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[2] The first robots to respond to the Fukushima nuclear disaster were built by iRobot, an American company. According to University of Tokyo engineer Yoshihiko Nakamura, Japanese robots were not ready to respond to such an emergency. A Japanese government program to develop robots suitable for responding to nuclear accidents was started in 2000, but shut down in just one year (Strickland 2014).

The Geminoid's act can nevertheless be a sacrifice, because to her creators she is human enough for this task. How can she be "human" and yet be neither with nor without life? Perhaps her liveliness, and even her humanness have little to do with "life."

Among the researchers that produced her and other machines like her, a human being is not a form of life but a form of communication. The human is defined as a communication system that receives, processes, and transmits messages with other entities in broader systems of communication. The human is distinguished from other entities by the characteristic ways that it transforms input messages into outputs. Due to these characteristics, the human can interface smoothly with some systems and link with others only with significant effort and adaptation. To these researchers, the Geminoid is equivalent to a human on the beach or at the bedside of the dying woman, because she can interface with the same systems as a human being would in those situations.

If a blood sacrifice affirms a meta-value that undergirds collective human life, then the robot's sacrifice in the play suggests to the audience that it is not "life" that grounds their collectivity but *communication*. Next to the dying woman, the robot speaks with her like a comforting human being would. When the robot is then sent to the beach, she is cut off from communication with the living, so that she can communicate with the dead. The sacrifice of communication marks communication as valuable.

The robot's act also shows that existing technologies have been created without regard for the human as a unique system of communication. Contrasting the Geminoid's act against the failure of other robots to address the disaster, Ishiguro and Hirata tell their audiences that current technologies are forcing humans to connect with them and the world in ways that do not respect human characteristics, not only in Japan, but in Europe, North America, and Asia, where they have shown countless others their play. Their play shows how a new type of technology, represented by the Geminoid, might be more "human-centered."

Why is it that communication has taken such a central place in how these researchers understand human beings? Furthermore, how are we to understand the importance they place on technology as a way to protect humans and help them flourish in this particular moment? Researchers in the field of Human-centered Technology (HCT) claim that technologies like the Geminoid must be developed so that people can interact "naturally with machines… as if they were interacting with other people or nature, in a cybernetic way that is truly human-oriented" (Tachi 2010, 172), rather than continue to be subject to "machine-centered" technologies that demand humans adapt to the needs of the machines. They invest in machines like the Geminoid their hope that technologies can change to better support and maintain what they consider to be the human.

My aim in this dissertation is to explore how in creating human-centered technologies, researchers imagine and enact what it means to be human. I follow these researchers to elucidate the conditions in which they have come to characterize humans as weakened and vulnerable, and human-centered technologies as those entities especially suited to protecting and caring for humans. It shows how these two mutually constituted figures—the human and human-centered technology—are enabled and sustained by the meta-value that guarantees the possibility of their connection: communication.

Here, by communication, I do not mean the act of exchanging information nor the media through which information is conveyed. I position communication as a meta-value. I mean communication in the way that people speak about the "life" in relation to which humans, animals, and viruses can be classified as "forms of life." Life itself is impossible to apprehend directly as an object; it becomes knowable through its concrete instantiations. Life is, as Michel Foucault has argued, "the sovereign vanishing-point, indefinitely distant but constituent" of modern forms of knowledge and power (Foucault 2002, 302). Rhetorician and philosopher of science Richard Doyle adds that life is the "unseen unity that traversed all the differences and discontinuities of living beings," becoming the "guarantor of biology, knowable only at a distance" (Doyle 1997, 11). Similarly devoid of material significata but ascribed ultimate regulative and ordering power over the world (see Rappaport 1999, 268), communication rather than life, I argue, is the meta-value that underlies the world of human-centered technology.

The difficulty with thinking about communication as a meta-value is that it is so easily conflated with life. Donna Haraway, for instance, wrote that communications sciences and modern biologies

> are constructed by a common move—the translation of the world into a problem of coding, a search for a common language in which all resistance to instrumental control disappears and all heterogeneity can be submitted to disassembly, reassembly, investment, and exchange. (Haraway 1991, 157)

In her view, communication and life are being pushed into a relation of equivalence in the current moment. Similarly, when first presenting the figure of the cyborg, Haraway argued that technologies based on cybernetics, the modern science of communication and control, have become "disturbingly lively, and we [humans] ourselves frighteningly inert" (Haraway 1991, 151). I interpret her reaction to be based in the assumption that if machines become capable of communicating like humans do, then this must mean that humans and machines are either both living or both are inanimate. Her cyborg transgresses the boundary between natural and artificial, but reinscribes life as the basis for the existence of both. We must, she argues, "acknowledge that machines are lively too" (Haraway 2006, 141).

Haraway's insights have made it possible to see the political and cultural stakes of emerging technologies that blur boundaries between the natural and the artificial. However, I believe HCT shows that her insight can be pushed further. Specifically, HCT demands that we question whether the relationship she sees between biology and communication science might be articulated in other ways.

In human-centered technology, life and communication are pried apart, with communication becoming the basis for life. Communication is the unity that traverses all the differences and discontinuities of beings. Forms of life do not communicate. Life is a form of communication. To deviate from Haraway's example, for HCT researchers, cybernetics did not make machines disturbingly lively or humans frighteningly inert. It made them into different kinds of communication systems.

This different foundation for thinking about life makes the ways that human-centered technology researchers think about everything that was based on that notion of life subtly different as well. Humans are not conscious beings that possess autonomous agency and intention. And this notion of the human does not inform HCT researchers' constructions of human-like machines, as Lucy Suchman has argued for robots and artificial intelligences in North America (2007, 254). In HCT, humans are always entangled in systems of communication and are themselves composed of smaller systems of communication. Similarly, the task for humans learning to be with technologies does not begin from the acknowledgement that machines are lively too. It begins from realizing that they are each systems of communication that cannot easily interface with each other. This makes the task of creating better ways for humans and machines to co-exist into one of creating better interfaces between them, or of reconfiguring or extending one to better interface with the other.

As Doyle points out for "life," communication is not some transcendental object, but the effect of a network of tools, rhetorics and work (Doyle 1997, 24). Communication is the result of a historically, culturally, and materially situated set of relations and practices that produces beings as forms of communication in the same move as it produces the unifying notion of communication itself. In this dissertation, I follow these relations and practices to flesh out how HCT researchers come to think of both the human and technology as forms of communication, what kinds of interventions this viewpoint affords the researchers for modifying humans and machines to better co-exist, and what kinds of collectivity they imagine humans and machines to live within.

1.1 Value: Theoretical Context

My dissertation's theoretical intervention is to address unresolved questions related to the nature of value in human–non-human relations that lie at the intersection of Posthumanist and Multispecies Anthropology, and the Anthropology of Values. Posthumanist analysts of human–non-human relationships have questioned sharp distinctions between human subjects and non-human objects, and nature and culture or society, showing that these frames are not constitutive and essential but constructed (Latour 1987; Haraway 1991). Human–non-human borders are transgressed by rethinking beings not as subjects and objects in themselves, but made "only by relation, by engagement in situated, worldly encounters" (Haraway 1994, 64), as "associations" among material-semiotic actants (Latour 2005), and as the "phenomena" made by specific "intra-actions" that take place in an experimental or socio-technical "apparatus" (Barad 2007).

Each of these approaches is proffered with the intention of revealing the grand narratives or "wholes" in the terms of which these interactions were conventionally understood—"nature" for Haraway; "modernity" or "society" for Latour—as contingent, if not fictitious and pernicious. Though dismissed by their intellectual critics as "relativists" and "anti-realists", [3]

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[3] The so-called "Science Wars" of the 1990s were the noisiest expression of this confrontation. On the "Science Wars," see for example Hacking (1999) and Fujimura (1998).

these authors have been able to identify the importance of the agencies of both human and non-human actors in the development of scientific knowledges and social relations, by rejecting obsolete modes of framing the world in their analyses. By rejecting human exceptionalism and questioning the primacy of human agency, the uncontestable becomes contestable, the agency of unexpected allies becomes tangible, and affinities and kinships with human and non-human others come to the cusp of being ontologically and politically salient.

Though anti-realists they may not have been, there has remained a lingering sense among anthropologists that posthumanist analysts have not been sufficiently reflexive about the kinds of assumptions about humans, non-humans or their interactions that might be hidden by their rejection of all overarching frames. For instance, Bruno Latour, perhaps along with Haraway the most influential theorist of human–non-human relations in STS and anthropology, has targeted analysts' use of the idea of "society" as an overarching context for explaining human–non-human interactions. Instead, he advocates methods such as "following the scientists" to see how *they* make context, which may look nothing like our received notions of "society" at all. But as, John Hartigan has argued, anthropologists often carry the unexamined assumption that our informants "[craft and contemplate] natural objects to affirm or reproduce an existing, hierarchical social order" (2013, 386), blocking attempts to understand other work that those objects may be doing. Anna Tsing (2010) elaborates that in Latourian "anti-context" explanations, gaps, misunderstandings, and omissions in the scientists' or analysts' perspectives can exclude important actors and relationships, leaving them unnoticed. As she points out, "Someone's [implicit] judgement of appropriate "wholes" has blocked our vision" (Tsing 2010, 48).[4] There is already a "meta-value" at work in the analysis, which has separated the beings and acts worth consideration from those that are not.

This meta-value is often assumed to be "life." This is most evident in an area that has been at the forefront of non-anthropocentric anthropology: multispecies ethnography. As S. Eben Kirksey and Stefan Helmreich explain in an overview of multispecies ethnography,

> Animals, plants, fungi, and microbes once confined in anthropological accounts to the realm of *zoe* or "bare life"—that which is killable—have started to appear

[4] This is a criticism that has often been made against Latour's version of Actor-Network Theory. See Amsterdamska (1990) and Martin (1998).

> alongside humans in the realm of *bios*, with legibly biographical and political lives. (Kirksey and Helmreich 2010, 545).

They locate an important shift in anthropological perspective that allow non-humans that were considered bare life to be written with humans in ethnography as *bios*. While this shift decenters the anthropocentrism of prior approaches in anthropology, it does so by shifting non-humans from one category or form of life into another, without questioning the foundation of "life."

Much of this work draws on Donna Haraway's notion of "companion species." Haraway, once the most vocal and enthusiastic exponent of the "cyborg" as a figure for thinking about human-non-human relations, now considers cyborgs a "junior siblings in the much bigger family of companion species" (Haraway 2003, 11). While she argues that companion species—dogs are her favorite example—are as implicated in questions of the natural, artificial, social, and technoscientific as cyborgs, the differences between dogs and cyborgs are significant as well. As she clarifies in a 2006 interview, "[Humans] do life in that way, as cyborgs—but it's not the only way we do life." For Haraway, life is more fundamental to humanness and non-humanness than the cyborg, with the result that the organic dog becomes the model for thinking about the cybernetic machine.

Thus, an innovative and promising area of research like multispecies anthropology rests on an exclusion of "lively" but non-living non-humans like the Geminoids. Viveiros de Castro (2012, 119-120) argues that the exclusion of computers and machines as "other" to humans may actually be constitutive of the field. He speculates that

> now that animals have a very dim presence in our life, we [anthropologists] can afford to consider them as potential co-subjects and/or appreciate their co-subject status in other cultures. The human/animal divide is no longer important to us. The human/machine interface, on the other hand, is what really counts[.] So, the function of "Other" has shifted from animals to machines, and above all those machines that may be conceived as having minds—computers. (Viveiros de Castro 2012, 119)

It is then no surprise that machines have drawn less recent interest than biological non-humans; if machines are made by humans based on human knowledge, then they are uninteresting because they cannot partake of life on their own, preventing them from becoming part of our analyses as "bios" and making them less than truly "non-human."

As Tamar Sharon (2014) argues, a basic dualist framework, which protects traditional notions of human subjectivity, is often a feature of posthumanist approaches. Andrew Pickering, for instance, who argued for a posthumanist understanding of reality as the emergent outcome of entangled material and human agencies. He distinguishes humans from non-humans because the former act intentionally, an assumption he maintains because "I think that this is right" (Pickering 1993, 565).[5] Others (e.g. Haraway 1994, 1991; Barad 2007) offer persuasive and politically attractive theories based on dissolving the assumption of the autonomous human subject. After having recognized that humans, technology, and nature are not stable entities, Haraway writes that "We must cast our lot with some ways of living on this planet, and not with others" (1997, 270). But the philosopher of technology Langdon Winner responds, "Other than observing that ways of living are endlessly contestable (which they certainly are), her writings offer no tangible suggestions about where, when, how, and in which direction particular lots ought to be cast" (2005, 401-402). They rarely offer a clear articulation of what understanding of the human they offer in response (Sharon 2014, 9).

This ambiguity, rather than driving human practice towards new forms of life, may inadvertently reproduce limited and even troubling visions of the world. David Graeber, for example, suggests that, if postmodernism made it impossible to imagine "a single standard of value by which to measure things" then perhaps this was because the universal market system, "the single greatest and most monolithic system of measurement ever created" had thrown the rest into disarray (2001, xi; see also Winner 2005). This means that the endless contestability of ways of life detected by posthumanists was the other side of the "freedom" of neoliberal subjectivity.

Some of this recent anthropological and STS focus on human–non-human interactions may thus be misleading, serving to foreground a particular vision of humans and non-humans that may not always resonate with those that matter to the people we are attempting to understand. In beginning our analyses with assumptions about what humans and non-humans already share, we tend to paint a picture in which the problem of their interaction is of their

[5] Pickering refines this view in his later work (2010). See, for example, his discussion of Ross Ashby (Pickering 2010, 111-112). See Sharon (2014) for a discussion of the tendency to maintain a conventional notion of human subjectivity in posthumanist theory broadly.

competing interests and the failure of humans to recognize the legitimate interests of others. Our approaches make it seem as though the main problematic of human–non-human interaction is the lack of recognition of non-human others by humans within a defined context of interaction.

Posthumanist and multispecies anthropology needs to develop a clearer sense of how people, especially those who experiment at the muddled borderlands of the human and non-human, imagine meta-values, which underlie the commonalities they perceive between humans and non-humans. It must understand how these people use imaginings of meta-values to construct the contexts in which their work becomes meaningful, and how their material practices continually reproduce, transgress, or transform those contexts. This is an approach that many anthropologists have used in exploring human values (Turner 2008; Lambek 2008; Rappaport 1999; Graeber 2001), but which has been largely absent in studies of human–non-human relations, precisely where new relationalities and therefore new meta-values are at issue. Posthumanist analysis must pay explicit attention to how meta-values are made, materialized, and translated and compared with each other and the worlds they entail, if it is to provide critical analyses of existing forms of human–non-human collective life and understand how change can occur in them.

I believe that an analysis of human-centered technologists' theories and practices of human information and communication can effectively respond to these problems in the current anthropological and STS literature on human–non-human interactions. HCT researchers share with posthumanist scholars a vision of human beings as relational entities that make and are made by technology. But rather than facilitate open experimentation in posthuman ways of life, their work shows the extent to which a relationally enacted human being is constrained by the systems in which it exists. They translate knowledges and practices from the domain of everyday social life into the idiom of cybernetics and further into technological devices. The bodily experiences they have with these devices feed back into how they imagine the world and their places in it. This process creates loops that stabilize the relationships between scientific theory, technological practice, social relations, and somatic experience. Each translation can also introduce moments of disruption, which reverberate through the feedback loop and can shift the basis of its stability. An analysis of how they create technologies that channel and mediate human interactions can thus offer new insights into how the meta-value that undergird human–non-human relations is articulated.

1.2 Communication as Meta-value

To illustrate how communication is articulated as a meta-value by human-centered technology researchers, it will be helpful to return for a moment to the robot on the beach. If she, as the subject of a potential sacrifice, enacts a "meta-value" and her sacrifice represents transvaluation itself (Lambek 2008), then what are the basic relations that her existence makes possible? What kinds of relations with what other beings does the meta-value she produces guarantee?

Conventional ways of analyzing human-machine relations predicated on the meta-value of life fall into two rough categories. The first is based on her circuitry, in which the human is reduced to an inanimate machine through their common exclusion from life. The second is based on her sociality, which brings the machine into the domain of the living with the human.

If we emphasize her circuitry, then we see her as a machine composed of circuits and actuators no different from those that might exist in an industrial robot. Her parts all fit together according to an explicit code, which clearly defines the function of every component in relation to the others to ensure its smooth operation. In such an analysis, every piece operates predictably, and when the system seems out of sorts, as when the courier first encounters her, there are mechanisms for correcting her and returning her to operation. When inserted into human connections as in the play, she translates and filters them into a form that can enter into broader technological networks of communication.

As a node that channels human potential through technological circuits, she easily becomes a part of a broader discourse in Japan that makes high technologies like her the key to the creation of a peaceful postwar society. Japanese economic growth and political change during the mid-twentieth century was powered in large part by the rapid development of consumer and industrial technologies, leading to its self-identification as a "nation founded by technology" (*gijutsu rikkoku*) (Morris-Suzuki 1994, 211). During World War II, Japan's scientific and technological research priorities and resources came under the centralized control of the imperial state to serve military purposes (Sigurdson 1995, 13), but with the end of the war and the occupation of the country by U.S. authorities, significant parts of Japan's research infrastructure were destroyed or dismantled to prevent rearmament (Nakayama 1991, 16). Near the end of the 1940s, the Occupation shifted from a policy of demilitarization to one of democratization and economic recovery in order to address the poverty and disarray facing the populace. Throughout this time, science and technology research were seen as key to the construction of postwar Japanese society that would not fall back into militarism.

From the late-1950s to the Oil Shock of 1973, Japan experienced tremendous economic expansion and increases in standard of living, but domestic wariness over the negative effects of rapid growth, such as pollution, growing labor costs, and intensifying international competition brought an end to the period of high growth (Morris-Suzuki 1994, 210). Since then and through the economic downturn of the Japan's "Lost Decade" in the 1990s, the country's government and industries struggled to find new areas in which they can be globally competitive. They then focused their attention on computing and information technology (Morris-Suzuki 1988) and, more recently, robotics.

Japan is currently one of the world's major producers and markets for robotics. According to a report from the Japanese Ministry of Economy, Trade and Industry (2013), in 2011, Japan produced 50.2% of the US$8.497 billion world market for industrial robots, used in the manufacturing industry. Japan is also currently the largest market for industrial robots: 26.6% of the world's operating industrial robots are in Japan. However, Japan's lead is gradually being eroded by other countries, particularly China, which is showing explosive growth in both industrial robot use and manufacturing (Ministry of Economy, Trade and Industry 2013).

In response to increasing global competition in industrial robotics, Japanese corporations and the state have looked for potential future growth in service robots that will work in close proximity with humans performing domestic, nursing, medical, and mobility support, roles that the Geminoid and other robots from Ishiguro's lab have been enlisted to fulfill. The Japanese Ministry of Economy, Trade, and Industry (2013) projects that in 2035 the market for service robots will be worth approximately US$42 billion (¥4.9568 trillion), nearly half of a $100 billion robot market. While this figure would represent only a few percent of Japan's GDP, such robots are anticipated to enable improvements in productivity and innovation in broader sectors of the economy, such as by extending the economically productive working lives of the elderly, spurring greater economic and social gains (New Energy and Industrial Technology Development Organization 2014). For a country that admits few immigrants and expects nearly 40% of its population to be at or over the age of 65 by 2060, robots and other technologies that supplement or replace human labour power are essential for ensuring an economic future (see Robertson 2007).

When linked through her circuitry to this set of connections, the Geminoid acts as a node for translating human potential into an electronic form that can be appropriated for the purpose of economic growth. This analysis reduces the human and the machine to a common code dictated by the imperative for economic growth. It makes both of them subject to what Haraway might call a "transnational informatics of domination" (cf. Haraway 2006, 135;1994, 161).

Another kind of analysis, one that emphasizes her "sociality," show that the robot is also in a different set of connections, which transforms her circuitry into a carrier of human sociality. In this view, the robot is the technological bearer of a cultural tradition that survives or is re-invented within capitalist postmodernity. For instance, many commentators in and on Japan present robots as continuous with the Japanese tradition of *karakuri* mechanical automaton dolls produced beginning in the 1600s (Schodt 1988, 60-61; New Energy and Industrial Technology Development Organization 2014; see also Glaskin 2012 and Sabanovic 2014). Others point to Japanese animistic spirituality or religion as uniquely accepting of robots as social others (see Jensen and Blok 2013). In either case, her circuitry is understood to have been made to match hegemonic images of human society. Jennifer Robertson supports this view, when she suggests that in Japan, "new bio- and robot technologies are being deployed to reify old or "traditional" values, such as the patriarchal extended family and sociopolitical conservatism" (2007, 369). The robot then becomes elevated to a form or adjunct of human life and acts as a conduit for affirming hegemonic social values. In contrast to Michael Hardt's claim that computers have become a prosthesis that makes humans "increasingly think like computers, and the interactive model of communication technologies […] more and more central to our laboring activities" (1999, 95), this analysis sees technology as conforming to existing models of social and political order.

Each of these two analyses—"circuitry" and "sociality"—start from the presumption of life as a meta-value, revealing different sets of connections depending on which side of life we place humans and machines on. The circuitry analysis proceeds on the basis that technologies dehumanize, making humans into machines themselves, making both human and machine non-living. The sociality analysis is based on humans making machines resemble certain kinds of humans, making them both into forms of life. Neither is false or incorrect, but they are more partial than analysts have tended to allow. Neither fully addresses what HCT researchers take to be necessary for smooth human interactions or for understanding what parts of the world become meaningful to human beings. By assuming human life as their bases, these analyses obscure that neither of these understandings of the robots' roles dominate the researchers' own understandings of their work. Researchers constantly compare such interpretations of technology's role in society and draw on them in different times and situations. The researchers themselves are often ambivalent about the importance of such framings of their own work, while at the same time strategically making use of them to ensure that their research can continue.

Similarly, the behaviors of the robots themselves are not easily interpellated into one or the other analytic framework. Consider the two moments in the play when the robot recites her poem. When the courier first comes upon her, she is locked in an endless repetition. She fails to respond to the calls of the courier, and merely reacts to the stimuli of her own mechanisms. She is acting as an automaton par excellence. When the courier encounters her, she is unresponsive, and to break her out of her loop he treats her as a machine. The courier then asks her to read poems on the beach for the dead and missing of the disaster. Again, presumably, she will repeat these poems endlessly. This time, however, the audience is not to imagine her as broken or malfunctioning, even though her behavior is essentially the same. We are now to see her mechanical repetition also as a gradual, asymptotic approach to the spirits of the dead and the eternity of human death. The two co-existing meanings of her repetitive behavior seem to hold circuitry and sociality in tension, without allowing one to collapse into the other with finality. That these two articulations of the robot co-exist in the play and for the researchers means that beneath life, there is another meta-value, communication, which joins them both together.

1.3 Systems of Communication

When the lights of the theater rise, the robot's world changes. The operator backstage who was giving her voice and gesture uncouples herself from her computer. The robot will only sit, motionless save for some pre-programmed gestures, until her power is cut, the air leaves her limbs, and she is packed away. For those on stage, backstage, and in the audience, the ambience of the room has changed. What people expect, how people act, and who they are, all shift in that moment. They become connected with each other in different ways, and give different reactions in response to what they observe in their new surroundings. But the exploration of the robot's place among humans goes on. She remains part of experiments to create human-centered systems that can help to maintain and stabilize the human as a system of communication. It the field of human-centered technology, it is communication and the forms it takes in various kinds of interconnected systems that matter most.

For HCT researchers, to see the human as a system of communication is to see it as a set of circuits that receive, process, and transmit messages with surrounding systems. When one system interacts with others, it does so through the exchange of messages or information between them. Each system receives messages, performs operations on them to convert them into new messages, and sends these new messages on to other systems. A system is therefore defined by the relationship it creates between its inputs and outputs.

In this view, there are many different types of messages. They may include stimuli from the physical environment, electronic, chemical, or neuroelectric signals, or linguistic and non-linguistic messages that are conventionally associated with human behavior. Any system must be able to understand the messages that it receives from other systems to be able to produce outputs. Each system is therefore further characterized by the kinds of messages it is capable of receiving and sending. Every system has a specific set of messages that it can receive, and others that it cannot. In other words, every system is sensitive of certain kinds of messages. When systems capable of receiving each others' outputs come together, they become nodes within a larger system of communication. This larger system coheres as a system because the repetitive exchanges between its nodes stabilize their mutual connections. HCT researchers view the human as a system that is sensitive to certain kinds of messages, and which is linked with other systems to become a node within a larger system.

The challenge that HCT researchers try to address is when the larger system contains two or more nodes that must interact to keep the system stable, but which cannot easily exchange messages with each other. In such cases, one of the nodes must adapt to be able to exchange the right kind of messages with the others. Considering the human as one of these nodes, the HCT researchers create technologies that can smooth the interaction between nodes. To be able to do so, their technologies must learn or be made to exchange the kinds of messages that humans are accustomed to exchanging. A technology that is capable of doing this is a human-centered technology.

When humans perform this act of message adjustment among themselves, the lab calls it "reading ambience." When humans read ambience, they observe what kinds of messages other humans around them are drawing on to produce new messages. Among humans, these messages are conveyed as linguistic utterances and bodily gestures and behaviors that people observe through their sensory organs. When people are sharing a reading of ambience, then their actions become understandable to each other, establishing and maintaining the relationships between them. A reading of ambience is the basis of what HCT researchers consider "natural" human interactions.

The HCT researchers therefore understand technologies that can permit the smooth exchange of messages between humans and other systems of communication as technologies that can read ambience (*kuuki wo yomu gijutsu*). Machines must learn to read ambience if they are to be able to act "naturally" in a "human-oriented" way (Tachi 2010, 172). To create technologies that can read ambience, they must translate the circuits that perform it from a human to a technological form. This requires the use of cybernetics.

1.4 Theoretical Schema

The theoretical framework that I have developed to understand the practices of HCT draws heavily from the researchers' own understandings of human beings and machines as cybernetic entities. I believe that my informants would largely agree with the framework that I have developed, but in order to present it here, I have had to make explicit certain assumptions and ideas that they usually leave tacit. To fill in these gaps, I use the work of Gregory Bateson and Jürgen Ruesch (1951), who developed a theory of human social interaction based on a cybernetic model of communication. I introduce some basic concepts here, and more fully develop some of its aspects over the course of the dissertation.

I have found it useful to think of communication systems in terms of what Bateson and Ruesch called the social matrix of communication. For Bateson and Ruesch, the social matrix is the medium that people perceive through "the repetitive and consistent bombardments with stimuli to which human beings are exposed" (Bateson and Ruesch 1951, 8). Through the social matrix, an individual interprets and influences the people and things around them. It is made up not only of the behaviors of other people, but also their material surrounds ("the objects, plants, and animals" (8)). The repetitive and consistent character of these stimuli from the social and material environment shapes participants to act in routinized ways to these stimuli, and induces them to seek out and shape social and material settings that activate these routines.[6] All human action is understood in terms of acts of communication through which people exchange messages in certain normalized forms, and which can be corrected by other parts of the matrix if they deviate from these forms. The social matrix embodies a set of preferred behaviors and modes of interaction according to which any given message becomes meaningful, and into which individuals are socialized. What I called a reading of ambience is similarly an understanding of one's situation which implies a set of preferred behaviors and modes of interaction that define meaningful information from meaningless background.

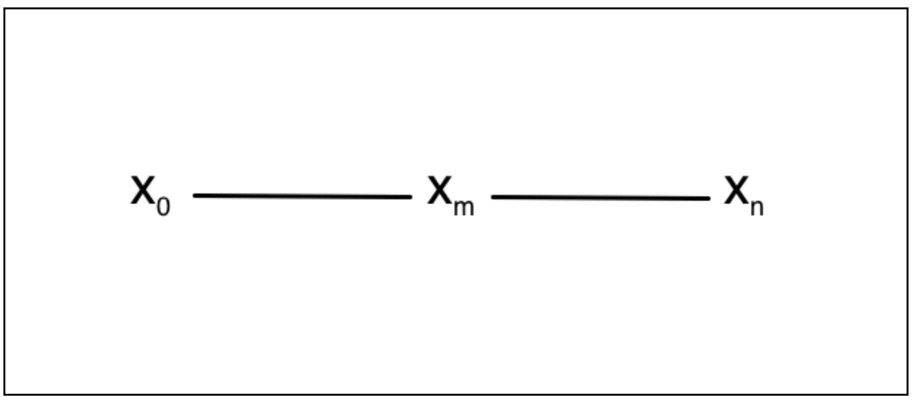

Figure 1. Basic communication system.

In order to approach how cybernetics thinks of the human as a system of communication, it will be helpful to begin from the most basic communication system, and then complicate the picture in three ways. The basic system we will start with involves three elements, consisting of

[6] Of the social matrix, Bateson and Ruesch write,

> The whole process can be compared to the bed a river cuts into the surface of the earth. The channel is formed by the water, but the river banks also control the direction of flow, so that a system of interaction is established in which cause and effect can no longer be isolated. (Bateson and Ruesch 1951, 8)

The social matrix is created by the interactions that it then comes to foster, producing an ensemble of dispositions and preferred channels and types of interaction that individual participants embody and tend to reproduce.

two participants or nodes, x_0 and x_n, and a medium through which they communicate, x_m. In a conventional understanding, communication takes place when x_0 sends a signal to x_n through x_m, which x_n receives. x_n is induced to reply, sending a signal back to x_0 through x_m. We can imagine this like a phone call, in which x_0 and x_n are people in a conversation, and x_m is the phone circuit between them.

First, we need to see this line as a loop. We might ordinarily think of a simple communication system as a kind of network with two points joined by a line, topologically, the system is a loop that connects x_0, x_n, and x_m with each other (Figure 2).[7] Every such circuit consists of a path through which signals are sent and another through which they are received. In some cases, the paths may be the same, but in general, we cannot assume that the input and output follow the same path.

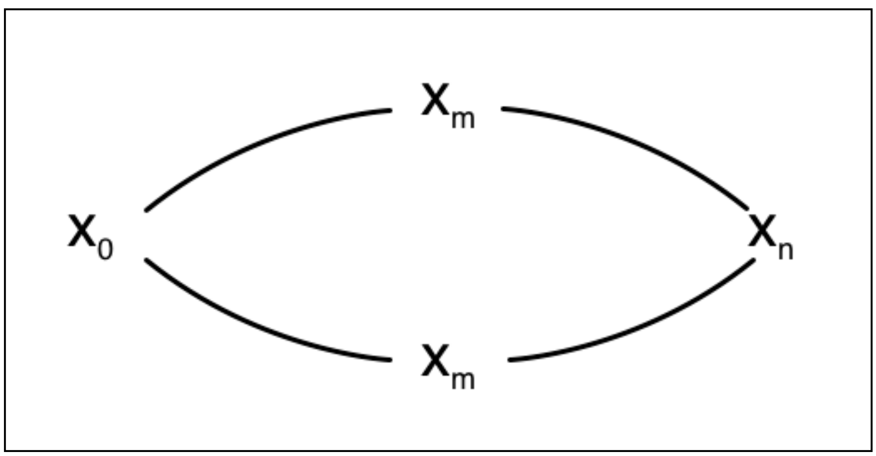

Figure 2. Basic communication as a loop.

Second, we need to pay attention to the space around the circuit as constitutive of the circuit itself. Rather than take the participants in the network as beings that create the circuit between them, the cybernetic viewpoint takes the circuit as being created by the "restraints" (Bateson 1967) around it. One can imagine the black strokes that marking the circuits and the participants as being "pushed" into those forms by the white space surrounding them.

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[7] x_m at the top of Figure 2 need not be the same as x_m on the bottom, but I use the same notation to signify both for simplicity.

Analogously, one might think of the black of the letters and the lines as the figure or "signal" of the circuit, and the white space as the ground or "noise" against which the signal becomes visible. Alternatively, one may think of the white space as populated by any number of x's and lines, which have suppressed in order to stabilize the circuit between x_0, x_m, and x_n. In any case, the point is that a communication system is not just something that transmits a signal; it conveys a characteristic relationship between signals and noise. Each message carries this signal/noise profile.

This means that, with each message that is sent around this loop, the signal/noise relationship that defines the circuit is reproduced. In fact, this is the condition of the circuit's stability. Each node in the circuit sends out a message. When the next node receives this message and it reproduces the correct signal/noise relationship, then it can be transformed and passed on to the next node, and so on. As the message goes around the loop, it reinforces the signal/noise relationship. This need not be the same signal/noise relationship across the entire loop, as long as adjacent nodes can properly pass on and transform the message into a form that the next node can transmit. The point is that the circulation of a message around a circuit creates and reproduces that circuit. Where a message fails to be sent on, then the circuit may weaken.

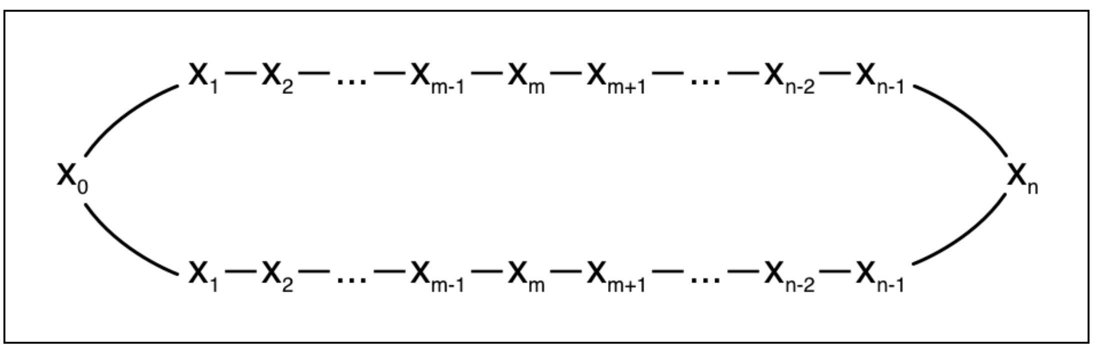

Figure 3. Basic communication system with nodes decomposed into systems.

Third, each of these nodes, x_0, x_m, and x_n, can potentially be decomposed into systems of nodes. Thus, we can think of the loop $\ldots\text{–}x_0\text{–}x_m\text{–}x_n\text{–}x_0\text{–}x_m\text{–}\ldots$, as $\ldots\text{–}x_0\text{–}x_1\text{–}x_2\text{–}\ldots\text{–}x_{m-1}\text{–}x_m\text{–}x_{m+1}\text{–}\ldots x_{n-1}\text{–}x_n\text{–}x_{n+1}\text{–}\ldots\text{–}x_m\text{–}\ldots\text{–}x_0\text{–}\ldots$ (Figure 3). How we define or decompose any particular x depends on how regular and predictable the nodes within a system behave in relation to each other. If, for example, x_2's outputs always correspond to the inputs it receives from x_1 in a one-to-one fashion, then the circuit x_1–x_2 can effectively be considered a single node, because they will always behave as a pair. x_1 and x_2 effectively become invisible as separate nodes. If however, x_2's output also depends on the signal that it receives from a third node x_3, then x_1–x_2 must be treated as separate nodes. If a node is part of more than one system, then it may be treated as a node in one system, but a system of nodes in another, because one system may provide a different set of inputs from the other, causing the node to generate different sets of outputs.

To summarize: any communication system must be understood in terms of nodes connected by loops that define signal and noise in relation to each other, and whose nodes themselves may be systems of nodes. Communication systems are distinguished from each other by the forms of signal and noise that maintain them, and the relationships between inputs and outputs that they produce.

In the viewpoint of HCT, all social and material objects and practices can be understood in terms of this basic schema. Human beings themselves are viewed as systems of interconnected information circuits, composed of systems and subsystems, and components of larger systems, as are material objects and social organizations.

Like other nodes within these systems, human beings engage with other nodes in countless ways, but through specifically human kinds of senses and forms of action. This body-wide engagement with the surrounding systems mediates a person's perceptions of them and guides their behaviors within them, while simultaneously articulating its borders as a subsystem among them.

1.5 Chapter Overview

In the following chapters, I address how communication has taken such a central place in how HCT researchers understand human beings. In addition, I explain the importance they place on technology as a way to support human beings in contemporary society. My focus is primarily on a place I call the Wearable Technology Laboratory, or the WTL.

Before introducing the WTL, I explain part of the history through which communication became central to HCT researchers' understandings of human beings. In Chapter 2, I briefly introduce debates over the role that science and technology should play in Japanese society that occurred following the end of World War II. At the time, many scientists, intellectuals, and politicians agreed that science and technology were the key for postwar progress, but they disagreed about the ends that should be pursued. Advocates of "technocracy" believed that science and technology should be used to promote economic prosperity and the establishment of a consumer society. In contrast, others wanted science and technology to be used to explore the possibility of more democratic and even "utopian" societies.

The new field of cybernetics emerged in the postwar period, and its founder, Norbert Wiener, was also concerned with how new technologies might create more humane societies or empower totalitarianism. Chapter 2 focuses on how Wiener's ideas were translated to Japan, and became a way to understand social and political oppression as a problem of communication. Cybernetics cast the entire universe as well as the humans and machines within it as systems of communication. By doing so, it brought Japanese researchers to focus on the interface between humans and technology as the point for creating better forms of communication and, consequently, for creating more human-oriented societies. One such researcher, Tachi Susumu, became a pioneer in the field of human-centered technology. I discuss his ideas and technologies, which came to influence many other researchers who joined HCT.

In Chapter 3, I introduce the Wearable Technology Lab to show how they understand their everyday social practices in terms of communication systems. The social relations in the lab are regulated by the requirement that all of its members "read ambience" to behave in acceptable ways. Lab members have been socialized into specific ways of reading ambience through their pre-university education, but must learn new kinds of behaviors when they join the lab. When a lab member fails to behave in expected ways, their reading of ambience is considered to have been mistaken, and other members perform actions to correct the reading of ambience. I show how the process of socialization into the lab impresses upon its members the importance of reading ambience for performing "natural" interactions.

Furthermore, I analyze how lab members understand the act of reading ambience to argue that it is based in the assumption that human social relations are systems of communication. I dissect the concept of reading ambience to show how it corresponds to the act of determining the kinds of messages that make up a natural interaction. Messages are defined by the kind of they carry "signals" and the "noise" against which these signals can be recognized. For a natural interaction to take place, the participants must exchange messages with the same kinds of signals and noise. Through this discussion, I show that the lab equates the act of reading ambience and the challenge of creating natural human interactions with the problem of making two communication systems capable of smoothly exchanging messages.

In the fourth chapter, I address how HCT researchers determine what kind of a communication system the human is. If natural human interactions are smooth exchanges of messages between communcation systems, then what defines the kinds of messages that are natural to a human? I argue that it is the body that defines these messages. I describe how HCT researchers use reverse engineering techniques to isolate the origin of intentional human behavior. Their reverse engineering is predicated on the idea that the human is a system of communication. But rather than try to reverse engineer how a person's conscious intention leads to intentional behavior, they focus on the body. Their experiments show that they body rather than consciousness is what defines the human as a specific kind of communication system. This chapter shows that for HCT researchers, consciousness does not drive human action, but is an output of the human system, challenging conventional dualistic views of the human based on the separation of mind and body.

In the fifth chapter, I move beyond the controlled context of experimentation to address the concept of a human-centered technology more directly. I examine a number of the WTL's technologies as well as two from related labs to develop a more detailed account of their view of the human body. If the human body defines the human system of communication, then what makes that system uniquely "human"? I argue that HCT researchers consider a system human if it produces illusions as outputs. I describe how these researchers take sensory illusions to be the unique outputs of the human communication system, and reverse engineer the processes through which humans experience illusions to establish the specific character of the human system of communication. Their focus on illusions demonstrates that a communication system is not a material object, but a specific set of relationships between input and output messages. The human is therefore a relationship between certain kinds of inputs and sensory illusions.

Chapter 6 asks how HCT researchers understand the social necessity and value of human-centered technologies. What kinds of societies do HCT researchers imagine their technologies helping to create? I begin by explaining the tremendous extent to which the

Japanese state had invested hopes for countering the challenges presented by Japan's aging society and declining birthrate in human-centered technologies. To sustain Japanese society against the gradual loss of human beings, human-centered technologies are positioned to take up the roles that humans are no longer available to fill.

I argue that researchers can imagine HCTs as contributing to the stability of society as it exists, but HCTs also make it possible for them to imagine other relationalities that might be more human-centered. I examine the lab's participation in a nationally funded project called "the Global Center of Excellence for Founding Ambient Information Infrastructure" (AIS-GCOE), as well as media art projects created by a member of the WTL named Nishida. I use these examples to illustrate that the difference between them lies in whether or not communication is equated with life. When the human is viewed as a form of life as in the AIS-GCOE, life serves as a constraint on the kind of human that the researchers can imagine. This constraint limits the connections that the human can have to those that reinforce existing visions of the human and society. In contrast, when the assumption of life is suspended as in Nishida's media art, other forms of relationality become tangible, if not fully explicable. This chapter supports my main claim that communication is the meta-value among HCT researchers, and that life is, at best, a form of communication.

In the conclusion, I answer the questions with which I began the dissertation: (1) How has communication taken such a central place in HCT researchers' understandings of the human? (2) Why do they place such importance on technology as a way to support human beings in contemporary society? Communication has taken a central place for HCT researchers through the confluence of existing social practices, the cybernetic interpretation of humans and technology, and the scientific and technological knowledges and practices of the labs. In the contemporary moment, following a postwar situation in which social progress has always been inseparable from scientific and technological development, human-centered technologies became a powerful and persuasive way for researchers to imagine the problems of their current society, and articulate visions of new ones that they might be able to create.

Based on these arguments, I suggest that anthropologists concerned with human–non-human relations should re-evaluate the bases upon which they analyze and account for these relationships. They have tended to imagine both humans and non-humans as forms of life, but such an assumption does not hold for human-centered technology researchers. They take communication as the meta-value that undergirds human existence. For them, humans are a form of communication, and life is perhaps a form of communication, or even a form of humanness. I conclude by discussing this argument and its implications for non-anthropocentric anthropology.

Chapter 2
The Human Use of Human Beings

2 Science and Technology for the People

On August 15, 1945, hours after the Showa Emperor's radio announcement of Japan's surrender to the Allies ended World War II, Prime Minister Suzuki Kantaro went on the radio to call on the populace to aid in the protection and survival of Japan. In particular, he asked the country to "strive for the progress of science and technology, which were our greatest deficiency in this war" (Morris-Suzuki 1994, 161). Whereas during the war, Japan's science and engineering research capacities had been centrally controlled for military purposes, immediately afterwards they were re-positioned as the basis for a new Japan. The U.S. Occupation authorities had largely dismantled what of the country's research and development infrastructure had not been destroyed during the war. But, it was not long before both they and Japanese scientists, bureaucrats, and politicians began to rebuild it with non-militaristic aims. As the historian Tessa Morris-Suzuki points out, for the Japanese after the war, "there was technology designed to serve the aims of liberal democracy, and there was technology designed to serve totalitarianism"; following the war, the former was to be nurtured and the latter was to be erased (1994, 162).

There was much disagreement over what kind of "democracy" postwar technology was to serve, however. Morris-Suzuki points out that to mainstream members of the Occupation authorities, democracy implied the creation of a consumer society and the development of military technologies to protect the state from the external threat of totalitarianism (163). For others, as well as some Japanese scientists and intellectuals, the democratization of technology was a utopian project in which science, technology, and society might fundamentally change each other to produce more radically democratic forms of society (163). After 1952, the less radical vision of technological and social order prevailed (Morris-Suzuki 1994, 164). Control over the country transitioned from U.S. authorities to the Japanese government, and technocrats in the bureaucracy attained a great amount of influence over academic and industrial research (Nakayama 1991, 31-32) as Japan's industries began to play a role in U.S. conflicts in Asia. While technocracy has remained hegemonic since then, the tension between these two visions—what Morris-Suzuki calls "utopian" and "corporatist" (1994, 164) or the historian of science Shigeru Nakayama calls "democratic" and "technocratic" (1991, 14)—persisted into the late twentieth century with grassroots opposition against industrial pollution and nuclear power development (Nakayama 1991, 141, 158). In post-World War II Japan, many agreed that science and technology had to be developed to ensure the survival of the country, but there remained a great deal of uncertainty and disagreement about what kind of society should be sought.

Cybernetics emerged during this same period, and became a science in which its proponents and observers have seen the potential for mechanistic, totalitarian control of human beings by technology and for more humane forms of human-machine co-existence. The root of these differing interpretations of cybernetics is a disagreement about what kind of being the human becomes in the cybernetic viewpoint.

Social scientific analyses of cybernetics in North America have tended to argue that cybernetics reproduced a limited and conservative notion of the human. In an influential 1994 paper on Wiener's cybernetics, the historian of science Peter Galison argues that cybernetic's view of the human was based on the image of combatants in the air battles of World War II. Galison argues that cybernetics extended the confrontation of humans with machines on the chaotic, mechanistic battlefield of World War II into a metaphor for relationships among humans, and between humans and nature. In Deleuze and Guattari's terms (1987), Galison interprets cybernetics to be a "royal science" that works to "prop up the state" (Pickering 2010, 11), by naturalizing a vision of human and technology that reinforces the existing social and political order. It is as a royal science that Galison sees Wiener's cybernetics making humans into the monadic agents of game theory, self-contained, autonomous and opaque to one another except for the messages they pass among themselves. These humans "[live] in isolation, struggling… to create order out of chaos" working towards "superorganization, silence, and control" (Galison 1994, 266).

When cybernetics was translated to Japan not long after World War II, it became the basis for understanding human beings and the world in which they exist as systems of communication. In contrast to Galison, cybernetics did not impose a conservative vision of the human, but provided the foundation for thinking about humans. On this foundation, researchers could understand and navigate the tension between "utopian" and "technocratic" visions of science and technology in postwar Japan, as based in different systems of communication, which imposed different constraints and affordances on humans, which were themselves systems of communication.

In this chapter, I argue that cybernetics did four things when it was translated to Japan. First, cybernetics brought Japanese human-centered technology researchers to the view that all perceivable beings and interactions were to be understood as exchanges of messages among systems of communication. Humans, technology, and nature could all be explained as communication systems in the cybernetic schema. Second, cybernetics provided Japanese scientists with a metaphysical account of the fundamental but imperceptible reality of the universe. They understood the reality that humans can perceive as instantiations of communcation systems, that emerge out of a more fundamental but inaccessible world. Third, cybernetics provided a way to think about a great range of problems from the cosmologiogical to the political to the personal, as rooted in gaps between systems that blocked or distorted communication.

Finally, cybernetics made the interface between humans and machines the location to introduce new technologies that could bridge these gaps. The pioneering engineer Tachi Susumu took this idea and developed it into "Telexistence" systems, interfaces that could allow humans to interfact "naturally" with other advanced technologies. It was with Tachi and Telexistence, which made humans, technology, and the world, all into systems of communication, that the field of human-centered technology began,

2.1 Cybernetics

The name "cybernetics" was coined by the American polymath Norbert Wiener (1894-1964), a professor at MIT, a child prodigy, a prolific writer, and the purported father of the field of cybernetics. He derived the word "cybernetics" from the Greek *kubernetes* or "steersman" (Wiener 1989, 15), because it seemed to him that there was no existing word adequate to refer to a field that dealt with the themes of control and communication with a statistical view of information across electro-mechanical, neurological, and psychological systems.

Cybernetics is a science of information systems. It deals with systems in which the outputs of a system affect its environment and the environment so affected changes the state of that system, creating a negative *feedback loop*. Negative feedback loops restrain the behavior of a system within a narrow range against external changes, producing what cyberneticists considered to be purposeful but non-deterministic behavior (Rosenblueth et al. 1943, 19-20). Cybernetics expanded the realm of control and communication science and engineering from dealing just with control mechanisms based on linear chains of causes and effects, but with unpredictable, non-linear, recursive systems that are capable of self-correction and environmental adaptation. Thus, cybernetics bridged an analytical gap between simple mechanical systems and more complex ones like living organisms and ecosystems, which have as their defining and common characteristic the capacity to maintain themselves as whole systems and maintain stable states. Such systems can remain stable in the midst of a range of environmental contingencies, and against the relentless march of nature towards thermodynamic entropy.

The simplest and paradigmatic example of a cybernetic system is the homeostat, an electrical device created as a thought experiment by W. Ross Ashby consisting of a coil that magnetically moved a needle, whose movement would vary the current to the coil (Pickering 2002, 415-417; Pickering 2010, 101-105). When homeostats are combined in certain conditions, their needles would reliably return to stable positions after being perturbed.

There are two crucial ideas at the center of cybernetics. The first is that the operation of such a cybernetic system does not primarily depend on the amount of energy flowing through the system, but on the variation of that energy level and how that variation induces variations in connected systems. What circulates through the homeostat is not just energy, but *information.*[8] Essentially similar but more complex mechanisms were quickly imagined by cyberneticists to be at the heart of all kinds of social, biological, cognitive, and electro-mechanical processes, natural and artificial (see Bowker 1993).

The second idea is that cybernetics thinks of the relationships between systems in terms of feedback loops, rather than cause and effect. For example, in cybernetics, human beings are not produced as particular kinds of subjects by social structure. Neither are social structures produced by the activities of human beings. Instead, a human is a set of circuits which can

[8] My description of information as variations that cause additional variations in other systems is a way stating Bateson's definition of information as "a difference which makes a difference" (1987, 459).

receive messages from other circuits, transform them, and send them back out to a second set of circuits. The series of messages is translated and conveyed by other systems, which may include technologies or other collectivities of humans until it eventually returns to the original human, setting off another series of messages. Each cycle of feedback reinforces both the circuit structure of human beings and the structure of the whole feedback loop in which they participate. Each part of the feedback loop has its own role to play in ensuring that the flow of messages is channeled in ways that maintain the whole. This means that any given subsystem, including human beings, only has a definite function in the context of a given feedback loop. Outside of a loop, a subsystem can only contribute to disorder, and cannot receive even the inputs it needs to maintain itself as a system.

Though Wiener is known primarily for his contributions to theories of control, communication, and information, he also studied philosophy with Bertrand Russell, developed anti-aircraft ammunition control technology for the U.S. military during World War II, and was an avowed pacifist and political critic in his later writing. To Wiener, cybernetics had the potential to enable unprecedented levels of anti-democratic totalitarian control but also held the promise of leading to humane forms of technology and society. This became the central argument in his 1950 book for popular audiences, *The Human Use of Human Beings* (1989).

Wiener's aim in *The Human Use of Human Beings* is to explain to the general public how society, technology, life, and the notion of order itself need to be conceptualized in the wake of cybernetics. In a cybernetic world, the order that humans experience can only be a tiny fraction of a moment within the long and inevitable decay of the universe towards entropy. In such a world, Wiener argues that humans must understand that they are only able to exist within narrow and limited conditions defined by the systems in which they participate. Within these limits, there are new possibilities for human life and survival, but to realize them humans must realize that order is not inherent to the universe. Because of these limits, people must dispose of the assumption that human progress will be endless which was especially prevalent in the US in the post-World War II period (Wiener 1989, 47). For Wiener, cybernetics should make people see that the order of the world, from the predictable reproduction of biological organisms, to the stability of ecosystems, the structure of human society, and the motion of celestial bodies, are all accidental, temporary, and limited in the grand scheme.

Wiener also wanted his readers to see that this meant that existing forms of order, particularly those of post-war American society were not necessary or natural, and that other societies defined by other systems of communication were possible. Wiener was explicit about the threats facing humanity in postwar America in the first edition of the book, which concluded with direct references to the common totalitarian character of “the Church,” the Soviet Communist Party, and the United States government in their exercise of political and social control and censorship. He argues that in its anti-communist fervor, the US had produced institutions that mirrored those of the Soviet Union—the McCarthy-era FBI, the Loyalty Oaths required of U.S. teachers up until the 1960s, and the House Committee on Un-American Activities (Wiener 1989, xxix)—without adopting any laudable guiding principles. Referring to “our military men and our great merchant princes”, Wiener writes “They have succeeded in being un-American without being radical,” (1989, xxix), and “[i]t is again the American worship of know-how as opposed to know-what that hampers us.” (xxx). We must resist these attacks on our liberties, he wrote, “if communication is to have the scope that it properly deserves as the central phenomenon of society, and if the human individual is to reach and maintain his full stature.” (xxix).

For Wiener, a just and humane society that protected human liberty was one that recognized and fostered human communication in all its range and diversity. In the U.S. of his time, he saw numerous examples of human-created systems that seemed to suppress these forms of communication. These lines appeared in the first edition (1950) but were deleted from the second edition (1954), during the height of McCarthyism in the United States.

Wiener’s book is a polemic that warns of the dangers of placing too much faith in emerging technologies of control, criticizing postwar American society and its assumption of the universe as an endless frontier, and its passive understanding that progress is natural and will continue. *The Human Use of Human Beings* shows Wiener, mindful of his responsibility as a pioneer of cybernetics, attempting to reveal the perils of technology to the public:

> What is used as an element in a machine, is in fact an element in the machine. Whether we entrust our decisions to machines of metal, or to those machines of flesh and blood which are bureaus and vast laboratories and armies and corporations, we shall never receive the right answers to our questions unless we ask the right questions… The hour is very late, and the choice of good and evil knocks at our door. (Wiener 1989, 185-186)

Wiener hoped that he could help his readers realize that existing forms of technology were one possibility among many. He wanted them to see that technologies imposed forms of communication on humans could make them less than human, instead of assuming that by virtue of being created by humans, they would necessarily serve human beings. Wiener senses a tremendous danger in both existing technological and social systems that, because of their mechanistic structure, could reduce the human beings that live in them to machines as well.

In spite of this expressed politics and cautious stance towards technology, Wiener is remembered in contemporary social theory primarily for developing cybernetics as a science of control and a philosophy of individualism. As mentioned above, Peter Galison has drawn on *The Human Use of Human Beings* to argue that Wiener's cybernetics implied a view of human beings, in which "We are truly […] like black boxes with inputs and outputs and no access to our or anyone else's inner life" (Galison 1994, 256).

This notion originated with Wiener's work on the wartime technical problem of electro-mechanically targeting anti-aircraft weaponry at incoming Axis aircraft during World War II. It also came from the intellectual debt that Wiener acknowledges to Leibnitz (Wiener 1989, 19), who saw humans as "windowless monads" that nevertheless interact through the exchange of light. Being "windowless," one could not see inside them, but only the light they reflected from their surface (19; Galison 1994, 256). Galison writes "To Wiener, the essential and unrelieved reality of the world was that the individual lived in isolation, struggling [...] to create order out of chaos." (266) He argues that Wiener, struck by the "uncanny" human-like behavior of self-correcting feedback systems, made them the model upon which the distant airborne enemy, the human pilot, and humans in general were to be imagined. The cybernetic view, Galison warns, "risks reducing the picture of human capacities to one of tactical moves and countermoves in a metaphorical extension of war." (262) Forged in the crucible of wartime air bombardment, cybernetics extended the confrontation of humans with machines on the chaotic, mechanistic battlefield of World War II into a metaphor for nature and society.

Galison's aim is to encourage caution in the appropriation of cybernetics for socially progressive ends by figures such Donna Haraway, who acknowledges the militaristic origins of the cyborg, but emphasizes its blurring of human–non-human boundaries and the partiality of its perspectives to challenge totalizing and mechanistic worldviews. Galison suggests that the troubling vision of human beings as black boxes at war with one another is deeply embedded in cybernetics. He argues that the boundaries that it has most powerfully blurred between human and non-human are those found on the battlefield (261), making any attempt to use cybernetics to support liberatory aims problematic. Like the predicament with technology that faced Japan as it emerged from World War II, according to Galison, cybernetics may appear to promise a new way of imagining humans and machines, but is always at strong risk of falling back into a militaristic worldview.[9]

2.2 Cybernetics in Japan

When translated to Japan, the book took on a different meaning that sparked the establishment of the field of human-centered technology. *The Human Use of Human Beings* was first published in Japanese in 1954, translated by Ikehara Shikao (1904-1984), one of Wiener's first doctoral students at MIT. It came just four years after its English publication, and was given the title of *Ningen-kikai ron*—"Theory of Human and Machine" or "Man a Machine."[10] A translation of the second edition, credited to both Ikehara and translator Shizume Yasuo, appeared in Japanese twenty-four years later, in 1979. Rather than an image of a world of individuals living in isolation and in constant combat against chaos, Wiener's book in translation articulated a vision of humanity as engaged in an ongoing interaction with the universe as "an opponent worthy of respect" (Wiener 1979, 34).

In a television lecture series broadcast nationally during 1999 by NHK, Japan's national broadcaster, under the title "Reading and Understanding Humans through Robots" [Robotto kara ningen wo yomitoku.], Tachi Susumu, the "father" of Japanese virtual reality research, says that the translation of the title of Wiener's book as *Ningen Kikai-ron* was an unfortunate but necessary one for the immediate postwar period. "Just after Japan's defeat in the war, with people struggling just to eat, a book called "humane ways of using human life" [*ningen no*

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[9] Perhaps in partial response, Haraway has moved away from theorizing "cyborgs" towards "companion species" such as dogs, compartmentalizing Wiener's contributions to her thought, along with "systems theories of all kinds" (Haraway 2006, 139). "I'm not really happy there," she states, "but I remember that there is much more than Norbert Wiener in cybernetics." (139)

[10] The title "Theory of Human and Machine" is my translation of the Japanese. "Man a Machine" is the original title of a work by the mechanical philosopher Julien Offray de la Mettrie's 1748 work *L'homme Machine*, which was also translated into Japanese as *Ningen Kikai-ron*.

ningen rashii katsuyou no shikata or *ningen no ningen-teki riyou*, his translations of the English title]—may have been unacceptable." Tachi's implication is that such a title would have been insulting to readers who may have still been living in the distinctly inhuman conditions of the postwar period. Nevertheless, it was evident to Tachi that Wiener's ideas, scientific and political, suggested ways for developing technologies that could serve human beings, rather than draw human beings into their service. Tachi references Wiener's book repeatedly throughout his career, and his viewpoint had a profound influence on his students, among whom are the two most senior professors in the Wearable Technology Laboratory, as well as a significant portion of researchers in Japan currently engaged in virtual and mediated reality technology research.

In a 2001 video interview, Tachi described how he first heard about cybernetics and Norbert Wiener on the radio in the early 1960s as a student at the University of Tokyo, and felt like he had been "hit by a bolt of lightning." He quickly went on to read all of Wiener's works, but the earliest printed reference to Wiener in Tachi's work did not occur until a 1984 English paper, in which he suggests robots can help attain Wiener's dream of the "human use of humans." Tachi's 2010 English book, *Telexistence*, does not mention Wiener by name, but clearly reiterates his earlier reference to Wiener. On its last page he writes that a "human-centered paradigm" must be cultivated "to avoid a fatal outcome" in the encounter of technology and humanity (Tachi 2010, 171-172). "Human-centered technology" must be developed so that people can interact "naturally with machines… as if they were interacting with other people or nature, in a cybernetic way that is truly human-oriented." (172) This is an idea that he has passed down to his students, and which is shared by others working in the fields of robotics and human-machine interfaces in Japan.

Tachi's most public references to Wiener came in the last of his series of eleven television lectures. The advance of technology, he says, had made the lesson of Wiener's book absolutely clear to him: If in the past, it was thought that "Science finds, industry applies, [and] man adapts", as was declared in the motto of the 1933 Chicago World's Fair, now technology should be "human-centered." It is science and technology that need to adapt to the needs and capabilities of human beings, and let them live lives that fit them, rather than the "machine-centered" [*kikai chuushin*] lives they are increasingly being forced into. Where Galison sees Wiener's text as a pivotal moment in making the world a mechanistic battlefield, Tachi reads the same text as a call to re-orient technology to be centered on human needs, comforts, and dignity.

How did Galison arrive at such a different understanding of Wiener's text from Tachi? Both read the same text, and are concerned with how Wiener configures humans and their relationships with each other and with technology, but where Galison sees Wiener making humans into antagonistic agents that must battle each other to create order in a chaotic universe, Tachi arrives at a view in which technologies can and should foster the full expression of humanity. In fact, Galison ignores Wiener's explicitly stated pleas against totalitarianism and for more ethical reflection on the effects of technology, and focuses instead on the military metaphors in and origins of cybernetics. Tachi, on the other hand, foregrounds Wiener's call for a humane technological politics and ethics.

Tachi's is not simply a selective reading favorable to the engineer's or the scientist's standpoint, as might be initially assumed. Indeed, Gregory Bateson promotes a view that opposes Galison's. Along with Margaret Mead, Bateson was a personal colleague of the "father" of cybernetics, Norbert Wiener (Wiener 1961, 24). In *Steps to an Ecology of Mind*, Bateson writes of the importance of a cybernetic perspective with a palpable sense of urgency:

> If I am right [regarding the cybernetic perspective], the whole of our thinking about what we are and what other people are has got to be restructured. This is not funny, and I do not know how long we have to do it in. If we continue to operate on the premises that were fashionable in the precybernetic era, and which were especially underlined and strengthened during Industrial Revolution, which seemed to validate the Darwinian unit of survival, we may have twenty or thirty years before the logical reductio ad absurdum of our old positions destroys us. (Bateson 1987, 468)

Bateson's interest in cybernetics is well known, and reflected in a range of his writings. His interests emerged in part through close interactions with Wiener, especially through the famous "Macy Meetings" which were held from 1946 to 1953.[11] Bateson's view of cybernetics suggests that more than disciplinary standpoint influences the differences between Galison and Tachi's readings. Instead, I suggest that Tachi's reading is due to the translation of the text to Japan, in which Wiener's text was linked to a system of assumptions about life, humanity, and the universe that permitted his favorable reading of Wiener. Specifically, the difference has to do

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[11] On the Macy meetings, see Bateson (1987, xiv), Wiener (1961, 17-18), Galison (1994, 254), Kline (2009, 335), and Hayles (1999, 51). See also Pickering (2010), who describes cybernetics more favorably, although his focus is on British cyberneticians.

with how Galison and Wiener's Japanese translators understood the significance of cybernetics as an account of the nature of the universe.

Wiener presented the struggle that humans face in trying to understand the universe as a confrontation with an "evil" that opposes order. In *The Human Use of Human Beings*, Wiener presented scientists as standing alongside "the warrior or game player," who differed only because of the kinds of opponents they battled or played their games against (Wiener 1989, 36). If the scientist, warrior, and game player are the "good," then what distinguishes them from each other are the kinds of "evil" they oppose. Wiener calls the two possible forms of evil "Manichean" and "Augustinian." The former is "passive" and does not try to deceive the other player, while the other is "active" and may try to cheat or change the rules of the game. Wiener asks what kind of evil it is that the scientist faces. He concludes that the kind of evil that faces the chess player or warrior is Manichean, but the one that the scientist confronts when attempting to understand the universe is Augustinian.

Where Wiener's Japanese translators diverge from Galison is on how different they consider these two kinds of evil to be. For Galison, the distinction between active and passive evils does not have any significance deeper than the tactics that a player uses to defeat them (1994, 232 n.8). In this view, the scientist is no different than the warrior, and is always fighting against one of two forms of disorder. In Japan, the two evils became considered as radically different. Instead of the Manichean evil being active, and the Augustinian one passive, Wiener's translators took Manichean evil to be being, and the Augustinian to be the non-being from which being emerges. From this viewpoint, the scientist is always struggling against a Manichean evil in the hope of glimpsing the Augustinian reality of the world.

2.3 Wiener in Translation

Wiener's distinction between Manichean and Augustinian evils arises from the *Confessions* of St. Augustine. In the *Confessions*, Augustine rejects the teachings of the "Manichees" of whom he had been one. The Manichees had led him to believe that his sins were not his own, but caused by an existence or substance distinct from himself, an "I know not what other thing, which was with me, but which I was not" (Augustine 1909, 5.10.18). Having rejected the Manichees, Augustine realizes that it was not a separate being that had led him to sin, but he himself. He had considered sin and evil to be being or substance, but realized that they were caused by his own imperfection in comparison with God.

Wiener uses Augustine's terms to name two forms of disorder that scientists may confront when trying to understand the universe. According to Wiener, the greatest development in science in recent history had been the demonstration of the fundamental indeterminacy of physical phenomenon, as symbolized by the shift from the deterministic universe of Newtonian physics, to the indeterminate universe of Gibbs and Lebesgue's statistical mechanics. In such a universe, no complete knowledge of nature is ever possible, only a range of more or less probable outcomes. Thus, scientific knowledge of the world is necessarily incomplete. In addition, this means that any order that we perceive in the universe is not the reflection of an underlying universal order, but a statistically unlikely conjuncture of different entities. A Newtonian universe, once set in motion, develops in an orderly and deterministic fashion according to well-defined laws. A statistical universe will inevitably tend towards disorder and randomness; any order that arises is temporary. This shift in perspective is fundamental to the cybernetic worldview.

What Wiener addresses with his Augustinian/Manichean distinction is the nature of a statistical universe's randomness and disorder. In a statistical universe, the "enemy" or "evil" that scientists confront in struggling to understand the universe is the "Augustinian" evil of chance, randomness, and chaos, rather than the "positive, malicious evil of the Manicheans," an active evil that actively tries to deceive scientists to prevent them from knowing the universe (Wiener 1989, 11). Like Augustine, who came to see sin as a sign of his own incompleteness in relation to God rather than caused by evil being or substance, scientists struggle with the necessary incompleteness of their own understandings of the universe. Scientists may nevertheless face Manichean evils who try to deceive them, particularly when they are dealing with other human beings in the actual pursuit of research, but this is an evil of a different kind than the disorder and randomness of the universe.

When analyzing Wiener's Augustinian/Manichean distinction, Galison's focus is on statements where Wiener argues that "The difference between these two sorts of demons will make itself apparent in the tactics to be used against them." (34) Galison interprets Wiener as saying that the "*only* difference [between the two is] that the "Manichean devil" used tricks, craftiness, and dissimulation against us, while the "Augustinian devil" did not change methods." (1994, 266; emphasis added) His distinction between the two is one of activity versus passivity. This allows Galison to conclude that for Wiener, the implications of whether an evil is Manichean or Augustinian are "merely" tactical (Galison 1994, 261); what is significant is that the relationship of humans with nature, machines, or other humans, is of the individual having to select tactics to deal with an opaque enemy other. For Galison, the cybernetic universe is not essentially Augustinian; it resembles a battlefield upon which black-box monads fight each other with tactics that change depending on whether their opponents are Augustinian or Manichean. Thus, Galison cautions against the then postmodernist vogue of invoking cybernetics to imagine ways out of fixed, naturalized identities: "In choosing the cyborg to lead the flight from modernism, one risks reducing the picture of human capacities to one of tactical moves and countermoves in a metaphorical extension of automatic airwar." (Galison 1994, 261).[12]

Much like how standard interpretations of human-machine relations rely on that assumption that life is necessary for communication, Galison's interpretation depends on reading Wiener's cybernetics as a specific way of imagining humans and the universe as forms of being, which is the condition of possibility for their interaction. Galison does not read cybernetics as a claim about the nature of being in the universe, but as an articulation of the universe specific to the socio-historical context of World War II science, technology, and militarism. Thus, Galison wants to temper postmodern enthusiasm for the cyborg, because it might be at risk of being mystified by cybernetics' false image of being. His intention is to expose the notion of a world as a "mechanistic battleground," the specific socio-historical matrix that he sees underlying Wiener's cybernetic universe.

Wiener's later translator, Shizume Yasuo, took the Manichean/Augustinian binary rather differently. Shizume reads Wiener not as offering cybernetics as a specific way of imagining being that can take Manichean or Augustinian forms, but by making Manichean evil into being in the abstract, and Augustinian evil the non-being from which all forms of being emerge.

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[12] Ronald Kline (2009) points out that Galison and many other historians of cybernetics have tended to flatten and unify a field that actually had no such boundedness or internal coherence in the Euro-American context. While I place Galison's interpretation at the center of the following comparative analysis, my aim is not to take Galison's account as a total account of the cultural effects of cybernetics, but as a foil to show how differing interpretations of the same text are possible in translation.

In his preface to the translation of the 2nd edition (cited as Wiener 1979), Shizume writes about the long process through which he discovered differences between the first, second, and revised second editions of Wiener's English text. He writes that his initial impression of the second edition was that, due to the pressure of McCarthyism, Wiener had been forced to temper his deepest critiques of American politics and capitalism. In one section, Shizume even received the impression that Wiener had appended lines in the later editions that display an optimism regarding American society (Wiener 1979, ii). Upon beginning his work translating the new editions, Shizume writes that he discovered that he was wrong about this reversal, and that Wiener's critical reaction to McCarthyism had actually been deeper than he had thought. He locates this deeper critique in Wiener's Manichean/Augustinian distinction.

Shizume interprets Wiener's statements about the Manichean and Augustinian evil to be an allegory for the threats facing scientific communities and American society. Shizume takes the final chapter, new in the second edition, to be Wiener's "declaration of war" against the Manichean world (Wiener 1979, iv). Wiener argues there that a society that everywhere sees Manichean devils that want to deceive and best it in order to triumph, will permit the use of "military strategems" in order to "win the war and itself become the ruling force." (Wiener 1989, 191) This is a society that would place "great value on obedience, confessions of faith, and all the restricting influences which hamstring the Augustinian scientist" (191-192). The Manichean world is a human world, which contaminates the real universe, and must be resisted. Shizume thus concludes, "McCarthy and Beria, Hitler and Stalin, may be in the past, but the Manichean world is not; it is in fact becoming increasingly sophisticated" (Wiener 1979, iv) and thus must be actively struggled against in order to maintain a relationship with the Augustinian world.

But living in a Manichean world of some kind is always unavoidable. According to Shizume, even in scientific communities, Manichean confrontation is an unavoidable feature of human relations, and in general, "Manichean communication cannot be escaped completely" (Wiener 1979, iv). Shizume's use of the phrase "Manichean communication" here, which does not appear in Wiener's original texts, is telling. Changing "evil" to "communication" neutralizes the moral overtones of the phrase, so that it can be used to refer to a more universal phenomenon. The Manichean then becomes not an "evil" to which some "good" must be opposed. The use of "communication" implies other forms of Manichean communication, which must be compared to a third standard to be judged "good" or "evil."

In translation, cybernetics becomes an account of the world in which the real that humans perceive is a Manichean system of communication that defines being, and which emerges out of an underlying Augustinian world. Manichean communications are not false images, as Galison's reading would imply, but partial and incomplete images based on the recognition that the Augustinian world can never wholly enter into human life, except through the human, and, in general, Manichean means that people have to engage it. If Galison sees cybernetics as a map for a World War II territory, then Shizume's Wiener hews closer to Bateson, who argues that what we might consider the territory is not an ultimate reality that we can draw closer to, but is itself is nothing other than another map in a long cybernetic chain of maps (Bateson 1987, 460-461).

Thus, the difference between Galison and Shizume is ultimately rooted in a disagreement about the metaphysical status of the Augustinian world. At one point, Wiener argues that the "black" of Augustinian evil is not a positive blackness but the absence of white, while in the Manichean world, black and white are "two opposed armies." (190) At another point, Wiener writes that Augustinian "evil" both is a measure of one's own "imperfection" (*fukanzensa*) (Wiener 1979, 32; Wiener 1989, 35) or limitations with regard to the universe, but it is also the absence of order itself (Wiener 1989, 34) rather than the active creation of disorder. In this view, Augustinian evil is not necessarily the passive existence of evil or disorder as Galison would have it, but non-being as such.[13]

With this Augustinian understanding of the universe, the Japanese translation of *The Human Use of Human Beings* implies an ethical posture for scientists, and humanity in general, that approaches the universe as an "honorable enemy" (Wiener 1989, 36), or as Shizume

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[13] At this point, I cannot establish its significance, but it is worth noting that Augustinian evil, when translated into Japanese, did not just mean the absence of being, but was rendered by the foremost Japanese philosopher of the period, Nishida Kitaro, in 1927 as *mu* (Nishida 2012, 64), which signifies nothingness as lack of presence. It also implies, in Nishida's extension of Augustine's logic, what he called "absolute nothing" that contains both being and non-being (65), a concept inflected by Buddhist thought. If Wiener's discussion of Augustinian evil, evoked the word *mu* for Shizume, then it is understandable why he would see humans as living in an Augustinian world that can only be apprehended through a Manichean mapping, because in Nishida's extension of Augustine, the world of human experience is brought into positive being through such an act of mutual recognition.

translates it, "an opponent worthy of respect."[14] Rather than make disorder into a positive evil to be combatted, as Augustine imagined sin to be when he was among the Manichees, Shizume reads Wiener's approach as an attempt to come to terms with his own and humans' imperfection and incompleteness in comparison with the cybernetic universe.

Moreover, this translated reading shifts the locus of morality away from the "good" scientists who combat "evil." If humans, scientists included, are always caught in some Manichean world, then some other standard is needed to distinguish "good" from "bad" worlds. Shizume sees Wiener as arguing that humans should struggle to create relationships with the Augustinian universe, in spite of its impossibility. But this interpretation shows that the moral center for distinguishing good from bad forms of communication lies in the human itself.

It then becomes a human duty to resist the appropriation of cybernetics and technology in general by "unprincipled" capitalists, politicians, and military men who work to maintain the existing world. All should attempt to pursue human relations in a form that mirrors the respectful relationship scientists should have with the universe, one in which both human, machine, and nature, each frayed and incomplete, are continuously remade through their ongoing encounters. Technology also must be made into a form that permits humans to encounter it as a respecting partner; it must foster relationships between the self and the non-self, between being and non-being, that are not adversarial and tactical, but open to the mutual becoming of each. All of this is founded upon a metaphysics in which the possible worlds that humans can experience are all systems of Manichean communication, which emerge from an Augustinian universe.

It is this kind of reading of Wiener's book and of cybernetics in general that Tachi presented to the Japanese public in his 1999 NHK television lectures, and instilled in his students, Terada and Nishida, as the idea of a "human-centered technology." But it is one that reproduces the technocratic-utopian tension that has structured approaches to science, technology, and society in postwar Japan. Tachi's vision to develop a human-centered technology expresses a relationship of humans and technology that is open to their mutual becoming, but also a vision of technology that helps humans to survive a technological society

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[14] Shizume translates the relevant sentence as,"Kagakusha wa aite wo sonkei subeki teki to minasukoto ga dekiru." (The scientist can look at [his] partner as an opponent worthy of respect.) (Wiener 1979, 34)

that has outstripped their "natural" capacities for adaptation. This tension between the utopian and technocratic views of technology remains a constitutive tension in the field of human-centered technology.

2.4 From the humane use of human beings to Telexistence

Tachi is one of five researchers who people in the WTL identified as a pioneer in the field of virtual reality and human-machine interfaces in Japan. He was a professor at the University of Tsukuba, and then the University of Tokyo, where he mentored both Terada, Nishida, and many other researchers of their generation who now make-up the bulk of active VR researchers in Japan. Genealogical links can be traced from Tachi and his generation to people spread across nearly a dozen universities. He was the first president of the Virtual Reality Society of Japan (VRSJ) (established in 1996) and the chair of the first International Conference on Artificial Reality and Telexistence (ICAT) (1991). I once mentioned in passing to a postdoc in the WTL my idea of writing the history of virtual reality research in Japan. He said that it would probably turn out to be a history of Tachi and his students.

Tachi was not only a pioneering figure in Japan, but was also present at the beginning of virtual reality research in the United States. He and his research were featured in Howard Rheingold's seminal book, *Virtual Reality* (1992), and he was one of three participants from Japan in an important 1990 NASA conference on Virtual Reality and Teleoperation, which brought together researchers from around the world working in these fields, including Marvin Minsky (see Chapter 4) and Jaron Lanier, who is said to have begun the modern use of the term "virtual reality."

Drawing from ideas he associates with Wiener, Tachi introduced the idea of technologies that can foster the creation of a humane technological society. As mentioned above, in his television lecture, Tachi describes a world that surpasses the "old" paradigm of technology, in which "science finds, industry applies, and man adapts." On the last page of his 2010 book, he writes that a "human-centered paradigm" must be cultivated "[t]o avoid a fatal outcome" in the encounter of technology and humanity (Tachi 2010, 171-172). The potentially "fatal" encounter between humans and technology that Tachi foresees has to do with the unmanageable "speed" of technological advance, which outstrips "the rate of individuals' adaptation and learning abilities." (Tachi 2010, 171) As he discusses in his television lecture, in the past, technologies developed more slowly, over long periods of time, on scales compatible with human abilities to adapt. More recently, technological development has accelerated, with people carrying mobile phones and using computers invented far less than a hundred years ago. To allow humans to better cope with such still novel innovations, Tachi argues that "human-centered technology" must be developed so that people can interact "naturally with machines… as if they were interacting with other people or nature, in a cybernetic way that is truly human-oriented." (172)

In his attempt to create such a technology, Tachi targeted his attention on the interface between humans and technology as the point where a human-centered technology must intervene. Telexistence, a term he proposed in 1980, consists of novel interfaces that allows its user to experience "the highly realistic sensation of existence in another remote place without any actual travel" (Tachi 2010, vi). In a telexistence system, a user provided with the right set of interfaces will be able to control a robot as though it were an extension of his or her own body "naturally." The user would feel as if she were actually in another place, occupying the body of the robot under her control. Telexistence creates interfaces that allow machines to "come unilaterally closer to man's natural senses" (14). Tachi considers virtual reality, the immersion of human users in computer-generated worlds, to be one form of telexistence, which also includes the immersion of users in actually existing, but distant locations.

The systems that Tachi developed over the course of nearly thirty years resembled large mechanical suits or chambers that enveloped the body of a user, projecting to him or her the viewpoint captured by a robot located some distance away. The user's movements would be picked up by numerous sensors surrounding the body, which were reproduced by the robot. They were impressive and, by many accounts, immersive devices, but they came with a tremendous cost. The systems required budgets of many hundreds of thousands of dollars to develop.

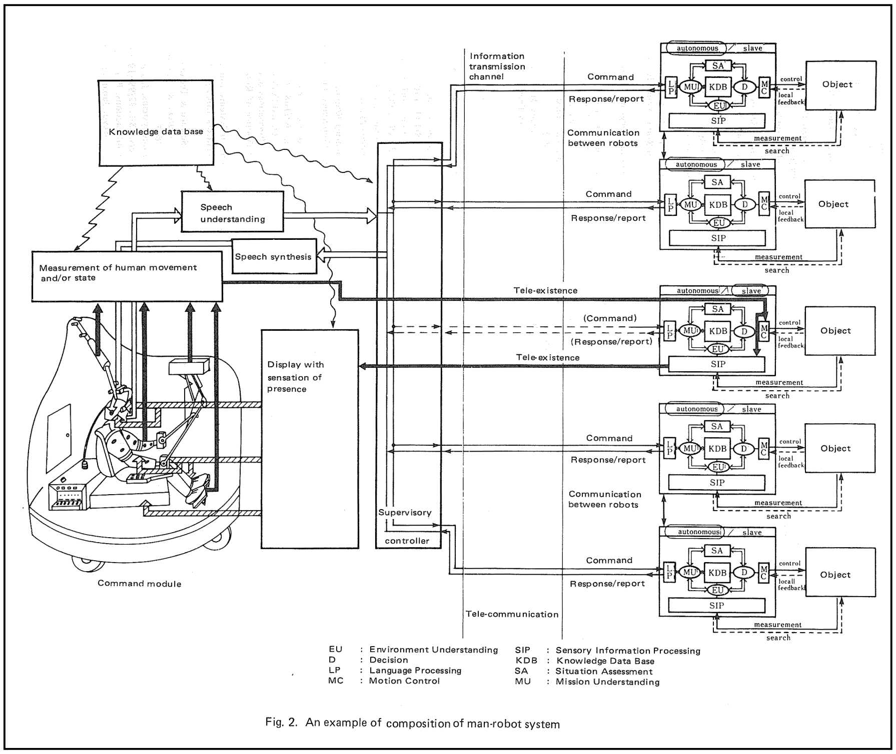

Fig. 2. An example of composition of man-robot system

Figure 4. Schematic of Telexistence system (from Tachi (1984)).

For Tachi, telexistence systems have two effects. On one hand, the technology may make it easier for people to take advantage of robots, freeing them from the ordinary constraints of time and space by allowing them to naturally control robots from wherever they might be. By doing so, telexistence can allow humans to work in situations that they would not otherwise be able to reach, be it a hazardous environment or a business meeting that is too far to attend in person. These systems integrate human beings into an existing and intensifying socio-technical regime defined by the kind of technocratic vision for technology that has dominated Japan since the end of World War II. Today, however, technocracy has intensified to the point where humans cannot keep up with ongoing technological advance. Put simply, humans are out of their evolutionary depth and need technological augmentation in order to adapt to contemporary life. When Tachi argues that telexistence can free humans from the constraints of space and time, what he is really suggesting is that these technologies can help humans integrate into a space and time not of their own making. Telexistence facilitates the smooth integration of a human body's labor into a technocratic system of economic production, and the reproduction of the consumer society.

The second effect is that the peculiar sensations that a user can experience when using a telexistence system suggest to them that other forms of order are possible. The strangeness of these experiences pushes users to imagine that their existing understandings of themselves as human beings may be partial, and only one choice among many. Tachi describes such an experience in an anecdote that opens the final chapter of his book about a telexistence-mediated "out of body experience" of seeing his own body from the vantage point of a robot avatar:

> I can never forget the wonderment of undergoing an out-of-the-body experience for the first time when I constructed a telexistence machine and saw myself through it in 1981. I remember that I was looking at my own back, who was observing someone, and I asked myself if I was actually looking at my own self. Then, who was I, who was looking at my own self? (Tachi 2010, 160)

Tachi is describing the sensation of feeling himself to be not inside his own physical body, but somehow distributed throughout the telexistence system of which his body was a part. This experience leaves Tachi with a question he cannot answer: "Who was I, who was looking at my own self?" This question points to an excess or noise produced by the interface of human and machine in the telexistence system, that Tachi believes may "release human cognition from the current cognition frame." (161) Tachi emphasizes the uncertainty and ambivalence that encounters with telexistence generate in how he understood and experienced himself as a human being. This is a moment in which he becomes able to compare and contrast two different ways of experiencing himself, relativizing the self that he had considered to be natural.

In Tachi's case, such experiences show that Telexistence does not necessarily subject human beings to being part of a technocratic society. It may also "release humans from their current cognition frame" (161) and become a tool for "questioning our identity our the notion of self" (162). This is a moment of "signal leakage." His telexistence system links people into a technocratic society, in which humans need technology to adapt. Telexistence helps to integrate people more tightly within this system. At the same time, at the point of interface between him and the technology, Tachi senses another possibility. The tight loop that binds him to the machine leaks in a way that suggests another way of understanding his relationship to himself and to technology. Equipped with his understanding of cybernetics and the Manichean/Augustinian distinction, he cannot dismiss this experience as mere noise, but takes it as a kind of glimpse of the Augustinian world beneath the Manichean image, and recognizes the possibility of another way of being human with machines.

What grounds both technocratic and utopian views in telexistence is the idea of the human being as a system of cybernetic communication. The telexistence system restages the postwar tension between the technocratic and corporatist or utopian visions of science and technology in society, but does so on the basis that the human is a system of communication.

2.5 Conclusion

In this chapter, I have discussed a formative moment for the field of human-centered technology. After World War II, there was a consensus in Japan that science and technology should be at the center of the new postwar society, but there was disagreement over whether research should serve “technocratic” or “utopian” goals.

Cybernetics, when it was translated to Japan, recast this disagreement as one of different systems of communication. In contrast to the conventional reading of Wiener’s book, represented in this chapter by Peter Galison, which casts cybernetics as an outgrowth of ideas forged on the mechanistic battlefield, the Japanese translation of the book emphasized cybernetics as an account of the underlying reality of the universe, and made the forms of being that humans perceive, including machines and humans themselves, into systems of communication.

This cybernetics struck Tachi Susumu like a “bolt of lightning,” and set him to join the establishment of the field of virtual reality in Japan, and led him to develop Telexistence as an attempt to realize what he saw as Wiener’s dream of a human-centered technology. Through these technologies, he focused on the interface between humans and machines as the point where technologies could be made to be human-centered.

He created telexistence to let humans extend the range of their productive work and adapt to the intensification of technocracy, but it also created a contrasting way of experiencing the self. Tachi’s inventions brought him to the realization that interfaces between humans and his technologies could suggest other kinds of order, and other systems of communication in which humans might flourish.

Chapter 3
The Ambience of the Lab

3 Introduction

In this chapter, I introduce the Wearable Technology Lab, where two of Tachi Susumu's former doctoral students, Terada and Nishida, serve as the top two professors. There they train a new generation of postdocs and students to continue the development of human-centered technology.

The question I address is, if human-centered technologies are ones that people can act "naturally" with, then how do HCT researchers learn to act "naturally" with each other? I look at how HCT researchers' ordinary social practices inform their understandings of how human-centered technologies should work. The work of Terada and Nishida's lab and their colleagues at Osaka University provides a useful clue for exploring this question: in their hands, "human-centered technology" became equated with "technology that can read ambience" or "*ba no kuuki wo yomu gijutsu*." What does it mean to read ambience?

To read ambience is a requirement that is imposed on people so that they behave in acceptable and appropriate ways with each other in a given situation. Reading ambience entails learning how certain aspects of one's social and material surroundings imply that certain kinds of communicative behaviors are appropriate. A person who has properly learned to read ambience can quickly assess the situation he or she is in, and behave in ways that others who can similarly read ambience will recognize as appropriate. The strength of the requirement for people to read ambience impresses upon people its importance as a prerequisite for natural and smooth human interactions.

The members of the WTL are adept at reading ambience, because they have been socialized to do so since long before arriving at the lab. Students in Japanese schools are frequently warned to read ambience so that they avoid offending or troubling others. They are taught that they must always be observing the situations they are in so that they know how they should be acting. A person who behaves unpredictably can have their behaviors corrected by others, and be made to adjust their readings of ambience. In the lab, these students continue to cultivate their readings of ambience to meet the expectations of people in the new setting.

While the requirement that they read ambience does not change in the lab, the way that the students understand the act itself undergoes a subtle shift: the requirement to “read ambience” becomes equated with the requirement to “reduce the mental load” of other lab members. “Mental load” is an expression used to refer to the negative effect that an unpredictable act of communication has on its receiver. It is also one expression within a class of similar expressions that refer to the result of a system receiving a message that it was not expecting. The use of “mental load” to refer to the effects of a student’s failure to read ambience suggests that HCT researchers understand social interactions among humans to be a system of communication.

Drawing on this insight, I develop the theoretical schema I introduced in Chapter 1 to offer an account of what the lab members understand as a reading of ambience as a means through which a node can be made a part of a system of communication. I argue that the act of reading ambience actually consists of two conjoined acts, what I call “explicit” and “tacit” readings of ambience. Explicit readings of ambience define the “signal” component of a message, while tacit readings define the “noise.” Ideally, the lab members should share both explicit and tacit readings, so that the lab as communication system can be stabilized. The explicit and tacit readings of ambience roughly correspond to what Pierre Bourdieu called the symbolic and practical masteries of social and material conditions that make up the habitus. However, the difference between explicit and tacit readings is not one of conscious versus unconscious knowledge, as it is for Bourdieu. Instead, it is a difference in the structure of the communication circuits to which they respectively refer. Equipped with this framework, I discuss two examples in which students had acted unpredictably and were subject to sanctions, and an additional set of examples in which students presented similar information but did not incur sanctions. My analysis of these examples demonstrates that the lab members act in the lab as though they are nodes in a system of communication.

The argument of this chapter shows the importance of reading ambience for creating smooth and natural interactions among members of the lab. It further shows how reading ambience can be interpreted as a way to adapt a node to become part of a communication system. This understanding of the act of reading ambience informs how the HCT researchers approach the task of creating natural interactions between humans and machines.

3.1 Introduction to the Wearable Technology Lab

The Wearable Technology Laboratory (WTL) is located on the northern edge of Osaka University's Suita campus, in a spartan, grey, rectangular building with the sterile designation of "E-6". The Suita campus is the largest of the three campuses of Osaka University, commonly called Handai, which are all situated in relatively quiet and affluent areas of Toyonaka, Suita, and Mino cities. They lie north of Osaka City proper, far from the busy shopping and business districts of the city center. Each November, maple and oak trees that cover the low, rolling mountains to the north are visible from higher buildings on campus as their leaves turn a vivid red. Tourists flock to the area in the autumn to walk amongst the trees and make the leisurely hike up to the Mino Falls. During school holidays when the free inter-campus bus was not running, I would commute from Toyonaka to Suita on the pricy monorail that connects the campuses with an elevated rail that provides a striking view of the mountain range.

Osaka University is one of Japan's former imperial universities, which were made part of the national public higher education system following World War II. Its predecessor institution was the *Tekijuku*, a school established in 1838 by the doctor Ogata Koan in what is now central Osaka. It was a school to teach western medicine, but its students also studied western scholarship more broadly drawing on Dutch sources. Prominent figures in Japan's 19th century modernization, such as Fukuzawa Yukichi, were among the Tekijuku's students. In 1915, following the Meiji Restoration, the Tekijuku transformed into the Osaka Medical University (*Osaka Ika Daigaku*) before becoming the Faculty of Medicine of the newly formed Osaka Imperial University in 1931, making it the second youngest of the imperial universities. Though at its foundation, the university had only faculties of medicine and science, by the beginning of World War II, it had gained a faculty of engineering, and merged with biological and industrial science research institutes. In 1949, it was re-established as a national public university under the name Osaka University, when it finally gained faculties of letters and law to become a more comprehensive institution.

Compared to its larger and older counterparts in Tokyo or Kyoto, Handai's student body has a regional character. In 2013, 54.2% of its undergraduate students graduated from high schools in the Kinki region[15] with 76.7% of the total coming from the areas of Japan west of Tokyo. It is common to hear versions of the Osaka or Kansai[16] dialects on campus, and for some students, it is a particular point of pride to be studying at the "Anti-Tokyo" University, reflecting ideas common among Osakans that people in Osaka are down to earth, friendlier, and more practical and industrious than the intellectual, bureaucratic, and "cold" people of Tokyo. Among some of the professors as well, one will hear of the difference in character between Osaka University and Tokyo or Kyoto. One professor, known for his somewhat peculiar research and eccentric personality, has said that the environment of Osaka, distant from the traditional centers of academic power in Kyoto and Tokyo, affords him the freedom to do research he might not otherwise have been able to.[17]

Though many of the students of Osaka University are very modest and sometimes even secretive about their accomplishments, they represent an elite group among their age cohort in Japan. The national public universities, particularly the former imperial institutions, are among the most difficult universities for students to enter in Japan.[18] Benefiting from the prestige of attending Osaka University, most of its students will go on to find comfortable employment in

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[15] The Kinki region includes Osaka, Hyogo, Kyoto, Wakayama, Shiga, and Nara prefectures in western Japan. Neither of the two most elite national universities—Kyoto University and the University of Tokyo—publish data on the geographic origin of their Japanese students.

[16] "Kansai" refers to the central western region of Japan, which includes the Kinki region, as opposed to "Kanto" for the region that includes Tokyo.

[17] Nevertheless, recent administrations have oriented Osaka University towards increasing its international character and profile like many of its peer institutions. Over the past ten years, the number of foreign students has nearly doubled, roughly following increases in foreign students nationally. In 2013, 1,985 foreign students studied at Osaka University. While only 2.1% of these were undergraduates, foreign students make up 18.2% and 11.2% of doctoral and master students in the university, respectively, with the vast majority of these (80.0%) coming from Asia. Reflecting the persistently regional character of its undergraduate student body, the increasingly international character of its graduate students, and the broader trend towards internationalization among Japanese universities, in 2011 Osaka University adopted the motto "Live locally, strive for the world" (*Chiiki ni iki, Sekai ni nobiru*) to symbolize its plan to establish the foundation for the institution's growth into the 22nd century. The university calls this transforming from Tekijuku to the World Tekijuku (*Sekai tekijuku*.)

[18] The former imperial universities are a group of seven elite national public universities that were established between 1886 and 1939. These include the University of Tokyo, Kyoto University, Tohoku University, Kyushu University, Hokkaido University, Osaka University, and Nagoya University. Seoul National University and National Taiwan University also have prewar roots in imperial universities established by Japanese authorities.

the public and private sectors, in many cases without feeling the economic and psychological effects of the neoliberal casualization of labor as intensely as other people of their age in Japan (Allison 2013). In the WTL, almost no graduating students have had trouble finding employment after graduation, which is illustrated by a page on the WTL's public website that lists eighteen famous companies at which its graduates have become employed. As one postdoc said to me, simply having graduated from Handai will often ensure at least a job interview. Major corporations actively court graduating students with numerous on-campus events during the winter recruiting season. Of the students who were graduating the year I was at the WTL and not planning to immediately continue with graduate studies, all had employment at graduation. Most had received job offers from major Japanese technology or engineering corporations, one from the Japanese subsidiary of a large US-based IT company, and another was joining a prestigious corporate research institution.[19]

The WTL's students' success in entering an elite university and respected corporations indicates their mastery of certain normative behaviors and perceptual categories. They have cultivated a habitus, an embodied capacity to "produce classifiable practices and works, and the capacity to differentiate and appreciate these practice and products" (Bourdieu 1984, 170), which is produced within a specific set of social and economic conditions. Most of the students in the lab, as well as many of the postdocs and professors, were of similar socio-economic class, from families of teachers or engineers, each of comfortably average upbringings. Correspondingly, for many members, the ideologically powerful image of a middle-class nuclear family supported by a male breadwinner (Kelly 1986) was an enticing lure. As a result of passing through this middle-class social milieu, all of the members had developed the taste and skills of discernment to navigate their paths successfully.

3.2 The Self Sought in the Lab

In her pioneering comparative ethnography of Japanese and U.S. high energy physics, *Beamtimes and Lifetimes*, Sharon Traweek wrote that American physicists see themselves as "an elite determined solely by scientific merit" based on an ethos of "competitive individualism"

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[19] The two undergraduate students in the lab who were not immediately pursuing employment had been accepted to graduate school, one at Osaka University and another at an equally, if not more prestigious institution located elsewhere in Japan.

(1988, 91). They consider it "unscientist-like" to be concerned with social relations or "how to get along with other people" (91) and young scientists are encouraged to express an "ignorance of human motives" as though insight into these would take away from their attention to science. In one particularly illustrative scene from her dissertation, Traweek describes how a physics graduate student began stuffing bread into his mouth at a restaurant. The professors were delighted by this behavior, and called the waiter to bring more bread (Traweek 1982 cited in Eglash 2002, 57). Traweek takes examples like these to be signs that a good American physicist is one considered by the other physicists to be able to "ignore the social" (Eglash 2002, 57) and avoid dealing with the "corrupting" and "arbitrary laws of humanity" (Traweek 1988, 102). A person who has read the ambience of such a lab acts with "social eccentricity and childlike egoism" (Traweek 1988, 91).

Nearly the exact opposite is true in the WTL. Rather than cultivate a scientific self that is characterized by eccentricity and egoism, the self sought in the WTL is one that is constantly aware of its social surroundings, judging what kinds of behaviors are appropriate to them. This self is one that has been socialized during nearly the entire period of school education to reject egoism and become adaptive to others around them. Before discussing this self within the context of the WTL, it will be useful to highlight the longer social trajectory and conditions in which people like the lab members begin to develop themselves.

In Japan, especially in recent years, many commentators describe the normative self as one that has learned to read ambience or "kuuki wo yomu." Ambience, according to anthropologist Kimura Tadamasa (2010) is a substrate for social interactions:

> "*Kuuki wo yomu*" […] means reading the mood or understanding what is going on in a given situation, and then knowing what to say and how to behave in the situation. Most participants [in Kimura's study of mobile phone use in Japan] express feeling obliged to "*kuuki wo yomu*" in social communications. In other words, they fear being labeled as "*kuuki wo yome-nai*" (cannot read the air; clueless) and ruining the atmosphere. (Kimura 2010, 209)

As Kimura points out, ambience serves as an objective reference point for a person to decide what behaviors are appropriate, which exercises a regulative force on individual behaviors and their "social communications." Ambience is not unlike what Dorinne Kondo (1990, 153) called *uchi*, "a center of emotional warmth and personal identity" that defines one's behaviors (see below.) Sociologists Hidaka Misaki and Kosugi Koji (2012) refer to kuuki as a repository of "hidden or tacit rules" (*anmoku no ruuru*), which the sociologist Doi Takayoshi argues people feel compelled to continuously monitor and assess in order to ensure that social relations proceed smoothly and without friction (2008, 7). To read ambience is to have achieved a mastery of normalized social relations.

Japanese schools are regarded as particularly important institutions for instilling the ability to read ambience in students, and ensuring their maturation into adults. Online, there are numerous school newsletters to be found which implore students to become able to read ambience, usually presented as life lessons from a principal or teacher to the student body.

These messages make clear that one who reads ambience should be able to use their bodies and words to demonstrate an understanding of their social position as students. The cultivation of bodily practices such as changing from indoor shoes to outdoor shoes at the edge of the school gym, as one newsletter from a junior high school in Hyogo prefecture notes, is a practice that will nurture students' sensitivity to their surroundings (Amagasaki Kozono Chugakko 2014). A newsletter from a junior high school in Tottori prefecture reminds students that the ambience of a high school admission interview requires them to make eye contact with their interviewers (Takakusa Chugakko 2014), while a junior high school principal in Saitama writes that students should avoid interrupting other people's conversations, and learn to speak respectfully to teachers, with whom a specific register must be used (Morii 2013).

Perhaps more illustrative of the act of reading ambience are the numerous ways described by school teachers and principals that students can fail to read ambience, and the consequences of this failure for a student. The Tottori newsletter lists the following as examples.

> People who do not think about their partners or surroundings, who prioritize their individual desires (hunger, sleepiness, desire to have fun), are unable to control themselves (and who become uncontrollable), who do not bear in mind the place or occasion, and who do whatever they want in the way that they want to. (Takakusa Chugakko 2014)

Such people, the paragraph concludes will not only be "disliked by others," but also "unable to fully realize their potential." Much like the earlier statement regarding school interviews, the implications of ignoring or misinterpreting ambience are not only immediate, but can reverberate into the person's future, affecting their ability to progress to the next level of education, or restricting their potential to develop into a full member of society.

To read ambience, students were being told, is to act deferentially to others who are present. According to Goffman, deferential acts "attest to ideal guidelines to which the actual activity between actor and recipient can now and then be referred" (1956, 479). Goffman argues that regular and appropriate displays of deference—what he calls "status or interpersonal rituals" such as salutations, compliments, or apologies (478)—confirm the relation that the actor and recipient have with each other, and imply a promise that the recipient will behave towards the actor in a particular way in subsequent interactions. These newsletters show that students were expected to master a set of behaviors, which would demonstrate their awareness of and deference to the students, teachers, and other adults around them. When these deferential behaviors fail to be performed, a student will have broken his or her "promise" to these others. Hence, the newsletters show that students who have failed to read ambience and behave deferentially appear "selfish," "unpredictable," and "uncontrollable" to the people around them. The "childlike and egoistic" attitudes valued among American scientists are exactly those behavioral traits that the requirement to read ambience in Japanese schools works to suppress.

At the same time, the schools do not wish students to become completely uniform in their behaviors. For example, the Saitama principal cautions that the peril of reading ambience is that a person might be swept up in a swirl of groupthink. He implores students to develop a simple and honest conviction that undergirds their behavior, rather than assume the attitude of an opportunist, waiting to see which way the wind is blowing. This implies that students should have a certain degree of awareness that they participate in the enactment of a reading of ambience, rather than simply follow the people around them in lockstep, while simultaneously managing their behaviors so that they do not appear selfish and unpredictable. Consequently, a recurring dilemma in Japanese discussions of ambience is of being sufficiently reflexive about how and why should behave in a given social situation, so that one is not completely subject to the whims of one's immediate social peers.

Within the lab, the cultivation of selves that read ambience continues, albeit in forms specific to the WTL. In the following section, I describe aspects of the lab's social and material setting used by lab members to situate themselves in the lab. Students must demonstrate that they can act appropriately in response to the familiar elements and display the flexibility to correctly read and internalize the acts associated with new ones. The professors and other senior members of the lab take on roles similar to teachers and principals mentioned above: where students fail to read ambience and act accordingly, they are ready to step in and enforce corrections, which the students should accept with deference.

3.3 Lab Roles and Structure

Two primary forms of scientific lab organization have been institutionalized in Japanese universities. In the past, Japan relied more heavily on the "*Koza*" or chair system which closely resembled French, German, and British systems of lab organization, and are conventionally understood to have been derived from the German system in the 19th century (though it took distinctive forms in Japan) (Traweek 1988; Bartholomew 1978). This system was characterized by the presence of an authoritarian leader (*kyouju*), who managed the research affairs of the assisting professors (*jyo-kyoujyu*), research associates (*joshu*), and students under them. Today, there are two systems, which due to changes in national law since 2007, are similar to the conventional American academic ranking system. In the *Daikouza-sei* (large academic unit system), the main academic staff consists of professors (*kyouju*), associate professors (*jun-kyoujyu*), and assistant professors (*jyo-kyou*). Though their titles reflect their relative seniority within the lab, each is responsible for supervising their own group of students. The structure is primarily horizontal. This system is usually employed in social science and humanities disciplines.

Traditionally in the sciences and engineering, the vertical *Shoukouza-sei* (small academic unit system) is employed. (Many labs have now moved to a Daikouza-sei system. The system used at Osaka University is seen by some as somewhat old-fashioned.) The titles for the main academic staff are the same as in the Daikouza-sei, but there are several clear distinctions in status based on age and level of education. In the WTL, Terada is at the top with the rank of professor, and the lab bears his name (the WTL is informally and most frequently referred to as "Terada-ken", or Terada Lab). Below Terada are the associate professor, Nishida, and assistant professor, Shinagawa, who each contribute to lab projects and administration under Terada's direction, but also conduct their own research. They range in age from their mid-30s to late 40s. All three professors are always aware to some extent of the work of all of the other members of the lab, and are involved in their supervision and training, but will always appear as co-authors regardless of their actual level of involvement in the work for any given paper. They are also the most stable members of the lab; each of the professors has been in the lab longer than most of the other members, and when Terada finally leaves or retires, the entire research program of the lab will likely change.

In addition to the tasks that they perform inside the lab, each of the professors is involved in administrative and teaching duties for the university outside of the lab, and research collaborations with colleagues inside and outside of the university. These put many of the professors' activities on slightly different calendars from the rest of the lab members and each other, so can appear somewhat unpredictable to students.

Within this system, the four postdocs (PDs) fall in the next rank. All in their mid-30s, they are relatively recent Ph.D. graduates, some recruited from labs operated by Terada's colleagues, and others hired through open recruiting processes to fill specific lab roles, such as experimental psychologist. The most senior PD had been in the lab for nearly five years, while the newest was entering his third year. Because they were hired by technical specialization, there is little stratification based on age or seniority among the PDs, but they all clearly rank below the professors. During weekly staff meetings, which only the professors and PDs attend, the office staff always prepare three coffees in the small kitchen adjacent to the administrative office, and set them in the lab's meeting room in the usual spots for the three professors, ready for when they arrive. The PDs are responsible for their own morning drinks.

The PDs are involved in non-lab activities to a lesser extent than the professors, and their calendars are usually similar to those of the students. They are the first point of regular contact for students regarding their research projects, and offer them constant guidance, support, and criticism, sometimes defending them from the pointed inquiries of the professors, who are in contact with the students less frequently.

Each of the PDs leads one of four "squads" of students focused on a different aspect of the lab's research. Kawasaki, the lab's psychologist and only female PD, heads the Experiment squad, Omoto leads the "Tsumori" squad,[20] Kashino the Device squad, and Nishiwaki the Integration squad. The squads each consisted of three to four students, and mixed undergraduate and graduate students, and were loosely structured around the PDs' areas of expertise and the

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[20] See Chapter 4 for a discussion of tsumori.

sub-areas of research defined by the professors. Kawasaki's Experiment squad focused on psychophysical experiments for testing the effects of the lab's technologies on human perception, and for using them to study human behavior. The Tsumori squad focused on experiments and technological development relating to the extraction and transmission of human intention. The Device squad generally did software and hardware development for head-mounted displays and cameras, while the Integration squad worked with a broader range of interface devices, including haptics, auditory interfaces, and the Galvanic Vestibular Stimulation device.[21]

The primary reason for the division of students into squads was to distribute the responsibility for supervising students. In the past, Shinagawa had been the first and main point of contact for students in the lab, but to lighten his workload, this work was spread among the four PDs. Each squad meets weekly to check in on every student's research progress. Every few weeks, the three professors (Terada, Nishida, and Shinagawa), sit in on the squad meetings to receive formal research progress reports from students. Positioned intermediately between the professors and the students, the ebb and flow of the PDs' workloads tends to correspond to that of the lab at large.

At the bottom of the heap are the students. At the beginning of each school year in April, a new cohort of students will arrive. Junior undergraduate students in the faculty are not affiliated with a lab until their third year at the earliest, when those with exceptional grades will be given the privilege of early admission to the lab of their choice. Most must wait until their fourth year, when they will be assigned a lab based on a list of preferences they submit to the faculty. The faculty will then decide which lab the students join based on their grades at that point. Those with the highest grades have a greater chance of getting their first or second choices. Graduate students are assigned to a lab based on their preferences and their performance on the graduate school entrance exam.

Each cohort of students is referred to by their level of progress in their degree programs. New undergraduate students are "B3" ("Bachelor, 3rd year") or "B4". New Master's students are "M1", while those in the second year of their doctorates are "D2". New students are assigned desks in the student's room at the opposite end of the lab from the postdoc's office, of which

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[21] The Galvanic Vestibular Stimulation device and head-mounted displays are discussed in chapter 5.

they have exclusive use. They will also receive access privileges to the lab's network, printers, shared mailing lists and calendars, and file server, on which almost all of the lab's past publications, data, presentation materials, and works in progress are stored. Most students belong to the lab for at least one year, and may remain for up to five or six years if they enter as an undergraduate and stay for two graduate degrees.

Students may still attend courses outside of the lab as students or as teaching assistants, but the vast majority of their time is spent inside the lab. Some keep pillows and blankets by their desks for when they spend the night on the sofa bed in the lab meeting room, and many have caches of snacks by their desks.

Given their relatively short stays there, their calendars are largely structured by the deadlines for graduation, according to which they must submit research proposals and theses, give papers at the requisite conferences, and prepare reports and presentations for the weekly squad meetings with their postdoc leaders.

On top of the calendar defined by their research, the students also all participated in several non-research activities, which each periodically brought the students together at the same place and time. On a weekly basis, students came together at the lab to perform cleaning duties. While university staff cleaned the washrooms just outside the lab by the elevator, no caretakers ever set foot inside the lab. Students were responsible for maintaining the lab itself. Sato, an M1 student who occupied the desk next to mine in the student room, was in charge of assigning the students cleaning duties, which she did using a random number generator. Every few months, Sato posted charts in the student's room and corridor, as well as by e-mail, showing which of the cleaning jobs each student was expected to do every Friday: vacuum, gather trash in each of the rooms in the lab (with the exception of the office that Terada and Nishida shared), clean the kitchen area, or take the lab's trash down to the collection area outside the building. The chart did not specify the time that such duties were to be performed, but the students needing to leave earliest that day would begin before leaving, which would serve as a cue to others to perform their assigned tasks as well. Although because of my age, family status, and research purposes, I sometimes was treated as a postdoc, I most strongly felt myself to be one of the students when I would enter the room shared by Shinagawa and the PDs after most of them had left, to navigate the vacuum cleaner around their desks. While keeping the lab tidy, during the summer months when their workloads tended to lighten, this weekly ritual also ensured that students who might otherwise wander away would find their way to the lab. Students were also responsible for the annual New Year's cleaning in January—also a custom in many homes—when every room was more thoroughly cleaned, and a couple of brave students would venture out onto an unguarded balcony to wash the lab's windows inside and out. Each cleaning socially and physically cleansed the lab of the disorder that may have accumulated during each week and over the year.

On a semi-annual basis, students came together for sports. Prior to and occasionally for a short time after joining the labs, most students were involved individually in intramural clubs. In Japanese universities, membership in sports, cultural, or social clubs known as "circles" or "bu" is often a necessary part of undergraduate student life. After becoming part of the lab, there was a tacit expectation that they would discontinue these activities. In the WTL, some of the junior undergraduate students maintained their affiliations with clubs, but many of the Master's and doctoral students had "graduated" from their clubs at the same time as finishing their undergraduate degrees. They understood that the professors expected them to devote the majority of their time to lab work, and spend their days in the lab.

As a lab, however, students did participate in two annual sporting events. The most notable of these was the "Suita-sai" sports festival, a two-week long event in which labs from the faculties of engineering and information science competed with each other in a variety of sports and games. Nakata, another of the M1 students, communicated with his counterparts in other labs, and recruited members of the lab into teams to play soccer, baseball, basketball, volleyball, tennis, and mahjong against other labs. A similar inter-lab bowling tournament was held at the end of the year.[22] While the students varied in their actual level of personal commitment to the lab (for some the WTL had been their last choice of labs to join), they all participated in these activities, in recognition of their obligations as members of the lab.

Any individual student will have a variety of relationships and obligations to family, friends, part-time jobs, or hobbies outside of the lab, but the rhythm of their lives are significantly determined by the regular, periodic events in which they were all bound to perform

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[22] When I told friends at Osaka University's anthropology department about these events, they looked astonished that such things still took place at the university, but they were unsurprised, saying that engineers enjoyed such group activities (*dantai koudou*).

specific routinized acts in the presence or proximity of their lab group. The daily arrivals and departures of students underlay the weekly cleaning duties and squad meetings, which ticked away the time between annual lab-wide cleanings, semi-annual sporting competitions, and regularly scheduled paper submissions and conference presentations. The visible performance of different displays of deference to the demands of the lab allowed them to demonstrate their ability to read its ambience and affirm their places within it.

The higher status of the professors and postdocs in the lab meant that they were not expected to participate in most of these frequent rituals, but at the most potentially disruptive moments for the social relations of the lab—the arrival or departure of lab members—they were necessary presences. Over the course of the year, there are several lab parties, which usually take place in lab's main meeting space. One party always takes place in April or May near the beginning of the school year to welcome new members of the lab. In December or January, there is an end-of-year party, and in late-February or March, a farewell party is held to see off graduating members. Parties are also always held at other times of the year when a lab member joins or leaves: one was held to welcome my family and me in early September, and another took place in October, when a new doctoral student arrived mid-year.[23]

The parties are scheduled and organized by the lab's "kanji" or social coordinator. At the time, Wada and Nakata, two M1 students, shared this responsibility. They ask all lab members their availability, schedule the date, organize what kind of food and drink will be served, and order or purchase all of the necessary items. Group research activities always take precedence over the parties, so the parties are scheduled to avoid conflicts with major experiments or meetings, but the obligation to attend the parties outweighs any individual's work. Students or staff who are experiencing particularly heavy individual workloads are still expected to attend the parties, whenever they are scheduled. Attendance was never stated as mandatory, but lab members felt obligated to provide a strong excuse to the organizers if they were unable to attend.

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[23] The other major event, the lab's end-of-summer trip, marked the middle of the school year, just after the end of the official summer break, when students may have come to the lab infrequently. It was a two-day event in which the lab members would eat, sleep, bathe, and play together. It also marked the beginning of the busier second-half of the school year, when many of the students would be working feverishly to graduate. Placed at a point in the year marking the sharpest change in the intensity of work, the end-of-summer trip put the members into a high level of close, sustained, and exclusive contact with each other.

(The most common and acceptable reason for missing a party was travel for research or conferences.) Unwarranted absence would be at the very least a sign of a lack of appreciation for the work of the social coordinators to accommodate all lab members in their scheduling.

A week or so before the party, the social coordinators will inform the rest of the lab of the cost of the party, which is shared by all lab members.[24] In the case of a welcome or farewell party, the people being celebrated will not pay anything. Otherwise, all members will contribute between 1200 and 3200 yen ($15~$35) of their own money, which depended only on their status in the lab. Terada will pay the most, while students and office staff pay the least.[25] The graduated payment scale reflects the sense that those of higher status were financially capable of subsidizing the leisure activities of the younger students. However, it also represented a kind of generalized reciprocity: the senior staff would have benefited from the same financial considerations when they were young students, and it was to meet this broader obligation modeled by their *senpai* (people higher in age and status) that they individually bore a larger share of the cost of the parties.[26] In return, the younger students must accept this care from their senpai by attending the events if at all possible, and at some point in the future, provide the same care to their students or junior colleagues.

On the day of a party, Nakata and Wada, along with one or two other students, will leave the lab in the late afternoon to purchase beer, wine, and other alcoholic and non-alcoholic drinks, along with a selection of snacks at a nearby supermarket. If food is being prepared inside the lab, then free students and postdocs will begin chopping vegetables and meat an hour or so before the start of the party. Otherwise, an order will be placed by phone to a nearby restaurant, which will deliver large platters of food. Professors would usually be busy until the beginning of the party, but would peek in periodically to check on the progress of preparations.

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[24] Non-lab members never participated in these parties, with the occasional exception of professors' children and, less frequently, spouses. Gatherings that included other non-members were always held outside of the lab.

[25] None of the office staff ever actually attended the parties, but were always listed among the possible participants.

[26] The payment scale also put the relative statuses of the members into unambiguous quantitative terms, which, on the rare cases it is necessary, allowed for clarification and correction of a member's status. For example, when initially collecting payments for the lab's summer trip, the social coordinators included me at the same payment level as the postdocs ("PD + Grant-san: ¥26,000"). Upon seeing this, Shinagawa told them that I should be charged at the same level as the students, resulting in a recalculation that reduced my payment, but marginally increased theirs.

Just before the food is ready to be served, Nakata and Wada will clear the meeting table of its papers and laptops, and begin calling the rest of the members into the party, although many will already be chatting near the entrance, attracted by the smells of food that have diffused throughout the lab. As in a seminar, all lab members will seat themselves around the table, the professors and postdocs usually sitting in the same seats that they take in seminars, with the students fitting themselves into the remaining spots. As people take their seats, cans of beer and cups of tea or soda will be distributed around the table, but most people will not take any sips until the party officially begins with a toast. Sometimes a postdoc will start drinking a beer before the toast, but will announce the imprudence of his (it was always a male) hastiness to the other members with a self-deprecating joke about his selfishness or the effect of work exhaustion on his judgment.

Once Terada is seated, either Wada or Nakata will bring the party to order, and invite Terada to say some words. As they wait for him to give his opening remarks, people will begin opening their cans and handing drinks to late arrivals, ensuring everybody has a beverage in hand. For a welcome party, Terada will give a brief greeting to the new members of the lab to wish them success, and ask the existing members to help them get accustomed to the lab. For the year-end party, Terada will tell the members that the months until the end of the school year in the spring will be difficult ones, but to work hard and not give in to complacency. When Terada finishes speaking, he will raise his glass for a toast, and say “kanpai”, which the rest of the lab members repeat, before taking long sips from their drinks and reaching for the plates of food arranged along the center of the table.

Three or four conversations will be taking place at different corners of the table, sometimes divided along the lines of status, with students congregating at one end and postdocs and professors at the other, although conversations between these groups are frequent as well. The only sounds will be of eating, drinking, and chatting; there is no background music played at these parties. Though some of the staff will continue to talk about lab work, the conversations will meander from topic to topic: there may be heated discussions about comics or sports, stories traded about the quirks of dialect, custom, and cuisine of their hometowns, or impromptu show-and-tells of favorite smartphones and electronic gadgets. Depending on the occasion for the party, one of the postdocs or students will take photos throughout the event. These will be uploaded to the lab's file server for the other members to view, and some will find their way onto the lab's public website, which contains photo galleries for the lab's major social activities.

The content of the conversations or activities during a party are not as important as the fact that for the two to three hours of a party, nobody will leave the room except to use the restroom or answer a phone call. The rest of the lab is completely deserted. Only when the food and drink are depleted and the hour nears 11 PM will the particularly busy students go back to their desks. They will return a short time later to begin the cleanup, which serves as a signal to the most enthusiastic drinkers that the party is winding down. By midnight, those who remain in the lab will be preparing to leave, or sitting down at their desks for a late night stretch of work, but rarely will anyone leave the lab entirely before the clean up has been completed.

Such social events are not unique to the WTL. As Kuwayama's (1996) study of school camps and Nakane (1970) and others' arguments about the pervasiveness of rigid hierarchies in many areas of Japanese life imply, the students and staff have and will continue to experience similar enactments of contained hierarchical social groupings throughout their lives, as schoolchildren, university students, and later as company employees. Such social events share the same idioms of practice and behavior of social activities that would be most familiar and accessible to those with a middle-class upbringing in Japan. A person who is used to the structure, recreational activities, and expectations of the WTL is well equipped to handle important aspects of life in other science and engineering labs, and workplaces they may encounter in the future: they have been well trained in reading the ambience of these places. The features of the lab and its activities that I have discussed limit the scope of acceptable relationships, and require members to socially identify as parts of tightly bounded and circumscribed groups. So circumscribed, lab members have a firm and static basis within which classes of expected behaviors are well defined.

The lab therefore has much in common with the notion of *ie* or household. Dorinne Kondo argues that Japanese households, as well as small factories or businesses, while comparable to kin groups or families in Western settings, are corporate groups that hold property over time (1990, 122). The members of an *ie* are defined by their status position within a hierarchy, and its members are determined either by birth or by marriage, although a person's permanent ie will often differ from their ie of birth. Membership in an ie gives each person a situated perspective of *uchi*, centered upon the ie, which marks the in-group of an ie as distinct from outsiders, or those who are *soto*. Uchi defines “who you are, how you speak, and how you act towards others,” depending on the other’s position relative to one’s ie (Kondo 1990, 153), and implies relations of strong attachment among its members. Uchi is, as Kondo writes, “a center of emotional warmth and personal identity” (1990, 153).

Figure 5. Posters hanging in the WTL. Left: "Be inspired; Create; Understand." Right: "Gather; Play; Laugh."

Accordingly, when acting as parts of the lab, its members continually draw on their existing understandings of appropriate behaviors in a conventional household, and perform them in the lab. While most lab members will only stay at the WTL for a short period of time, their identity during their time at the university is strongly defined by their association with the WTL, such as during the Suita-sai sports festival, when teams were defined solely by one’s lab membership. And while some of the students felt a very low level of emotional attachment to the WTL (it had been the last chance of lab to join for some), the lab’s group social activities were a collective acknowledgement that one should ideally feel some kind of emotional and almost familial attachment to the lab. As the slogans on a pair of posters made to represent the lab’s goals showed, the WTL was not just a place to “Be inspired; Create; [and] Understand [*Hirameku, Tsukuru, Wakaru*],” but also “Gather; Play; and Laugh [*Tsudou, Asobu, Warau*.]”

As part of the uchi of the lab, the members, and students in particular, had also to adjust their behaviors to the specific context of the WTL. Students may enter the lab without having performed their own experiments or research before. They may have never given a presentation at a conference, or had to write a paper worthy of journal publication. In addition, they have never dealt with the lab’s specific technologies, research practices, or with the professors, postdocs, and students of the WTL. All of these unfamiliar conditions require new members to fully deploy their abilities to read ambience.

3.4 Mental Load

The most explicit means through which the expectations and responsibilities for the WTL’s members are laid out is on the lab’s internal webpage. It contains many pieces of information and advice necessary for success in the lab, such as expectations for the number and type of journal publication for each level of student, guidelines for constructing presentation slides and writing papers, and procedures for making arrangements for travel to conferences. It also includes a section which explains the behavior that is expected of WTL members in stark terms. This section is entitled “Preparedness” (“*kokoro-gamae*”, literally, the posture expected of one’s “heart/mind” (Yuasa 1987, 72) or “human spirit” (Lock 2002, 150)). The only section of the webpage marked as a “required read”, it contained a set of bullet points divided into three parts:

On research:

- Adhere to deadlines
- Responsibly execute the instructions you are given to completion.
- Practice presentations one week before the actual presentation day.

On research funds:

- Because the Terada-ken [WTL] is [financially] well off, people tend to forget how grateful they should be.
- When using research funds, use them responsibly.
- Reimbursement for personal funds used for research is impossible.
- Purchases for which a reason cannot be stated cannot be made.
- Funds for travel are not guaranteed.
- Follow the instructions given to you by the administrative staff. (There is a lot going on behind the scenes.)

What it means to be part of the Terada-ken:

- Be conscious of the negative consequences of rash statements and behaviors.

- E.g. If you tell an outsider, "I only slept an hour yesterday, so I'm exhausted!" [in Kansai dialect], bad rumors about the Terada-ken, such as "I heard that nobody gets any sleep at Terada-ken" may spread unexpectedly.
- Constant complaining creates a negative spiral, stopping good students from joining the lab.
- "You've worked hard and gotten into Terada-ken, so enjoy yourself here." – Professor Terada.

Useless traditions must be thrown away:

- Mimic the good points of your senpai [senior students or lab members]. Don't mimic things that don't benefit the lab.

Proposals, requests, and consultations:

- You are responsible for changing the Terada lab.

Don't doddle; do well:

- If you do your work conscientiously and enthusiastically, then the mental load on the professors will lighten.

Terada originally wrote the document and accordingly its tone is of a master giving lessons to his apprentices, similar to the school newsletters mentioned earlier. It includes practical advice for success in university that would apply to any student, but it also reinforces the extent to which students should see the lab as a single unit separate from other labs around it, especially in the third section. Students are not to express their concerns or complaints to people from outside of the lab, in order to ensure the improvement and success of the lab as a whole. The channels for expressing these thoughts must stop at the edge of the lab.

The directive to "mimic the good points of your senpai [but not to] mimic things that don't benefit the lab" expresses the dilemma facing students in behaving in ambience. In a social group that is structured by differences in age and levels of academic progress, and which requires lower status members to defer to the demands of higher status ones, new students are faced with the need both to emulate senior members of the lab, but also to constantly judge whether or not the things their senpai are doing are "good" for the lab, because the lab's shared reading of ambience is ultimately more important than any one person's. It falls to each individual member to constantly read ambience in order to act appropriately within it rather than simply mimic the behaviors of their senpai. Further, the students are given the responsibility to "chang[e] the Terada lab," showing that each member, regardless of status, has some ability to change the ambience of the lab, although as the other guidelines show, most of the power still lies with Terada and the senior members.

It is the last statement, however, which provides the best perspective for understanding the social dynamics of the lab. The statement expresses the reciprocal obligations between the professors and students: the professors will care for and worry about students who are not being successful, but it is the students' responsibility to reduce the need for this concern by working "conscientiously and enthusiastically." By doing so students can reduce the "mental load" or burden (*shinteki futan*) on their professors.

This "mental load" is a signifier for an amorphous quantity that grows or shrinks depending on how well students fulfill their responsibilities to the lab. While never explicitly represented as a number, the term and its synonyms were an index for several forms of discomfort.[27] A higher mental load could be experienced as inconvenience, frustration, or physical or mental exertion. In general, mental load was a result of an act that was somehow out of place. As an index of a given act's unpredictability, mental load is the result of an incorrect reading of ambience.

Students are expected to minimize mental load in two concrete ways, which show that mental load is tied specifically to unpredictability of a student's communicative acts from the standpoint of senior members of the lab. First, they must be able to clearly and simply communicate the rationale, goals, and procedures of their experiments to the professors. They must, in other words, demonstrate a mastery of the conventional forms of communication in the lab. Students' work is scrutinized at every stage of development by professors and PDs to ensure that the necessity and novelty of every experiment is explicit, that the experiment as performed will be capable of providing results that will answer the question as posed by the student, and that the conclusion is as clearly and persuasively presented as possible. In practice, this responsibility is demonstrated the production of clear and effective texts and slide presentations. Indeed, one section of the internal website dealt exclusively with the creation of effective slides and the norms of performing a slide presentation in a conference setting. This results in a reduction of mental load in the staff by allowing them to concentrate on the students' technical arguments. The staff also valued research originality and creativity in their students, but were

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[27] Other terms used in equivalent ways were cognitive load (*ninchi fuka*), stress, and discomfort or strangeness (*iwakan*). Ninchi fuka was typically presented as being inversely proportional to other quantities such as *reality* (e.g. the "reality" or persuasiveness of a perception can increase or decrease) or the feeling of human *presence* (*sonzaikan*). These terms are also discussed in Chapter 5.

more likely to let a well planned, clearly articulated, and uninspiring project pass than a creative one that was presented poorly. Here, mental load is related to the extent that a student is able to make the signal that the professors receive as clear as possible. If, through a poor command of the lab's norms, a student were to include information that was not expected as part of the signal, this would cause an increase in mental load and reflect a mistaken reading of ambience.

Second and more importantly, the students must show their commitment to research by adhering to schedules for interim research presentations, consulting the academic staff on a regular basis, and responding to their requests and suggestions in a timely, appropriate and sincere manner. That is, they had to maintain an awareness that would enable them to communicate at the appropriate times and places in the expected ways. Students needed to understand without being explicitly told when it was appropriate to approach their professors for feedback. They had to develop a keen, non-verbal awareness of the senior members' individual situations, and a judgment for when certain kinds of communication were appropriate.

Throughout the lab, there were numerous ways to grasp what other members of the lab were doing at that moment. A whiteboard just inside the entrance of the lab, for example, had magnets with the names and ranks of all of the lab members on it. Each member diligently moved their magnets to squares marked "In the lab," "On campus," or "At home" to let others know what they were doing. The lab also shared a Google calendar on which all of the lab's activities and deadlines were listed. Through such means, students were expected to know what others' were doing.

Since all lab members had been provided with the means to remain aware of what others were doing, the failure of a student to communicate in a predictable manner with the professors and PDs was not only a technical and material inconvenience to them (it would require longer hours and weekend work for the professors to meet their responsibilities to students). It also demonstrated a student's lack of appropriate care for the personal and professional circumstances of the professors and other lab members. Thus, mental load increased when students failed to monitor other members' situations, and forced senior lab members to communicate according to students' schedules and contexts rather than the converse. Since an increase in the professors' mental load was understood as a failure to read ambience, a student who communicated unpredictably could have their moral character called into question, and face harsh sanctions, often in front of their fellow students.

According to Bourdieu, the kind of social knowledge that permits students to act appropriately in the lab is embodied in their habitus, their embodied capacity to “produce classifiable practices and works, and the capacity to differentiate and appreciate these practice and products” (Bourdieu 1984, 170).

The habitus is made up of two kinds of “mastery”: practical and symbolic. Bourdieu writes that practical mastery

> is the competence presupposed by the art of behaving *comme il faut* with persons and things that have and give ‘class’ (‘smart’ or ‘unsmart’), finding the right distance, by a sort of practical calculation, neither too close (‘getting familiar’) nor too far (‘being distant’), playing with objective distance by emphasizing it (being ‘aloof,’ ‘stand-offish’) or symbolically denying it (being ‘approachable,’ ‘hobnobbing’). (Bourdieu 1984, 472)

In order to conduct oneself appropriately in a social situation, one must share significant aspects of the practical mastery that others have of that situation. Practical mastery is a knowledge of social practice that inhabits habitus and exists below the level of conscious awareness. Where people fail to conduct themselves appropriately, then they become subject to what Bourdieu calls “negative sanctions” (1977, 78), corrective actions that shape their behaviors into more appropriate forms.

Bourdieu points out that at the same time a person or group has a more conscious understanding of the reasons for their behavior or their explanations of their own behavior.

> [Practical mastery] in no way implies the capacity to situate oneself explicitly in the classification (as so many surveys on social class ask people to do), still less to describe this classification in any systematic way and state its principles. (Bourdieu 1984, 472)

The account that a person can give of their own behaviors Bourdieu calls a person’s “symbolic mastery of experience” (Bourdieu 1984, 463). Symbolic mastery must be a false representation of a person’s practical mastery, and it is practical, unconscious knowledge that drives behavior.

I interpret the act of reading ambience in a largely consonant manner to what Bourdieu calls symbolic and practical mastery. However, reading ambience differs from Bourdieu’s account in that it is not based on a strong distinction between conscious and unconscious knowledges of social practice. For Bourdieu, practical mastery is unconscious knowledge that contains the principles that generate social practices. In contrast, symbolic mastery is a false conscious representation of those principles. Critics of Bourdieu have suggested that this view removes the possibility of human agency in the face of a determining social structure, and argued that it is more accurate to think of people as at least partially conscious of the reasons for their own behavior (Ortner 2005).

While I agree with this criticism in spirit, I believe that blurring the boundary between conscious and unconscious knowledge does not sufficiently correspond to the understanding of "natural" human interactions that people in the WTL have. The close association between the concept of mental load and acts of communication suggests that lab members view their social relations and the act of reading ambience in terms of systems of communication. More tellingly, the lab's understanding of conscious and unconscious awareness defines the difference between them in terms of the structure of the circuits through which messages are channeled. This implies that the lab's social interactions cannot be understood except in terms of systems of communication.

In the WTL, the difference between the conscious and unconscious is related to "attention" or "*chuui*," a function of the brain that Terada described in an e-mail to all of the WTL members as an "interrupt circuit or flag for prioritizing information passing between subconscious and conscious systems [*Ishiki-ka kei to ishiki-kei no aida de yaritori sareru yuusen jyouhou furagu/warikomi sen.*]" Whenever a person is observing his or her surroundings or performing some action and an unexpected situation results, chuui "wakes consciousness up" (*ishiki kei wo tataki okosu*), giving the unexpected information a priority flag or activating an interrupt circuit to bring the information to conscious attention, where it can be dealt with. Terada implies in his e-mail that chuui is always operating, flagging some information as important and leaving other information below consciousness (*ishiki-ka*).

In his dissertation, Nishida does not consider attention a function but a limited resource that is used up by conscious action. However, he makes a similar argument to Terada, while adding an insight into how conscious and unconscious action are based in different kinds of circuits. He distinguishes between what I have been calling unconscious and conscious actions as behaviors that pass through "low order" and "high order" systems (*kouji-kei* and *teiji-kei*) in the brain. High order systems are those that compare sensory inputs with stored memories. Nishida writes that for a person to consciously perceive (*chikaku suru*) the information that he or she is currently receiving, it must be compared against prior memories, giving them a basis with which to interpret current information.[28] Conscious perceptions are those that pass through circuits that allow this comparison process.

In contrast, low order systems that deal with behaviors that remain unconscious do not go through this memory comparison process. They simply perform their functions automatically and therefore do not drain the limited "resource" of attention. As such, a person can perform actions that do not leave consciously accessible records in their brains. To understand these, they must observe the result and interpret it afterwards. In other words, self-correction through feedback and comparison with past actions is a fundamental part of high order systems, whereas low order systems cannot be corrected without being raised to high order system processing.

This difference between low order and high order systems, Nishida suggests, is structural. Low order systems are structured "simply and linearly" (in the sense that a cause directly and predictably produces a set effect) as opposed to high order systems, which are made up of "complex overlapping loops" that require interpretation to produce a result. This resembles a discussion from Bateson and Ruesch (1951) regarding self-correction in systems of communication, in which they associate the ability of a system to self-correct to its circuit structure. At the levels of the social matrix they call "group" and "culture" (Bateson and Ruesch 1951, 280-283), transmission can proceed from one sender to many receivers or many to many. In both of these cases, correction of the sender's message by the receivers is difficult if not impossible, because the one has a limited capacity to receive messages from the many, necessitating the messages' abstraction and loss of specificity. In addition, the sender may find it difficult to recognize the origin of the messages he or she does receive, which obstructs the process of self-correction because the sender cannot easily compare the message he or she sent to the response that was received. In the one-to-many case, Bateson and Ruesch further point out that the function of senders tends to become specialized, so that they start to pay less attention to messages that come in resulting in what Nishida called "simple and linear" behavior.

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[28] In the WTL, consciousness is considered to be a recalled memory. See Terada's discussion of human consciousness as a function of memory in section 4.4 for clarification on this point.

To correct errors in these larger systems, Bateson and Ruesch suggest that the networks can be "short circuited," (282-283), bringing a sender and receiver into a closer one-to-one association, so that the sender can directly receive negative sanctions or corrections from a receiver. This corresponds to the "interrupt circuit" mentioned by Terada, through which unconscious processes can be raised to consciousness.

Based on the WTL's account of the fluid relationship between the conscious and unconscious, I suggest that the act of reading ambience cannot be divided into conscious and unconscious masteries of social conditions, as Bourdieu did, but that it can be divided into explicit and tacit readings of ambience. Explicit readings of ambience deal with the aspects of a communication that are ordinarily processed in ways that make them consciously perceivable. Tacit readings of ambience deal with the aspects that are processed automatically and without rising into consciousness. The latter are processed through complex and overlapping loops in high-order systems and the former through simple and linear low-order systems.

Tacit readings of ambience provide people with understandings of behaviors that should pass through one-to-many or many-to-many circuits of communication, in which the behavior of a message sender cannot be easily corrected, or the sender becomes less sensitive to the messages that they receive. Explicit readings of ambience give them knowledge about behaviors that should pass through one-to-one or many-to-one circuits, which allow for mutual comparison and correction of the receiver's behavior by comparison with either one or many senders.

Thus, what I am calling tacit and explicit readings of ambience are not exactly differentiated by what a person is consciously or unconsciously aware of, but by what that person has become habituated to processing consciously or unconsciously. As part of the process of socialization, people must learn which parts of their environment need to be treated explicitly, and which need to be treated tacitly; which need to be joined in a way that allows the imposition of negative sanctions and corrections and which do not; what information is of high priority versus what is of low priority.

The act of reading ambience may therefore be understood as the process through which a human node in a system of communication selects the messages it receives from surrounding nodes to produce outputs that have the correct signal/noise profile for that position in the system. One may think of a person as a node within a network of many possible communication lines of different types, which may include language, bodily practice, and various kinds of physical and perceptual interactions. These are marked in Figure 6 by blurred and unblurred chains of xs, as well as the white space surrounding the reader of ambience, in which further xs are implied. Out of all possible interactions that a person may be involved in at any given time and place, a subset of these (the section marked by the blue arc) contribute to a person's behaviors (the chain x_{s+i}. There is always more than one such chain that results, but I show only one for simplicity.) When this subset leads to expected behaviors, those that provide stabilizing feedback to the rest of the system, then that person can be said to have read ambience successfully. That is, he or she knows what to pick out of ambience in order to produce expected behaviors, and those behaviors became a part of ambience, feeding into subsequent readings of ambience, reinforcing them.

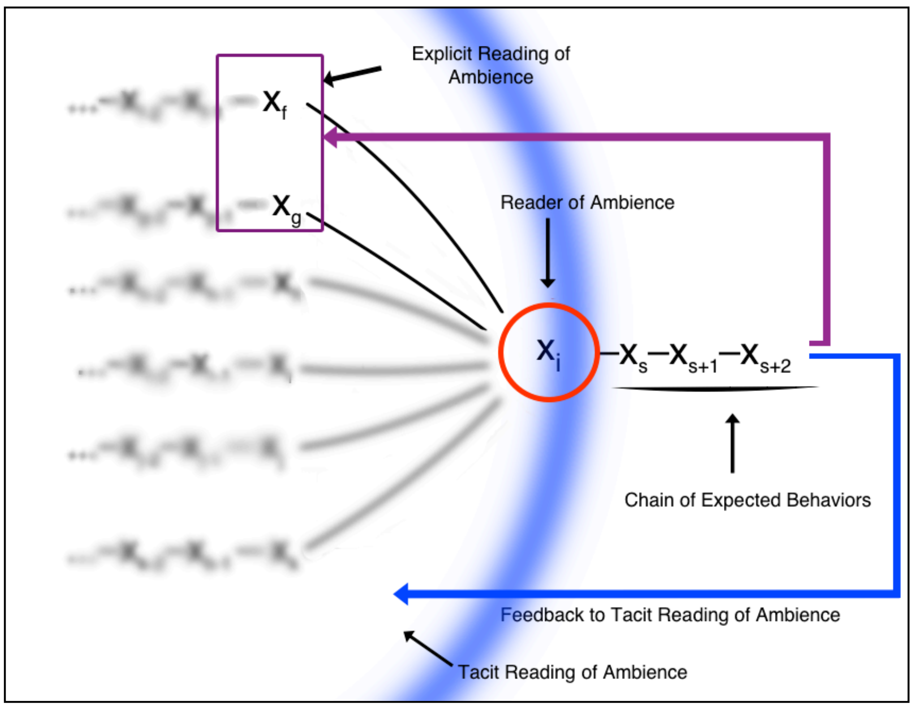

Figure 6. Explicit and Tacit Readings of Ambience

In this schema, an explicit reading of ambience is a further subset of ambience. Out of all of the inputs that a person may receive, only a selection enters into the conscious calculations that a person performs to send a message. A student's explicit reading of ambience will show her, for instance, that in the context of a seminar presentation, she should use verbal communication and the content of her slides to exclusively transmit information relevant to the lab's research. In contrast, the tacit reading of ambience guides her towards an understanding of the assumptions that ordinarily should go without saying: how slide presentations should be organized, how arguments should be presented, what dialect and register of speech to use, how to comport herself, how to dress, and so on. The explicit reading of ambience concerns those parts which make up the signal of a message, while the tacit reading deals with its noise.[29]

In the following section, I use two examples to illustrate how this schema helps us to understand the actions of the lab members. I focus on two events in which students were admonished during seminar presentations, for increasing their seniors' mental loads. In the first case, an M1 student named Uchimura was pushed into silence by an interrogation from the professors and postdocs during a practice conference presentation. Uchimura had demonstrated a failure to properly read ambience by performing a poor presentation, and in the subsequent discussion, became silent in the face of his professors' demands to speak in order to avoid increasing their mental load. In the second case, Wada, another M1 student, was dressed down during a squad meeting by assistant professor Shinagawa and Nishiwaki, his squad's postdoc leader. Wada's case shows the consequences of failing to remain silent, and attempting verbalizations that end up increasing mental load. In response, he used e-mail to write an apology to his squad members in which he acknowledged the inappropriateness of his verbalizations. I show how these students' actions can be interpreted in terms of readings of ambience in a system of communication.

3.5 Reducing Mental Load through Silence

It was mid-September. Uchimura was in the midst of preparing a paper that was to be presented at the meeting of the Virtual Reality Society of Japan in Hokkaido the following week. The VRSJ conference is one of the most important for the lab. The organization emerged out of the work of the generation of researchers previous to Terada's to gather the research done by engineers interested in virtual reality and human interface technologies under one scholarly umbrella. Members of the Terada lab are invariably present at each annual meeting, as are many of Terada's colleagues. All students are expected to have presented in at least one Japanese conference before they graduate, so professors often choose the VRSJ for students to fulfill this

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[29] The tacit reading of ambience concerns what Bateson and Ruesch call "metacommunication": "all exchanged cues about (a) codification and (b) relationship between the communicators." (1951, 209).

requirement. Before a conference, the amount of contact between the professors, postdocs, and students intensifies significantly. Students must practice their presentations repeatedly in front of other lab members, and a practice session with the professors and students in attendance is required at least one week before a conference. Students had to receive the approval of professors before giving the presentation at a conference. If a presentation did not receive approval, practices would be repeated until either the professors were satisfied or the day of the presentation arrived.

Uchimura was readying himself for one such practice presentation. His was to be the second of two presentations that morning. I arrived just before the scheduled 9:30 AM start, and settled into one of the seats surrounding the narrow grey table facing the screen, a compact LCD projector on a raised platform at its center. During these presentations, all eyes, even those of the presenter, were focused on the glowing slides at the front of the room.

All students were required to attend these sessions to pose questions and give feedback to their fellow students, and also so that they could learn the expectations that the professors have for conference presentations. To remind students of this, Shinagawa had sent an e-mail about that morning's sessions on the lab's mailing list. Nevertheless, when I arrived, there were no other students at the beginning of the session other than the two presenting. All four postdocs and the three professors were there to notice this fact.

In another e-mail to the students following the sessions, Shinagawa acknowledged that his expectations of them may not have been clear, and begrudgingly absolved the students for their absence, but he ended his mail with the remark that it was troubling to him that not a single student attended. He concluded his note, "Aren't any of you interested in other people's research?" Students interpreted the e-mail from Shinagawa as an expression of anger and disappointment, but responded to it incredulously. "How am I supposed to know that?" the students said, as they saw the e-mail arrive at their individual computers, but none would ever venture to voice these opinions to anyone other than their fellow students. Nearly all the students attended the lab-wide practice sessions that immediately followed.

The first presentation that morning was by a doctoral student named Ikegami, which went off without a hitch. Ikegami was the only D student in the lab at the time, and had been there longer than even Terada. (He had joined the lab as an undergraduate, when it was headed by a professor who had since retired.) He had given an earlier version of the presentation the previous week at his squad meeting, and this morning's presentation was almost identical, except for some refined content and a few updated charts. As he spoke, he faced the screen, rarely looking back towards his audience. His body was bereft of movement, except for when he gestured towards specific points or charts with a long stick. So intense was his attention on the slides that one would be forgiven for thinking that the breath that carried his words originated not in his body but the slides.

He had rehearsed various versions of the material over the past few months, so this morning, the audience had little advice to give, except for the occasional remark on details of the slides. He was a capable presenter. He had a mastery of his research that reflected his years of experience in the lab, and the clarity and completeness of the slides testified to this. He spoke in careful, measured, well-practiced phrases in the standard "hyoujun-go" dialect that was expected in such presentations, through which he conveyed the material on the slides. He responded to the professors' few questions with lines that were lifted almost verbatim from the lab's papers. The professors were very familiar with his work, and Ikegami was well aware of their expectations.

Then came Uchimura's turn. Immediately, one could sense an air of anxiety come over the front of the room. When he was with other students, Uchimura was often jovial. He was the butt of many jokes in the lab, but the source of many more. He was well liked by the other staff and students, and it was usually his laughter that set the mood in a room. His manner was easy but formal, and regimented but boyish in a way that matched his black crew cut hair, love for baseball, and the playful Kansai dialect he used with his fellow students. But when he was required to present in front of the lab, his face solidified into a pallid, hyperformal expression. He spoke in the standard dialect that was expected in formal academic settings, and had practiced and memorized his presentation script.

The paper he was presenting was on the use of sounds to alter bodily motion, using a sensory phenomenon known as "auditory vection." His experiments investigated whether subjects listening to sounds that rose and fell in pitch while moving their bodies would be induced to move more quickly or over a greater distance depending on the dynamics of the sounds they heard.

Receiving the long metal pointing stick from Ikegami as he took his position at the front of the room, Uchimura held it with both hands between his body and the audience, appearing on guard. He leaned on it throughout the presentation, as if he needed its support. The others in the room were silent during Uchimura's presentation save for Terada, who grunted, laughed uncomfortably, and shook his head to himself as Uchimura gave his presentation. Uchimura, certainly sensing Terada's apprehensions, paused between slides to swallow, and interrupted himself often to catch his breath. End of the summer though it was, both cuffs of his shirt were damp from wiping the steady flow of nervous sweat from his brow.

When Uchimura's presentation ended, there was a moment of complete silence in the room. Uchimura eyed the professors and postdocs anxiously, well aware that he had not met their standards for a conference presentation. Finally, Shinagawa spoke up. "You went over your allotted time," Shinagawa said with a heavy sigh, "but that was the least of the problems with the presentation."

Uchimura was directed to return to his first slide, and the staff's critiques began, line by line and graph by graph. Beginning with Terada, they drilled into his presentation, starting with the most basic questions. What was he trying to argue? What was the purpose of the experiment? Was he doing a psychological experiment on a novel perception, or was he trying to show the effectiveness of a specific method of inducing or guiding bodily motion? Uchimura's intentions, they said, were not clear from the presentation he had just given. What were his baseline results? What was the relationship of this work to previous research?

The questions and critiques did not let up for nearly two hours, and Terada grew increasingly frustrated. With each question, his voice grew louder, and Uchimura seemed to shrink. He was silent for long stretches after Terada's questions, and when he finally did speak, he fumbled for words. An agitated Terada demanded that Uchimura speak up and give any answer at all rather than stay quiet. The discussion gradually came to exclude Uchimura almost completely. Terada, Shinagawa, and Nishida debated what result could be pulled out of the presented findings mostly amongst themselves, with occasional input from the postdocs. Terada questioned Uchimura intermittently, to make sure that he was paying attention to the conversation, but it largely proceeded without Uchimura's voice. When the session finally ended, Uchimura returned to the students' room silently, and sat down at his computer. After the professors and postdocs dispersed, Shinagawa and I took him out for a late lunch, and attempted to comfort him, but Uchimura said little as we ate. Several weeks earlier, Uchimura had joked to me that he had given a presentation in the past, thinking that he had understood what was needed—"wakatta tsumori de happyou shita"[30]—but then, like today, he had been told that his actions had not captured Terada and the lab's plan or intention at all. I would hear later that on the day of his presentation in Hokkaido, Uchimura was revising his slides until the last possible moment.

A few weeks later, I was sitting in on preparations for a different experiment with a pair of postdocs and Shinagawa. Terada came in to check on our progress, and started speaking with Shinagawa about an e-mail from Uchimura. Seeming genuinely confused, Terada asked Shinagawa how Uchimura could sound like he knew what he was talking about in his e-mails, but during presentations and seminars, he can be asked a question and stand in silence for minutes without offering a response. "What is his problem?" Terada asked. After one of Uchimura's practice sessions, Nishida explained Uchimura's poor performance away as "stage fright." But, stage fright only seemed to capture a small part of the reason for Uchimura's silence. Indeed, in the other cases where students were similarly criticized, the professors assigned blame to other factors, like carelessness or inexperience on the part of the students.

Uchimura's silence had far more to do with how his position within the lab structured the forms of communication available to him in the presentation setting. In the context of a presentation, students are expected to communicate verbally in highly circumscribed, that is, predictable and expected ways. As the example of Ikegami's successful presentation shows, when students present their work to their professors, they must reflect back to the professors the answers that the professors would expect themselves to give, if they were in the student's position. The high reliance on prepared scripts and rehearsals, and the numerous cycles of corrective feedback between students and academic staff were designed to ensure that the gap between the two was never too great. In some cases, it could work against the students as well. If they were perceived as simply repeating what the professors told them in a previous meeting or

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[30] The word "tsumori" is key here. As I discuss in Chapter 4, tsumori can refer both to a conscious intention, but also the intention reflected in one's actual behavior as interpreted by a third party. Thus the tsumori that one has when performing an action may not match the tsumori one performs.

conversation, the students would be admonished for their lack of originality, initiative, or commitment, but this was less important for conference presentations than in seminars or research discussions, when there was still time to substantially shape the direction of a project. In presentations, the trick for students was to predict the professors' intentions, and verbally convey these to them with perfect clarity.[31]

If the students' predictions were accurate, then the need for professors to bear a mental load in order for a communication to be successful was minimized. In Uchimura's case, however, his predictions had proven to be inaccurate, and he had incurred negative sanctions from the professors for causing an increase in mental load. His silence during most of the discussion following his presentation can be interpreted as a way to avoid increasing the mental load on the senior lab members by preventing further transgressive verbal statements. Uchimura's silence was an expression of deference to the professors, which he performed also by taking on the burden to correct his own assumptions and future behavior to be more predictable to the professors. After having already been made aware that his presentation had failed to meet the expectations of his professors, any further attempt to actively intervene in the discussion was risky, and may have been seen as impertinent.

[31] I myself had to be cautious when speaking with students about their work. On several occasions, I ventured to offer suggestions for possible research directions to younger students in the meeting room after presentations. Though I was, in many cases, less familiar with the expectations of the lab than they were, because of my senior status, which was performed in part by my venturing to speak about their work, the students strained to integrate my suggestions, never contradicting or opposing my suggestions out right in person, though they were often rightly ignored after the conversations ended. My own position as a person with little experience in the lab could not enter the conversations, because that class of statements would have been transgressive of the lab's ambience.

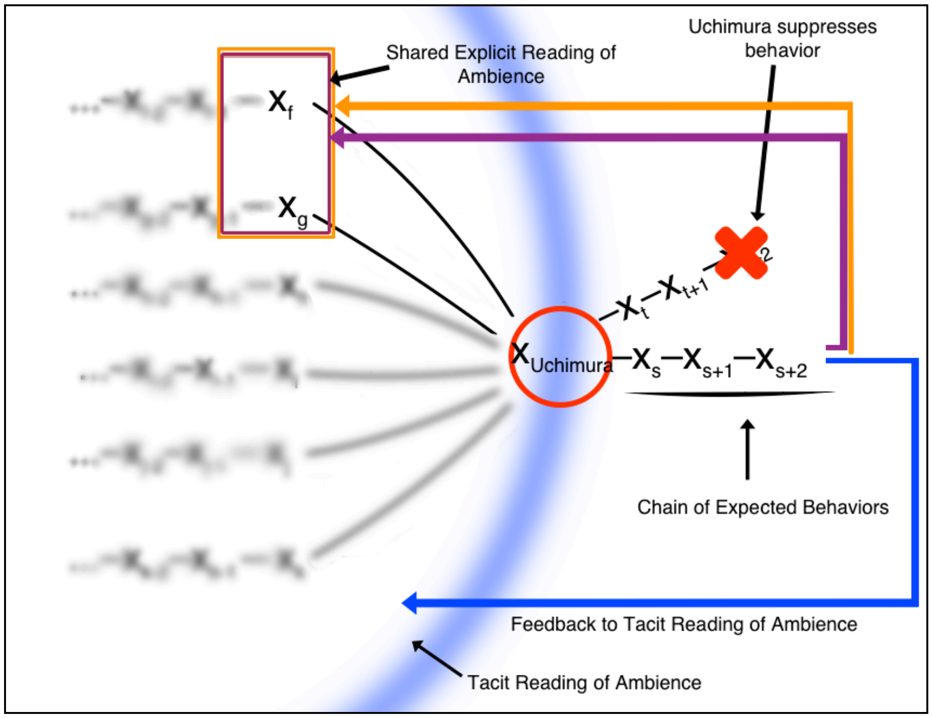

Figure 7. Uchimura's behavior during his professors' corrections. Uchimura suppresses his behavior, and observes the professors to make his explicit reading converge with theirs. Professors' tacit readings of ambience not shown.

Uchimura shared this position with the other students who were or should have been in attendance. Public displays in the lab like the one Uchimura suffered were as much tools for socializing other members of the lab, as they were ways of criticizing and correcting the presenting student. Students were expected to be in attendance at these practice sessions so that they would have the opportunity to view successful and unsuccessful presentations by their fellow students, and experience the consequences of the failure of one of their peers. The professors made it a point to raise their voices and shift to an aggressive register of speech to impress their level of disappointment on the students. Sometimes, the professors would turn towards the silent students in the audience, demanding that they raise questions or offer comments, and questioning their commitment to the lab or respect for the presenter when they remained silent. The regular repetition of such performances renewed the communicative conventions of the lab space. In order to recover from such incidents, students could do little except to revise their presentations, and offer them to professors again in successive practice sessions, reverting to acceptable forms of verbal expression, and recalibrating their sense of the senior lab members' intentions for the lab's research.

For seminar or conference presentations, such as those by Ikegami and Uchimura, the professors have clear expectations for what can be mentioned verbally or in the content of the slides. Students that meet these expectations can be said to have performed a good reading of ambience, in that they behaved in ways that demonstrated an understanding of what requires explicit, conscious attention, and what should remain tacit, or unsaid. Ikegami had mastered this ambience, and the professors reacted with no sanctions against his behavior. His presentation remained a one-to-many communication. Uchimura, on the other hand, had sent them a noisy signal: unclear graphs, confusing logic, and a muddled presentation made it difficult for the professors to focus on his arguments. What should have remained tacit could not pass without being commented on and corrected. When it had become clear that Uchimura was not able to adequately perform the reading of ambience, his professors went on to impose negative sanctions and correct his behaviors.

Above, I mentioned that corrective behavior can require short-circuiting a one-to-many interaction with many-to-one or one-to-one interactions, so that the sender and receiver can more easily compare their behaviors and make mutual adjustments. In Uchimura's case, the interactions in the room oscillated between one-to-one interactions between him, Shinagawa, and Terada, and a many-to-one interaction of the professors and PDs with Uchimura. Terada and Shinagawa's direct engagements with Uchimura began the process of self-correction, but when the discussion came to exclude Uchimura, the process shifted to a many-to-one interaction. As Bateson and Ruesch point out, in a many-to-one interaction, two things can happen. First, the "one" can become specialized in its role as a receiver and become unable to send out its own messages. We can view Uchimura's silence then, as also a result of this many-to-one structure.

Second, because it has a limited capacity to deal with information, the one must go through abstract and simplify the information it receives from the multiple senders in order to be able to process it. Here, we may see that this need to abstract may aid the process of Uchimura's socialization, because it produces a general sense of what corrections that the professors and PDs as a group wanted to impose, rather than any one of them individually.

That little deviation is permitted from the lab's acceptable explicit reading of ambience was even more starkly demonstrated in one of the few moments when a student did attempt to oppose his professors. It came during a meeting of the Integration squad, when Wada was reprimanded for his failure to respond to a professor's feedback. In this case, the student briefly attempted to verbally justify his own actions, but this constituted a challenge to norms about what could be verbalized in a seminar. The attempt was unsuccessful, and Wada, like Uchimura, took actions that served to renew the lab's shared explicit reading of ambience relations as his professors worked to define it.

3.6 Challenging Readings of Ambience

Before this meeting of the Integration squad, I visited Shinagawa at his desk to let him know that I would be attending, and get his approval. That meeting was not scheduled to be one that the professors attended, but Shinagawa was going to appear nonetheless. Nishiwaki, the PD squad leader, suggested that I make sure with Shinagawa that it would be ok for me to be present. Shinagawa gave his permission, but said that he "was going to get angry." At the time, I did not understand what he meant, and I assumed that I had misheard him. I left Shinagawa behind at his desk, and took a seat in the meeting room with Nishiwaki and the other students in the squad, including Wada.

I later recalled an e-mail that Shinagawa had sent to the lab's e-mail list four days before that meeting, directed at students who were submitting presentations to the upcoming Systems Integration conference (SI).

> I don't know who has been checking your papers, but I hope you've had at least a PD looking at them.
> Speaking from my own experience, you need to take your paper to a professor at least three days before the deadline and receive advice. If you can't be ready three days in advance, then you need to approach the professor apologetically ["atama wo sagete", literally, "with your head lowered"] and tell them when your paper will be ready. Even if it means that the professor will get angry with you right before the deadline, you must somehow get their time and have your paper checked.
> If you don't say anything, then no information will reach us.
> If you don't say anything, it means you haven't told us anything about your paper.
> We can't know if anyone has even checked it.
> There's no way any of you should think that you can get away with this. Do you realize that you're working under the name of the Terada Lab?
> This message is not just for the students going to SI. Compared to the past, this year, there is not enough pro-activeness and sense of responsibility [among the students].

> Don't any of you want to produce the best papers you can? [...]
> These aren't assignments for class; it's not enough just to fill the pages.

The text of this e-mail shows that Shinagawa's expectations have not been met by the SI-going students, and elucidates many of the aspects of the social position he expected of students. He explains his expectation that "at least a PD" must have looked at their papers, but doubts that even this has happened. Shinagawa also tells the students that they must think of themselves first as members and representatives of the WTL. The repetition of "If you don't say anything" in the middle of the e-mail and the use of the phrase "with your head lowered" places the onus for the students to seek out the professors for advice, while clarifying that they must act deferentially when doing so. It also highlights the failure of the students to give the professors the opportunity to make any corrections; without being approached by students, the professors had no way to judge the completeness or value of their papers and guide them in the right direction. In the absence of these checkpoints, Shinagawa could only "hope" that the students had someone else looking at them.

Significantly, the reason that a student may have for a delay in approaching a professor does not appear at all in the text, and in a similar e-mail a week earlier, Shinagawa stated more explicitly that the papers must be finished "no matter what it takes." Whatever the personal circumstances of the student that may have contributed to a delay, in the context of the lab, these all were subsumed under the act of "not saying anything" and lack of "pro-activeness and sense of responsibility" of the student that this reflected. Though as individuals, the professors may feel a great amount of sympathy and understanding for *a* student—as when Shinagawa invited Uchimura to lunch—when it came to *the* students personal factors were irrelevant. The professors' expectations were to be met. If not, their lower status required the students to take on the burden of seeking out corrections.

In spite of Shinagawa's cryptic warning, the early afternoon meeting of the Integration squad began as normal, with each student discussing their current progress to their PD in turn. It started with a presentation of research from Toriyama, an undergraduate student, which was followed by a long conversation between her and Nishiwaki about the next steps for her to take. During this time, Wada and Uchimura sat by with their computers open in front of them, alternately following the conversation and working on their projects, contributing little to the meeting, except when explicitly called upon by Nishiwaki to ask a question. She was followed by Uchimura, who went through the same steps as Toriyama to discuss his current work. This was a few days after his failed practice presentation, and he explained that he had not had enough time to integrate all of the professors' suggestions. Nishiwaki let this pass and Uchimura's time on stage ended uneventfully.

Near the end of Uchimura's time, just over two hours into the meeting, Nishiwaki stepped out of the room abruptly, and returned with Shinagawa in tow. Shinagawa silently took a seat at the corner of the table next to me and across from Wada. Wada's presentation began. Nishiwaki called on him to begin with an explanation of the status of his submission to the SI conference, whose submission deadline had passed over the weekend. Wada had not yet sent his paper to the conference organizers.

Wada went through the suggestions that he had received the previous week point by point, showing how he had or had not been able to make use of them. Wada spoke carefully, slowly, and formally, keeping his eyes focused on his computer screen or the slides projected at the front of the room. Just six minutes later, his presentation was over. Nishiwaki confirmed with Wada: "Is that all?" Wada answered with a simple "Yes."

Finally, Shinagawa spoke up. "I don't understand a thing you said." He paused for several seconds before speaking again. "How did you take the suggestions from the last week and put them in your paper? What conclusions did you reach?" Wada returned to his slides, and began repeating a section of the presentation. When Shinagawa mentioned an instruction that Wada had received earlier to recalculate some of his results, Wada again referred back to his presentation. They went back and forth several times, with Shinagawa pointing out another area of vagueness, and Wada rebutting, starting each time by saying, "As I mentioned in my presentation..." Shinagawa, growing increasingly annoyed, asked to see the raw data, which Wada agreed to bring him after the meeting.

Nishiwaki then asked Wada about comments on the paper that he had sent by e-mail the day before. He had received no reply from Wada. "I told you that the abstract was no good as it was, verbally. What happened after that?" As the conversation unfolded, it became clear that Wada had been the subject of Shinagawa's earlier e-mail. The previous week, Wada had submitted a draft of his paper to Shinagawa and Nishiwaki, in which the discussion section was incomplete, graphs were mislabeled, and the abstract was unfinished. Shinagawa and Nishiwaki both returned the draft to Wada, telling him that it was too partial to provide any feedback on, and to finish it and return it to them as soon as possible. Wada had provided another version two days later, but few changes had been made. They demanded to know why he had failed to approach them or provide them with a complete draft for the rest of that week.

"If you had shown me what points to fix," Wada said to his professor and squad leader, "I would have fixed them." Almost simultaneously, Shinagawa and Nishiwaki lashed out at him. "Are you joking?" Nishiwaki shouted, pounding the table with his fist. Wada paused to take a deep breath and rub his eyes before he answered. He tried to defend himself by saying that he had stayed up all night, and that the paper was as complete as he could have possibly made it. This excuse seemed to anger Nishiwaki further. Nishiwaki demanded that Wada describe how much time he had spent on the paper. "What kind of life have you been living? Prove that you did your best, because the paper doesn't show me that you made any real effort. When did you start writing?" Wada hesitated to answer. Nishiwaki persisted. Wada attempted to direct the question away from any concrete discussion of his activities over the past week, and returned to the issue of the professors' corrections. "You didn't like *how* you were told, so you decided not to do anything at all," said Shinagawa. "It's disrespectful," he continued. "It's not the way to do things. Don't you feel any remorse?" Shinagawa went on to repeat many of the points from his e-mail. "This is common sense. This paper is going out into the world. It's not the same as something that stays inside the lab." Wada finally responded with a simple, "I understand", ending Shinagawa and Nishiwaki's twenty-five minute long interrogation.

The entire time, Uchimura faced downwards and Toriyama sat looking at the wall in front of her, neither of them making eye contact with anyone else, but understanding that they were expected to experience the escalating situation. When the seminar finally ended, we all left the room to return to our desks, but Wada sat in the meeting room alone for another thirty minutes.

During that time, he was writing an e-mail to the people who had been in the squad meeting that day, which he sent out a short time later.

> I want to start by apologizing for the inexcusable things that I said in a space of discussion ["*giron no ba*"]. I am truly sorry.
> I knew that what I was saying was childish, but both my research and my private life have been difficult recently, and I ended up saying things that I regret.
> Last weekend, I was away attending memorial services, and worked from late

> Sunday until Monday night. When I was then reprimanded by Nishiwaki-san, I was too exhausted to make prudent judgments, and I became more anxious and worried than was necessary.
> I understood the burden on the professors, and I know that it was me who was in error, but I was unable to contain my anxieties, and ended up verbalizing them [“*kuchi ni dashiteshimatta*”. Literally, “[I let the anxieties] leave my mouth.”]
> This time, I not only embarrassed myself in front of my professors, but also my colleagues and junior students, but the result has been that my ill feelings have disappeared, and I now feel clear and replenished. If the meeting today had not happened, I would have continued holding my resentment, and so I carry no ill will from the meeting. I am deeply grateful to my professors, who have guided a person as immature as I am, and to my fellow students, who have been kind even though I have been selfish.
> To all of you, on whom I have been a burden, I will approach you to apologize when my emotions are in order. I would ask that you continue to interact with me as you have in the past.

Wada’s apology in this e-mail focuses not on the shortcomings of his work on his paper, but on his transgressive speech acts. He expresses regret for saying childish things, and verbally expressing his anxieties, which are inappropriate for a “space of discussion.”

The primary error that Wada identifies is that he allowed personal affairs to interfere with his judgment over what constitute appropriate statements in the seminar, resulting in a “burden” on his professors and fellow students. These were signs of selfishness, and at the end of the e-mail, he makes clear that he understands that it was he who was the burden. By expressing his embarrassment and recognizing his own “immaturity,” Wada places himself in the role of the novice who has failed to live up to the expectations of those more adept. Ending with a declaration that he now feels “clear and replenished” and a request that his colleagues not change their behavior towards him, Wada’s e-mail renews his commitment to communicate in the lab’s expected forms, thereby reaffirming the relationships between him, the professors, and the other students.

Whereas in the seminar Wada came close to but ultimately resisted mentioning the actual activities that led to his late submission, in the e-mail he permits himself to refer to difficulties in his “private life” and his attendance at “memorial services”—likely a funeral for a relative. If he had mentioned these circumstances during the seminar, it would have constituted an attempt on his part to alter the explicit reading of ambience, and the norms recognized within it. Invoking his obligation to his relatives in the one-to-one interactions with Nishiwaki and Shinagawa would have immediately implied the question of whose reading of ambience was to be corrected,

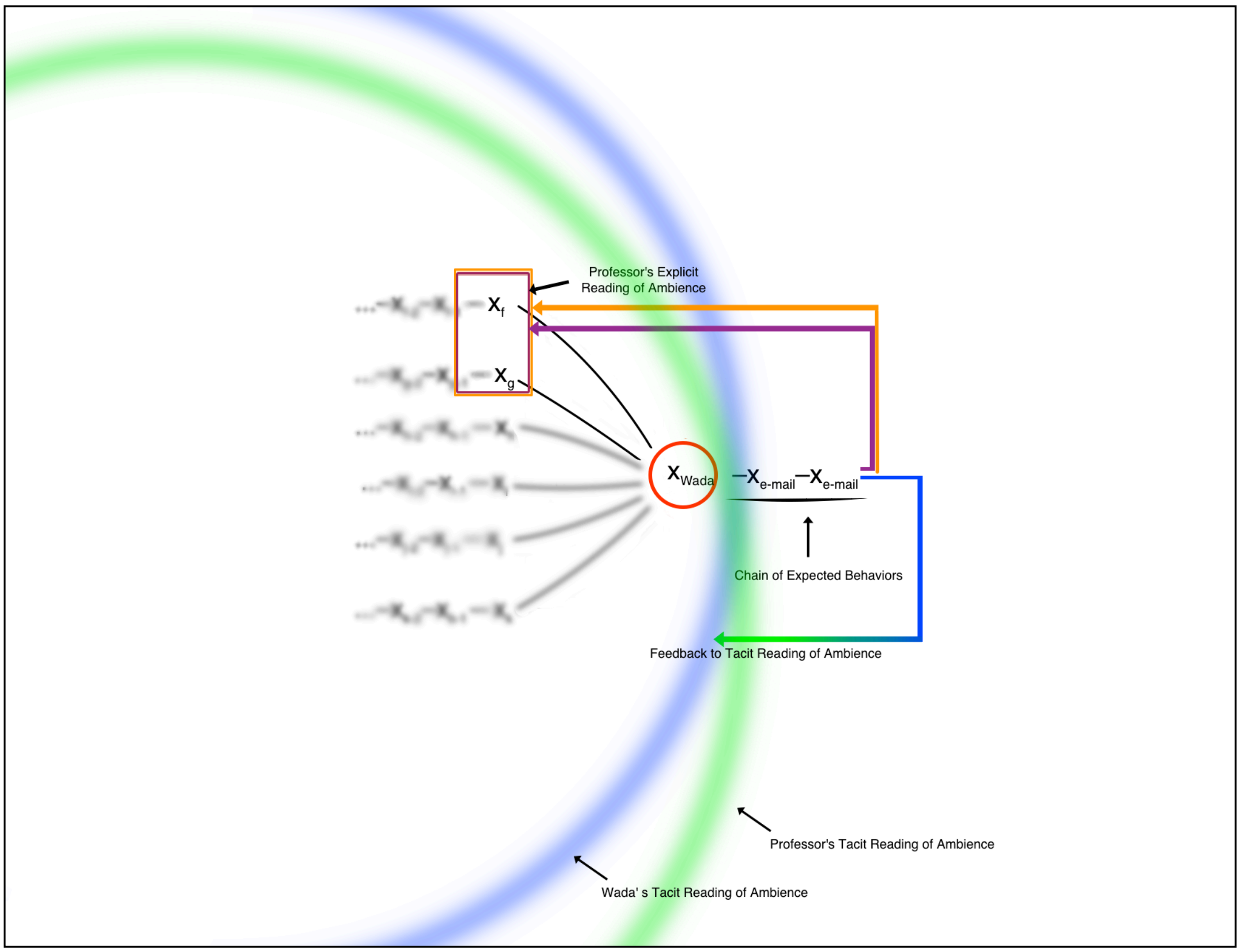

Figure 8. The e-mail allows Wada to share his professors’ explicit readings of ambience, while altering what can go into the tacit readings (Professors not shown. Only one professor’s tacit reading is shown).

and would have placed the professors in the awkward position of having to weigh Wada’s obligations to his family against those of the lab. They undoubtedly would have understood

Wada's behavior, but to have to do so in the seminar would have destabilized the boundaries of the lab as a social unit, and threatened their explicit readings of ambience. By ultimately refraining from mentioning this in the meeting, Wada was attempting to reduce the mental load on the professors.

In the context of the e-mail, however, a brief reference to the memorial services was acceptable. E-mail was often used in the lab to convey messages that would have been out of place in more direct, verbal situations. It was the preferred means, particularly among students and between students and their superiors in the lab, for stating direct requests (such as payment for lab activities, attendance at meetings and practice presentations, or to correct some inappropriate behavior). Such requests were often directed to the lab as a whole or students as a group, even when it was one or a few students that were actually the intended receivers. This had the effect of implicitly addressing all students, which was useful as a means for group socialization and of shaping the ambience of the lab, but it also gave students some latitude to disregard any single e-mail as irrelevant to him or her as an individual, which led, for example, to the students' poor attendance at Uchimura's practice presentation. They could receive an e-mail without directing their attention towards it. Similarly, as a one-to-many communication, Wada's e-mail did not require a response, allowing the professors to avoid attending to it and maintain their explicit reading of ambience.

Professors, though they did not shy away from direct confrontation as the above shows, also preferred to express misgivings, apprehensions, and demands to students through e-mail first. For instance, Shinagawa's punishment of Wada came only after a series of three e-mails over the previous three weeks, which each contained the same basic message as his verbal confrontation that day. Though the message was the same, when it was distributed by e-mail it became less adversarial and immediate. It was only when the message failed to capture Wada's attention after several attempts that Shinagawa stepped into the seminar room and directly addressed Wada, "short-circuiting" (Bateson and Ruesch 1951, 282-283) the group's usual communication channels to ensure that he had been understood.

Wada's e-mail apology reveals a paradox that students in the lab must negotiate. He and the other students face strong pressure from senior members to act in expected and predictable ways that reflect their commitment to being members of the lab. This is effected through social and material practices, such as the negative sanctions that Uchimura and Wada experienced, that required them to minimize professors' mental loads, and therefore bring the students' explicit readings of ambience more in line with their own. At the same time, because of the hysteresis effect, the students' tacit readings of ambience can never be made to precisely coincide with others'. The disjuncture between the two requires students to learn to suppress their attachments to family and other areas of life outside the lab from verbal communication in lab settings such as the seminar. This is the source of the "anxiety" that Wada mentions in his e-mail.

To cope with this, the members must deprioritize them and remove them from the signals of the lab's ambience. Hence, while it was clear to everyone present that Wada's life consisted of more than what could be recognized in the seminar, when he was challenged to verbalize them, he refrained from doing so, and in his apology, he specifies it was his mistaken judgements about what could be verbalized in the seminar that had caused offence and imposed a burden on others. Similarly, the requirement on all of the students to make their presentations mirror the intentions and expectations of the professors, and the constant demands placed on students to act not as individuals but as elements of the Terada Lab embody this tendency towards making their explicit readings of ambience coincide.[32]

Moreover, perfect coincidence is undesirable, as it was for the junior high school principal who did not want his students to become mere fence sitters. An M1 student named Yamanaka produced a particularly effective illustration of the undesirability of total identification with the lab. In December, the M1 students, most of whom were not planning to pursue doctorates immediately, were in the middle of the corporate recruiting season. They were frequently absent attending company recruiting events and job interviews. I often saw them browsing websites such as "MyNavi" and "RikuNavi," which carry recruiting information and advice for students in their position. Yamanaka had encountered online news articles and blog posts expressing a negative reaction to one of MyNavi's ads. The ad consisted of the MyNavi logo and motto, surrounded by a border of photographs of 20 men and women of recruiting age. The photos were face shots of the kind required on the resumes applicants submit to be considered for a job opening; they all wore the standard "recruit suit"—a black suit with a white

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[32] This pressure applies to professors as well. Both Shinagawa and Nishida mentioned to me separately about how they feel constrained in pursuing their own work because of their membership in the WTL.

shirt, plus a dark tie for men, except that each had their right hands poised beneath their chins in the manner of Rodin's Thinker (the motto was "For all the thinking student jobseekers.")

The ad had garnered a negative response, Yamanaka explained to me, because all of the students looked practically identical, allowing for no individuality. One blog described how Twitter had erupted with posts calling the ad "revolting." The ad had seemed particularly troubling to these posters because the recruiting season marked the transition of students into adulthood. The ad's implication that students had to lose their individuality and conform to a single ideal to become adults had induced the negative reaction.

To parody this, Yamanaka created a version of the ad entitled "TeradaNavi—For all the thinking students." His version replaced the faces of the jobseekers with Uchimura's face, to present the idea of a lab that did not permit the individuality of the students as similarly revolting. Yamanaka's graphic showed that it was because every member in the lab was different, that they were not all the same uniform "self" there, that the lab could function. We can also recall the contradictory demand made of students in the "Preparedness" web page, which told them that they must both mimic their superiors, but judge when to mimic them would go against the needs of the lab.

This shows that even though two people may share an explicit reading of ambience, this does not mean that their tacit readings of ambience coincide as well. In other words, different tacit readings of ambience may be joined to the same explicit reading—different kinds of "noise" can maintain the same "signal". But where two people already share similar tacit readings of ambience, negative sanctions on explicit readings tend to push their tacit readings to converge as well, because the scope for a person to change tacit reading is limited by the hysteresis effect.

This presents a dilemma to members of the lab. On one hand, they lived among various negative sanctions and corrective mechanisms that worked towards making their explicit readings of ambience match those expected by the professors. On the other hand, they resisted the total coincidence of their tacit readings, because it is both theoretically impossible and practically undesirable. Because these two readings are joined by the function of chuui, it is difficult to make one's explicit reading match the lab's while maintaining some uniqueness in one's tacit understanding.

As a result, there are ways to channel aspects of one's tacit reading of ambience into behaviors that do not increase mental load in the lab, but allow them to be maintained. To do so, lab members relied on two strategies. The first was to clearly spatially and socially separate their non-lab activities from the lab. Members took various measures to harden the lab's boundaries from the outside to prevent inappropriate behaviors, relationships, or obligations from being expressed in the lab. Professors who were married with children, for instance, would not bring their families into the lab, unless they were reasonably certain that few other people would be there. Several members of the lab had become couples, but they never made any mention of their relationships or displayed any hint of affection for each other within the lab. This was to the extent that, when a marriage between a recently graduated student and one of the lab's administrative staff was announced, the students were caught by surprise. By clearly separating the inside of the lab from the outside, their uchi from the soto (Kondo 1990), these members could limit their behavior in the lab to that which conformed to its explicit reading of ambience.

Most of the students, however, lived alone near campus and spent the majority of their waking hours (and some of their sleeping hours) at the lab. For many of these students, clear isolation of the lab from other areas of their lives was more difficult to maintain through spatial and temporal separation. Thus, as an additional strategy, these students found ways to express within the lab and, in some cases, have recognized by other members, the attachments each of them had to things that belonged outside of the lab. That is, they found ways of maintaining aspects of their own readings of ambience that did not easily fit within the lab's shared reading. Wada's use of e-mail to mention his family obligations is one example, which shows that mediated or otherwise indirect methods of conveying such information exist.

What these methods do is exploit the gap between explicit and tacit readings of the lab's ambience. They maintain the explicit reading of the lab's ambience that the members share, and act through their tacit readings in ways that do not incur negative sanctions. These methods do not raise mental load, because they do not directly alter the prioritized signals in the lab. They modify the noise, making space for students to maintain rather than have suppressed the aspects of themselves that might not otherwise fit the lab.

3.7 PowerPoint

As I have discussed, there are strong constraints on what can be verbalized in the lab without being received as transgressive, which can lead to corrective action by PDs or professors. This is linked to an obligation on students to minimize the mental load of their professors, which requires them to be mindful of and adaptive to the times and places where the professors are available, and to communicate the content of their research to them as clearly and directly as possible. Finally, recall that there are forms of communication in the lab that were directed towards the lab at large, rather than a single sub-group or individual, namely, electronic media, primarily e-mail but also the web, such as the lab's "Preparedness" webpage, which could be used to issue requests, reprimands, or mentions of non-lab attachments, as Wada did. Given these conditions, one would expect such a medium to be, 1) electronic; 2) appropriate in situations where all lab members would be present; and 3) directed at no individual in particular. Such a medium would not directly challenge explicit readings of ambience or increase mental load, but would allow the subtle expression and maintenance of aspects of a student's tacit readings of ambience that do not precisely match the lab's shared reading of ambience.

One medium that satisfies all of these conditions is the PowerPoint presentation. In many areas of academia, slide presentations have supplanted other forms of public document. In Japan no less than North America, electronic slides projected onto large screens are integrated into the design of new classrooms and old facilities are jury-rigged to facilitate their display in some form. At conferences and workshops, both presenters and audience members focus their visual attention on the slides, and lab members rightly look upon them as an extremely important means through which to display their work. Slides are passed around by e-mail among the lab members for revision and comment numerous times before any conference or presentation, and numerous versions of all of the lab's presentations are archived on the lab's file server. In the WTL, students are presented with guidelines for creating effective presentations, and are trained in the design of PowerPoint presentations as part of their professionalization.

While slides are almost always produced for major presentations to external audiences, students create many more for frequent internal presentations. Whenever a professor is in attendance, a slide presentation is mandatory, but they are also nearly always used for smaller presentations within squads as well. They facilitate the visual presentation of graphs, tables, and other complex information, and professors assessing a student's progress will spend hours gazing at the slides they have produced to gain purchase on the research that the student has performed. The students prepare for this level of interrogation by preparing countless other tables and graphs of data, which they place in dozens of slides after the presentation set, to which they will refer if needed. I often sat by as students worked late into the night on their slides. It is work that is quiet, solitary, and which seemed to end only when the actual presentation began.

Students used PowerPoint presentations to demonstrate their understandings of their own research and mastery of the expected forms of communication, but they were also often used for purposes similar to Wada's e-mail: to convey in an indirect way, aspects of the self that could not be completely encompassed by the lab. The slides were a means for making room in the lab for those parts of themselves that students wanted to maintain, but faced suppression if they were expressed in other ways. Students used PowerPoints to present messages that would have been difficult or inappropriate to explicitly raise in the lab, especially in front of professors. They expressed the attachments that the students maintain to life and the passage of time outside of the lab, to their personal non-research interests to which they can only devote a small amount of their energy, and to the pressures, stresses, and anxieties associated with being a part of the lab.

They did this through the graphics, backgrounds, and hidden features in their slide presentations. The students spent an inordinate amount of time on the visual appearance of the slides crafting graphics and animations. The students looked at this design work as respite from the tiring labor of writing the presentations themselves. They rarely used the software's built-in templates or the lab's standard format, which was used for external presentations. What might easily be dismissed as window dressing superfluous to the research content of the presentation was in fact a way to allow students to place aspects of their selves disallowed by other means of communication in front of the professors' eyes, without demanding a response from them. These aspects of the slides deftly negotiated the affordances of the lab to allow the presentation of otherwise problematic or disruptive information in a form that would not raise others' mental loads and result in negative sanctions.

Wada was most respected by the other students for the skill with which he crafted his presentations, and he used this ability to add unmistakable signatures to his work. On a slide explaining an experiment for measuring eye movement, he placed an intricate animated representation of a subject with eyes moving back and forth in time with the flash of little thunderbolts indicating electrical stimulation. In another presentation, Wada placed what appeared to be randomly scattered lines about the bottom of his final slide. When the presentation file was edited, the lines could be stretched into a dozen pictures of Pikachu, his favorite Pokémon character. Not all of his touches were as subtle as these Pikachus, but they were all in plain sight to everyone in attendance. If they were hidden, one of the other students would discover the secret, or Wada himself would reveal it, and the students would rush to their own computers to download the presentation from the lab's server to find it for themselves, acknowledging Wada's cleverness as they did so.

Wada's Pikachus are part of one category of slide that integrated things of personal interest to the presenter into the visual motifs of the slide presentation. They could be subtle, like Wada's Pikachus, or overt, such as the intricate graphics of a robot an M1 student named Yamanaka created for a presentation, which he modeled after characters in his favorite animated series. In another of his presentations, Yamanaka hid a small picture of Uchimura in the background of one of his slides, which he revealed to the students after the seminar to great laughter. In another presentation, Yamanaka began with the image of a silhouetted young girl running with a piece of toast in her mouth. In the corner of every other slide, in the background of the slide number, was a piece of toast with pink hearts surrounding it. These are references to a common trope associated with Japanese comics written for young women, in which a schoolgirl running late to school with her breakfast in her mouth turns a corner and unexpectedly collides with the boy who will become the object of her affection. For Yamanaka, it was a fun way to express the idea of technologically induced *ittai-kan* (the feeling of oneness) that was his research theme.[33] Terada was often a fan of the same series, so when he recognized such references, he would comment on them during seminars. This verbal acknowledgement was permissible here because it was initiated by Terada, and could therefore not be easily regarded as transgressive.

Another category of slides contained visuals that showed significant dates or the changing of the seasons outside of the lab. As discussed above, the temporalities of the lab were

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[33] See Chapter 6 for a discussion of ittai-kan.

multiple and largely disconnected from the flow of time outside. Conference deadlines, thesis submission dates, and meeting and cleaning schedules dictated the timelines on which the students worked. But students would use their slides to reference temporalities outside of the lab. For example, November 11, 2011 (2011/11/11) was declared by food manufacturer Glico as "Pocky Day"—the numbers in the date resembled the Pocky chocolate covered cookie sticks they manufacture. Both students who presented in the lab seminar on that day referenced Pocky Day in their opening slides, one overtly by taking images from Pocky advertising, and the other more subtly, by including Pocky Day among a massive list of the other things, both major and minor, that were being celebrated that day (November 11th is also Peanut Day, Nagano Mushroom Day, and Soccer Day). Set in tiny type, these dates appeared as part of the colorful geometry of the slide background. During the height of typhoon season in Japan, another presentation began with a satellite map from a weather website showing the projected path of a typhoon that was then approaching Okinawa, accompanied by a drawing of a tree with its leaves being blown off by a strong wind.

The third category of slides is one in which students made their worries and anxieties most evident. These contain images or messages that reference the toll of working in the lab on the student's emotional or physical state. A presentation by one M2 student did not include any images on its first slide, but carried at the bottom edge the text: "These days, when I wish I had four heads and eight arms." A slide produced by an M1 student showed an image of a sleeping cat in the corner, while in the center was a picture of the back of a smartphone with the message, "But I'm so sleepy" written on it. Another by the same student shows a small rodent-like cartoon character running in terror from a series of random English letters. At the time, that student was planning to use random letters as the visual stimuli for a psychophysical experiment.

The third example was created by Uchimura for his first presentation to the entire lab since his disastrous series of practice presentations. His first slide showed the simple title of the presentation in large red letters, with the subtitle: "The beginning of the second half of the year, and the end of my [or our] life." Behind the red text was the faint monochrome image of a sign displayed near a "suicide point," an area where a high number of suicides occurs in Yamanashi prefecture near Mt. Fuji. The text on the sign read, "Your life is a precious gift from your parents. Please think calmly about your parents, siblings, and children. Don't suffer alone. Please talk to someone." The sign includes the phone number for a suicide prevention office at the prefectural police department. The image was only displayed in front of the professors and staff for a moment. It was followed by a different slide with a subtitle more descriptive of his research, which was shown as Uchimura waited to start his presentation. Uchimura's slide was a striking expression of the competing obligations of family and lab, and the pressure that the lab placed on him to suppress his attachments to family. The lab pushed him to work in a way that evoked his own death; the thought of his family kept him on this side.

Notably, the student presentations that conveyed the messages that expressed the students' negative feelings and posed the most direct challenges to the lab's reading of ambience, appeared only in those presentations for lab-wide seminars, where all members of the lab would participate. This was because in the smaller squad meetings, at which only a PD and fellow student squad members may be present, these presentations would not have been a one-to-many message, which any individual member would be free to ignore, but a one-to-one message from the student to the PD. In such an interaction, the message would have demanded the PD's attention, setting off a process of mutual correction, putting the student in the same predicament as Wada during his confrontation with Shinagawa and Nishiwaki.

Though they differ in degree and intent, slides in each of these categories were ways in which students were able to express statements that would have been difficult or inappropriate to raise in the lab explicitly, particularly in the context of a seminar presentation. They represent attachments that the students maintain to the world and aspects of themselves that could not be expressed in the lab in other forms. These messages were not addressed directly to other members of the lab. They were mediated and indirect; but they made use of the characteristics of PowerPoint slides, a central means of research communication in the lab. The students' creative use of their slides reflects a careful reading of the lab's ambience, and its subtle manipulation to serve ends that were less publicly recognized or acceptable. The fact that students used such means without inducing a senior member to correct their behavior demonstrates that their ability to read ambience is cultivated and that they have been able to take advantage of a medium that can introduce extra-lab attachments without increasing mental load. They subtly altered the tacit aspects of ambience, changing the noise to modify the signal. In this way, they navigated the gap between their tacit readings of ambience and the lab's explicit reading of ambience to perform behaviors that would let them maintain a sense of themselves as people not completely defined by the ideal that the lab demanded.

From the students' actions in seminar to their use of PowerPoints, the above examples suggest that the act of reading ambience can be understood as the process by which a node becomes part of a communication system in a way that allows it to be completely subsumed by that system. As I discussed in Chapter 1, two systems that act with perfect predictability in relation to each other can "disappear" behind the image of a single system. The act of reading ambience makes a human node a part of the communication system of the lab in a way that contributes to that system's stability, but it also leaves room for that node to maintain some level of distinctiveness within the system. This can occur because a tacit reading of ambience—the node's contribution to the system's noise—may be different from the pre-existing noise of the system, but it cannot be corrected directly, provided that it does not interfere with the signal, or the explicit reading of ambience.

3.8 Conclusion

In this chapter, I began by asking, if human-centered technologies are technologies that humans can interact with "naturally" as though they were interacting with other human beings, then what do HCT researchers consider "natural"? As I have shown, such "natural" interactions are predicated on the participants being able to "read ambience."

The lab's concept of mental load and its members' understandings of the nature of human consciousness and unconsciousness show that reading ambience is understood as an act through which a person becomes part of the lab's system of communication. I expanded this insight to argue that reading ambience consists of two conjoined acts: an explicit and a tacit reading of ambience. An explicit reading of ambience guides lab members towards performing predictable behaviors that will not increase others' mental loads. At the same time, lab members draw on a much larger body of knowledge accumulated over their lives in order to generate their behaviors, their tacit readings of ambience. Explicit readings can be understood as those that contribute to a person's understanding of what the signal of a message should be, while tacit readings feed into their understanding of what can be treated as noise. The border between explicit and tacit readings of ambience is determined by "chuui" or attention, which acts as a priority flag marking information that should be processed consciously from that which can remain tacit.

Explicit and tacit readings of ambience are further distinguished by the structures of the circuits through which they are performed. Behaviors based on explicit readings of ambience tend to be enacted through one-to-one or many-to-one circuits, which facilitate the mutual comparison and correction of the participants' behaviors. Tacit readings of ambience produce behaviors that pass through one-to-many or many-to-many circuits, which make it difficult for senders to make corrections to their own behavior, and also free receivers to ignore specific messages. If a person's behavior is based on a variant explicit reading of ambience, he or she may perform an unpredictable behavior that draws the receivers' attention, increasing their mental load. To correct these behaviors, as in the cases of Uchimura and Wada discussed above, participants may reconfigure communication circuits into structures that do allow for correction and the imposition of negative sanctions.

While the lab's social mechanisms work to make its members' explicit readings of ambience converge, their tacit readings cannot be corrected directly and do not immediately necessitate a comparison between divergent readings. They therefore offer an avenue to the lab's members to behave in the lab in potentially disruptive ways without incurring negative sanctions. In the last part of this chapter, I discussed how students use e-mails and PowerPoint presentations to send messages that subtly transform tacit readings of ambience without challenging the lab's shared explicit reading.

The discussion in this chapter has demonstrated that the HCT researchers view social interactions among humans to be a system of communication, in which systems become able to work well with each other by reading ambience. Through their social practices, the lab members come to see the act of reading ambience as essential to natural and smooth interactions with humans. This understanding informs how the lab designs human-centered technologies, but to create such technologies requires them to develop a clearer picture of what kind of system the human itself is.

Chapter 4
Tsumori

4 Introduction

How do human-centered technology researchers experimentally determine what kind of a communication system the human is? In this chapter, I discuss how HCT researchers develop an understanding of the human communication system through experiments that focus on the human body instead of its conscious intention as the key to understanding how humans behave. To do this they use reverse engineering techniques that (1) are premised on the idea that the human is a system of communication, whose interface with its surroundings is the body, and (2) focus on the body as the source of intentional behavior in this system. Their experiments show that the body defines the human as a specific kind of communication system that is different from other communication systems, such as machines.

I establish this argument by focusing on how the WTL focuses on a human's *tsumori* as the expression of its intention. Tsumori is a Japanese word that is commonly translated as intention. It contrasts with another word for intention, *ito*, which refers to the conscious understanding a person has of his or her own intentions. Tsumori refers to both what a person explicitly intends and to the intention that they tacitly express to others through their behaviors, which can differ from the conscious, explicit intention. Tsumori always implies a possible lack of correspondence between the intention of which a person is conscious and the intention that others interpret from their behaviors. Where there is a gap, it is the latter that is taken to be the person's "real" tsumori. The lab's focus on tsumori as intention illustrates how they do not locate the origin of human action within a person's mind, but find it in the relationship or interface of the human with its surroundings.

To determine how a human interfaces with its surroundings in ways that reflect tsumori, the researchers try to reverse engineer and reproduce the process through which humans spontaneously produce a behavior in response to some stimulus. Reverse engineering is an engineering practice in which a finished product's behaviors and structures are analyzed to produce a copy or model that can mimic the functions of the original. When the lab applies this technique to human behavior, reverse engineering becomes a way to translate the circuits through which a human being interfaces with its surroundings into a technological form.

The lab's use of reverse engineering on the human being is possible because of several assumptions about what they consider the human to be, and how humans and machines are similar or different. Most obviously, it shows that the researchers view human beings as a system of communication similar to machines. I explain this by discussing the use of cybernetic ideas and computational metaphors by Terada, the WTL's head professor, who articulates an understanding of human beings as functionally equivalent to electronic systems of communication.

The difference between human and machine systems then lies in the particular way that they establish relationships between input and output signals. Drawing on concepts from computer science, I argue that the difference between human and machine systems of communication lies in the way that they differently encode information from their surroundings. That is, they work on different forms of signal and noise.

As I argued in the previous chapter, the relationship between signal and noise is established by a reading of ambience. Therefore, in order for a machine to be able to predict a human's tsumori, it must share its explicit and tacit readings of ambience. By analyzing the lab's experimental practices, I show how they accomplish the convergence of the human and machine's tacit readings of ambience by both closing and constraining the social practices surrounding them and by restraining the body of the human subject. The experimental restraints placed on the human subject's body show how it is not only the social context of an interaction that enters into a reading of ambience. The bodies of the human subjects themselves are a reading of ambience.

This chapter shows that, if the HCT researchers consider the human as a system of communication, then the human's material body is an essential part of that system. Furthermore, it shows that conscious intention is not the source of action, but is an output of the human system of communication. This suggests that for HCT researchers, the conscious mind is not separate from the body but entangled with it, in the way that a bodily behavior cannot be separated from the body that performs it.

4.1 The Laws of Tsumori

Tsumori is an exceedingly common word in Japanese, but it seems to strike even native speakers as somewhat peculiar. When I first asked Ikegami and Uchimura, two graduate students in the lab, what tsumori was, they looked at each other and laughed uncomfortably. Tsumori had become a keyword in the lab ever since the head professor, Terada, had come upon the idea a few years earlier. Tsumori can be translated into English as "intention" or "belief", or "plan" depending on the context of its use, but these words seemed to fail to capture something important. Ikegami and Uchimura began by trying to explain the common meaning to me.

Across its many and versatile uses, tsumori always seemed to have two sides. Ikegami told me that tsumori was about how a person acts based on their belief about their situation, which may or may not be accurate. If a person believed that he was helping another, but his actions ended up causing that person harm, then the first person would be said to have had the tsumori to help. Uchimura compared one's tsumori to Schrödinger's Cat, a thought experiment from quantum physics that is used to explain the indeterminacy of quantum phenomena: one may believe that the cat inside a closed box is dead or alive, but the cat is not in either state until the box is opened and it is observed. Similarly, one may have a belief about what one's tsumori is, but one cannot know exactly the state of one's tsumori until afterwards, when the action and its effects are known. This is what he meant when he spoke about a previous failed presentation: *Wakatta tsumori de happyou shitara chigau to iwareta*—I presented with the tsumori that I understood [what I was doing] but when I did so, I was told [by a professor] that this was not the case.

Tsumori can also refer to a belief that a person holds, which they do not expect will end up being fulfilled. A person who is working as if his life depended on it would be *shinu tsumori de hataraiteiru*—to have the tsumori to work so hard so as to kill oneself, though one would not actually want or expect death. When Uchimura created the PowerPoint presentation containing the image of the sign at the suicide point, he was undoubtedly feeling that the lab expected him to be *shinu tsumori de hataraiteru*.

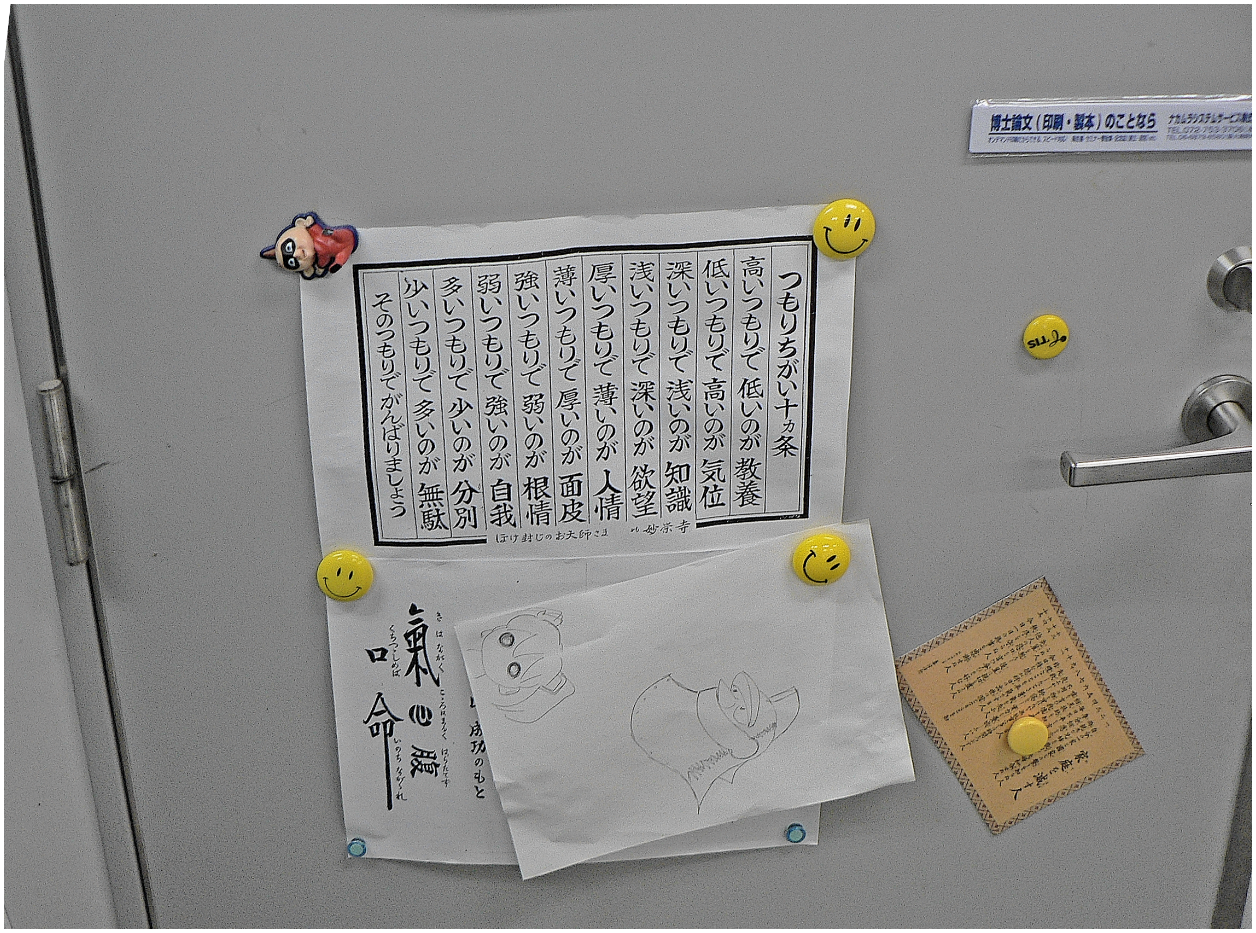

Figure 9. The Ten Laws of Mistaken Tsumori.

This two-sidedness of tsumori was evident in a poster I found posted inside the door of the student's room entitled "The Ten Laws of Mistaken Tsumori" that I passed each day whenever I left my desk. The poster was purchased during one of the lab's summer trips by a former student who had specialized in tsumori experiments. At the bottom of the poster was the name of an obscure shrine or temple and a reference to a "Boke Fuuji no Taishi-sama," a "Great Teacher" or Buddha of preventing senility. The text is a series of couplets, each referring to a tsumori which when acted upon, actually reveals that person's belief about the tsumori to have been mistaken.

> What you believe rich but is modest is your education.
> What you believe modest but is rich is your pride.
> What you believe deep but is shallow is your knowledge.
> What you believe shallow but is deep is your greed.
> What you believe thick but is thin is your humanity.
> What you believe thin but is thick is your arrogance.
> What you believe strong but is weak is your determination.
> What you believe weak but is strong is your ego.

> What you believe plentiful but is meagre is your judgement.
> What you believe meagre but is plentiful is your waste.
> Let us act as though these things are true.

The word “tsumori” appears in each of the lines above. I have translated it as “believe,” in all lines but the last, where “as though” stands for it. It is an imperfect translation, because “believe” lacks tsumori’s implication of action. In the sign’s text, tsumori implies that the addressee of the “laws” believes, for example, that he or she is very modest and lives and acts according to this understanding, when in reality, their acts show him or her to be excessively prideful, presumably from the vantage point of the Great Teacher. One may believe as though oneself is one way, but the result of that action ends up revealing that one is the opposite. In the context of the sign, tsumori entails inescapable limitations of self-awareness about one’s intentional actions. What one is doing may never be quite what one thinks he or she is doing. In its final line, again invoking tsumori, the sign implores its readers to bear in mind all of the previous lines, be humble, and constantly reflect upon their own actions and beliefs.

What is important about tsumori is that it depends on more than the conscious intention of an individual. This is in contrast to another word, *ito*, that is also translated into English as intention. Whereas ito refers more straightforwardly to something like conscious intention, tsumori seemed to point both to this and something just beneath or beyond an individual’s conscious awareness. One cannot be mistaken about one’s own *ito*, because it signifies what you think you are doing. However, one can be in error about one’s own tsumori, because it must be mediated through something, such as the perspective of a Great Teacher, before one can truly know what one’s tsumori was.

It was this two-sidedness that seemed to have focused the lab’s attention on tsumori as the source of intentional human behavior, rather than the more straightforward ito. It reflected the sense even when people believed they knew what they were doing, their bodies might be doing something else. When I pushed them to explain what the “tsumori” in “tsumori communication and control” was, Uchimura and Ikegami began to struggle. Seeking a starting point, Uchimura opened a browser window on his computer, and went to an online Japanese-English dictionary, a tactic that the lab members often employed when attempting to explain something to me. The dictionary told him that in English, tsumori was “intention” or “plan,” at which both Uchimura and Ikegami grimaced wordlessly, in quiet agreement that neither of these words corresponded meaningfully to what they had come to think of as tsumori in the lab.

Whenever their attempts at providing a clear definition of tsumori failed, students would often begin describing an experiment done by a past student. The lab's website introduction to tsumori summarizes the background for this experiment under the heading, "Tsumori control: The realization of a control scheme based on the segmentation of motion." Beneath an embedded video showing what appears to be a woman using two control joysticks to move a robot, the text—entitled "Towards 'Tetsujin 28-gou'"—presented the background for that study.

> This research aims to make it possible to use simple controls and commands to freely move a robot. The hint for free control comes from the robot control method from the famous robot manga "Tetsujin 28-gou." Tetsujin 28-gou is controlled very easily with only (1) an antenna, (2) 3 buttons, and (3) a lever that is grasped. With only these controls, the Tetsujin flies freely through the air, punches, and defeats its adversaries. What can be done to make these controls a reality?

The technical goal of tsumori research then can be understood as bridging a disjuncture between the input to a system by a human user and the output that the system must produce, in this case the complex movements of a robot. Because the control system presented to the human user is relatively simple, the movement of the robot cannot correspond in a direct way to the possible states of the control mechanism. In the terms of the lab, the degrees of freedom of the robot are much greater than those of the control scheme. If no one-to-one correspondence between the controls and the robot's range of actions is possible, then other sources of information are needed to make up the difference. Tsumori contains the information needed to traverse this gap.

When introducing the concept of tsumori control, the lab's papers contrast tsumori control with two other possible control mechanisms. Imagine a robotic arm that is capable of reaching out and grasping a cup. In one control scheme, the controller might have two buttons, one to reach out and grasp the cup, and another to pull the arm back in and release the cup. In this case, the controls are easy for a user to understand, but they can only be used to control the arm in a very limited fashion. The arm may be capable of more complex movements, such as rotating its wrist or independently moving its fingers, but these are eschewed in favor of having simpler controls. In addition, the user must also learn to associate specific buttons or controls with their corresponding movement. The range of human movements that might possibly be useful for controlling the arm is reduced to the act of pushing buttons. In this control system, the number of degrees of freedom of the controller is low and equal to the degrees of freedom in the robotic arm.

In an alternative scheme, the controller might be made far more complex. The example given by the lab is of a "Telexistence" system, which was pioneered by Terada's mentor, Tachi Susumu (see Chapter 2). This system consists of a complex exoskeleton-like device that encompasses the user's body with position and motion sensors, so as to directly measure the actions of the user. The user could then simply extend his or her arm and gesture as if to grasp the cup, and the robotic arm would mirror these movements. This scheme has the advantages of great flexibility and intuitiveness. The user would not have to learn any specialized control scheme, and would ideally be able to move the robotic arm in any way that he or she could move an organic arm. In this system, the degrees of freedom in both the controls and the arm are high and equal. The disadvantage of a Telexistence system is the complexity and expense of the control mechanism.

Tsumori control fits in between these two control systems. It would employ a simple controller, but analyze the user's inputs to predict his or her intention. If the user intended to grasp a cup, he or she would use a moderately simple control to enter some commands which a computer would interpret to move the robotic arm accordingly. In a tsumori control system, the number of degrees of freedom are not equal; it is low in the controller and high in the robotic arm. Because the number of degrees of freedom of the robot is greater than for the controller, any input from the controller is ambiguous and can be associated with multiple output actions. However, by identifying the tsumori associated with an input, the machine will be able to select the output most likely to have been the one intended out of a range of possibilities.

Another frequently invoked example presented on the lab's website and some of its student theses depicts a young boy sitting in front of a television. He is watching a robot do battle in a television show with a set of toy robot controls on the table in front of him. Completely engrossed by what he is seeing on TV, he pushes and pulls at the sticks, convinced on some level that he is actually controlling the robots on TV. It does not matter to him whether the controls are "really" doing anything; as far as he is consciously aware, he *is* controlling the robot. The boy is *soujyuu shiteiru tsumori ni natteiru*—he has the tsumori of controlling the robot. Tsumori control was a means to make it possible for the child to actually control a robot in the way that he imagines. His movements, though untrained, should bear some relationship to the movements he saw the robot making. If this meaningful information can be extracted from his movements, then even a small child may be able to control a complex robot using a simple set of controls.

These examples reflect what is imagined in the WTL to be an *intuitive*, *non-verbal* communication interface between a human and robot, one that does not impose a cognitive load on the human user in order to establish clear communications with it. The child in this example has a clear and conscious sense of what he wants the robot to do, but he has not learned how to control a robot, and is not consciously reflecting on what kinds of joystick movements he should be using to control the robot. He is reflexively moving in a way that he feels should produce the results that he is observing on screen. If the "circuits" through which these automatic movements are channeled can be analyzed and reproduced, then a computer would have the means to extract the tsumori that drives the child's non-verbal intuitive movements, and match the outcome he observes to his conscious intentions.

That the child's conscious expectations for the resulting robot behaviors are not challenged, and that he moves the joysticks without reflecting on them means that the tsumori control system has established a circuit with the child's low order systems as well as his high order ones so that the ambiguity of the joystick signals that the child inputs can be resolved. In other words, to interpret the behaviors that the child issues through his explicit reading of ambience, the machine must also share his tacit reading of ambience: it must know the child's "noise" to be able to interpret his "signal."

Tsumori therefore has two "levels." At the explicit level, the child *has the tsumori* of controlling the robot. He believes this to be true. At the tacit level, the child is *transmitting the tsumori* of his hand motions to the joystick, whose specific relationship with the actual movements of the robot is initially unknown. A tsumori controller would analyze the hand motions that the child is performing and attempt to generate a relationship with the robot movements that match the child's conscious tsumori. Then, if the child should find himself in control of an actual robot, the tsumori controller will know how to translate the child's movements into the robot's movements. To bridge the gap between human and machine through the extraction of tsumori also bridges the gap between a person's conscious and unconscious tsumori.

Notice that the process that the tsumori controller uses to generate the appropriate robot motion is the reverse of the process that the child uses to produce the hand motions. In the child, the motions of the TV robot are processed by some part of his brain and body and translated into hand movements. In the controller, the hand movements are processed by a circuit and linked to the motions of the TV robot. To produce a system that can perform this transformation, the lab uses a method called reverse engineering. The reverse engineering of a technological system is a well established practice that can both produce a copy of that system, and provide insights into its mechanisms. The application of reverse engineering to human beings also has a long history in the information sciences, and it is one of which the WTL is a part.

4.2 "Act as though you are in control."

One of my most frequent interlocutors at the lab was Toyoda, a B4 student. When I arrived at the lab, he had just received the news that he had passed his graduate school entrance exam and been accepted to the software engineering lab of his first choice for next year. He had originally wanted to join the lab as an undergraduate, but his poor grades at the time placed him in the last of his six choices of labs to do his undergraduate thesis, the WTL. He made the best of his situation and worked hard, studying for his graduate school entrance exam when he could. Many a morning, I would find him sleeping on a sofa in the meeting room following a late night facing his computer screen.

Toyoda had no interest in becoming a professional researcher. In the life he imagined for himself after university, he had a secure job, a wife, and children. University was a means for him to achieve that stage of adulthood. He was relieved to be moving to a place where he could deal with what he saw as the clean world of software and leave behind the messiness and noise of hardware and psychological experimentation. Moreover, he preferred applications-oriented research that he said would benefit people's lives more directly. Toyoda was less interested in knowing what humans are than he was in making their lives easier. For now, he was going through the motions until his time in the lab came to the end, though these motions were often quite complicated.

As the end of the calendar year approached, I began spending many late evenings with Toyoda as he rushed to gather the data that he needed for his graduation thesis. Toyoda would often burst into the student's room, wearing the same white t-shirt and track pants from the day before. I would hear him from the other side of the partition that divided the room in two, going from desk to desk recruiting people to experiment on, starting with those in his cohort or lower. It was only in desperate times that he would ask students more senior to him, especially if it was late at night. I was a "D" student, senior in both status and age to Toyoda, but my peculiar role as an ethnographer and my willingness to be experimented on meant that I was frequently asked to volunteer by Toyoda as well as nearly all of the other students. I participated in numerous experiments with Toyoda, over the course of several months.

At the time of my first experiment with him, Toyoda stood by the door of the student's room and called out, "*Onegaishimasu*," prompting me to stand and walk towards him. He led me across the hall to the experiment room, and flipped the sign on the door to show the side reading "In Use" after I had entered. Toyoda's experiment was off to the side of the room, behind the laparoscopy training setup and the computer station that the lab members used to edit presentation videos. A wobbly old office chair faced a controller with a pair of joysticks mounted on a stiff matte metal base, which was clamped firmly to a desk. A battered pair of headphones belonging to Toyoda sat on top of the controller, connected to a black notebook computer set off to the side in front of a small stool. Facing the controller was a large LCD computer display, showing the familiar lush green hilly background picture of Windows XP. The corner of the screen was covered with an optical sensor fixed in place with black electrical tape. A wire led from the sensor to a set of exposed circuits mounted on a small breadboard, which was connected by another cable to the notebook computer.

Toyoda seated me in the chair and began explaining the experiment. You will now be shown a video of a human being performing actions, he said, taking on a formal tone, rather than the friendly way we usually spoke to each other. "Using these controls, please act as though you are controlling that person." The screen in front of me would show a countdown from 5 to 1, and then another countdown from 10. When the second countdown reached 3, I was to place one hand lightly on each stick to enter the stand-by position. When the countdown ended, the display would show a short video of a person doing a sequence of body movements. I was to move the sticks along with the video so that I felt as though I was controlling that person, and remove my hands as soon as the video ended with a hard cut to black. Each video was one round of the experiment, after which the procedure would repeat from the first countdown. “Can I move the sticks however I like?” I asked. “However you feel like moving them,” Toyoda answered tersely. He repeated, “*Soujyuu shiteiru tsumori ni natte kudasai*.” Move the controls as though you are moving the person.

The sticks looked like the handlebars of a bicycle mounted vertically. They had very little give, making it impossible for me to judge what kinds of stick movements were actually being recorded. I assumed that the sticks registered horizontal movement, but I wondered out loud to Toyoda whether twisting or vertical motions were also being recorded. He would not tell me. For the third time, he told me just to act as though I was controlling what I was seeing: “Soujyuu shiteiru tsumori ni natte kudasai.”

He checked that I was ready, and I nodded. I put on the headphones, which blocked out sounds from the rest of the lab with white noise played from a looping sound file on his computer. He typed some commands into a terminal window. I saw him enter my name and some numbers taken from a list scribbled in his notebook. He nodded to me and hit the keyboard to start the countdown. When the first countdown reached zero, he hit another key on his computer, which sent a stream of numbers down his screen. I focused on my display, and waited for the video to appear.

A person appeared on screen, the camera looking down on him from behind in what looked like a narrow corridor. I soon realized it was Toyoda himself. In the video, he swept his right arm forward then up, followed by the left arm. Then both arms pivoted so that they were extended outwards to each side. He next raised each arm straight up, and then lowered them to his sides through an arc in front of him. Then the screen went black, and the countdown began again as Toyoda tapped in a few extra commands to reset his data recording program. The movements of the figure in the video were regular and regimented, as though their beginnings and ends were precisely timed. I imagined Toyoda hearing the click of a metronome as he recorded himself doing these movements.[34] Each set consisted of ten rounds. The video shown in each round showed the same movement, but the playback speed varied from 3 seconds to 10 seconds. Sometimes, the speed of the movements would change during the playback. When the video was shorter, I would struggle to keep up with the image, pulling and twisting the joysticks erratically.

I initially faltered with the timing of my commands. The video would appear suddenly out of a black screen and the figure would begin moving immediately. In the first round, I desperately tried to catch up to the video, pulling and twisting the sticks in every direction. As the rounds went on, I started anticipating the start of the video, and settled into a pattern of stick movements that I could reproduce with what felt to me like consistency. As the figure in the video performed each movement, I heard a drumbeat and a description of each motion in my head– "up, left, around, and down..." and so on.

After each set of ten, Toyoda would pause the video and gesture for me to take the headphones off for a short rest to ask me how I was feeling and whether I needed a longer break. I would sit for a moment trying to refocus my eyes on something else in the room. I felt fatigue from concentrating on the same spot on the screen accumulating in my eyes and temples. Halfway through the experiment, I said to Toyoda, "I feel like I'm doing the same thing over and over again. Is that ok?" Toyoda dodged my question: "Don't think about anything."

I completed the set of experiments over the period of an hour, and at the end, he asked follow up questions. "Did you sense a rhythm or tempo in the movements that you saw in the video?" he asked, which I had. His other questions focused on whether or not I had encountered trouble entering commands when the speed of the video changed, and whether the commands I entered were different for the various speeds. I had felt like the faster speeds had made me abbreviate some of my movements so that I only clearly marked the end points of the person's movement on the joysticks, whereas for slower videos, I had been able to trace the arc of a

[34] After the initial round of experiments, Toyoda switched the video to one of a person doing Tai Chi, in response to a criticism from his professors that the rhythm of the movements in the first video was too obvious. The rest of the procedure remained unchanged.

complete movement. We would meet many more times in the subsequent weeks to conduct additional rounds.

In Toyoda's experiment, I played the role of the child watching television, and the video of Toyoda stood in for the robot doing battle on TV. Even the type of controller that I was using resembled the one depicted on the webpage. Though I was aware that I was not actually controlling the motions I saw on screen, Toyoda repeatedly told me to act *as though* this were the case. I was to act with the tsumori that I was in control.

Toyoda told me several weeks later, after the experiment had concluded, that its aim was to understand how people broke up the motions they saw into segments. If a relationship could be derived between the segments that I created reflexively in my hand movements and the motions that were being presented on the screen, then this would provide hints as to how my brain was turning visual information into discrete units, and these units into motion.

Toyoda's experiment reflects several assumptions about the nature of the human brain and body that are rooted in cybernetic and computational ideas. In this view, my tsumori can be analyzed because I process it as digital units; my behaviors reflect these units because my eyes are inputs that transform physical stimuli into units, processed by my brain, and my hands convert these units back into physical motion. I am therefore a *black box* that can be reverse engineered.

4.3 Terada's Black Boxes

「すなわち人間は、感覚がインプット、運動がアウトプットである情報的なブラックボックスとして定義ができ、定量的に解析することが可能になります。本講座では、このブラックボックスを解析することによって、人間の感覚ー運動メカニズムを解明し、このメカニズムを利用したシステムを開発しています。」

"In other words, the human can be defined as an informatic black box that has sensations as its inputs and movements as its outputs. This laboratory works to reveal the sensory-movement mechanisms of humans by quantitatively analyzing this black box, and developing systems that use these mechanisms."

—From the WTL website's research outline

Regardless of the time of year, Terada's optimism and curiosity seemed immune to the seasonal changes in workload that pass through the lab. He was never perturbed by the many trips he takes to conferences and workshops around the country, the frequent visits by reporters or company representatives looking for flashy new gadgets to cover or appropriate, or by the almost constant writing and checking of grant proposals, presentations, and papers. On the lab's internal web site, new students are cautioned not to complain about sleep deprivation or fatigue to people outside of the lab, lest bad rumors spread about the Terada lab. Terada seems never to have had any such complaints.

This day in December, I had arranged to sit down with him for a conversation. Unlike most of the others in the lab whose comings and goings adhere to similar late morning until late evening schedules, Terada tends to be unpredictable, even to himself. When I approached him to set a time for a formal interview, he immediately gave up trying to remember when he had an open moment and pulled out his iPhone, joking that it was the thing running his day. "I just do as it tells me," he laughed.

On the day appointed by his phone, he led me into the small multi-purpose room attached to his office. Terada was wearing grey slacks and a short-sleeved white button-up shirt when we sat across from each other at the small table. He projects presence and confidence, commanding profound respect and sometimes awe from his colleagues. He is also something of a youthful anomaly to those around him. Terada is in his forties, but a postdoc commented to me how he can seem child-like in the way that he pursues the objects of his curiosity, a trait that was signified by his hair, which displayed not a hint of gray, but a light suggestion of boyish brown compared to the flatter black hair of the other men in the lab. In the midst of seminar discussions, he would sometimes become consumed by his own thoughts, conversing with himself as his students tried to follow the zigzagging logic of his monologue. When he arrived at an answer he would immediately jump back into the fray with a new set of questions, giggling and smiling. The same smiling teeth would also sometimes bite through the lab members' comments and presentations, tearing through flesh even as they got to the marrow of the matter. These aspects of Terada were the inspiration for the lab's unofficial mascot, a contentedly smiling bear (in Japanese "kuma") wearing the GVS device, one of the lab's creations. Various combinations of the professor's name and "kuma" found their way into the names for servers and access points to the lab's network. A whiteboard in the elevator lobby just outside of the lab announced

“Welcome to the Terada Lab”, with a hand-drawn parody of a wildlife warning sign: “Beware of bears in the area.”

Terada considers the ultimate goal of his work as drawing the “human being’s blueprint” (*ningen no aojashin*). By this he meant that becoming able to draw its blueprint was equivalent to building and understanding the human being. He locates one origin of his current work in Tezuka Osamu’s classic comic “Tetsuwan Atom” (in English, “Astro-Boy”), a classic Japanese manga starring a mechanical superhero boy. Like many of his contemporaries, he was enchanted by the idea of a robot that he could become friends with. But from the beginning, he was more interested in building that robot than befriending it. “I’m the type of person,” he said, “who isn’t satisfied unless I can reproduce something for myself. That’s why I wanted to build one.”[35] He told me, “When I thought about what it would mean to create a [human-like] robot [like Astro-Boy], I realized that I would have to understand humans very well. If I didn’t understand humans, then I wouldn’t be able to build a robot, so I realized that my real goal was to understand human beings. Being able to build a robot that is just like a human would be proof that I understand human beings.” He added, “I don’t think there is any other way for me to do research.”

The procedure that Terada describes for creating a “blueprint” of a human being is that of reverse engineering. For a technological device or an industrial good such as a car, phone, or software application, the production process typically begins with the definition of specifications and the iteration of abstract designs, culminating in the manufacture of a material product. This movement from abstract characteristics to concrete product is known traditionally as “forward engineering.” Reverse engineering, as the name suggests, goes in the opposite direction. It begins

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35 Terada was well known in the lab and among his colleagues as an obsessive anime, manga, and science fiction fan. His knowledge of these areas of popular culture was rivalled by almost nobody else in the lab, except for the postdoc Kashino, with whom he would often engage in passionate conversations, which the people around them often felt ill equipped to join. Terada took many hints for his research from his encyclopedic knowledge of science fiction. He explained to me how he advised new students to read the “Ghost in the Shell” manga so that they would have a sense of the technologies and the world that he wanted to approach. He had co-authored two papers with his mentor, Tachi Susumu, about the methods of robot control that appeared throughout the history of robot manga. These papers advocated science fiction as a useful tool for scientists and engineers for inspiring research and invention. Many of the devices in the lab, from the virtual reality headsets to the joysticks used in the tsumori experiments and the Trochoid robot, had clear antecedents in popular science fiction.

with an example of a finished product, and uses various techniques to analyze its workings, often with the aim of reproducing that product or creating a working understanding of that product (see Raja and Fernandes 2008; Rekoff 1985; Chikofsky & Cross 1990). A car manufacturer may purchase a rival's product and disassemble it to understand how it was constructed, possibly shortening the development time for their own competing product. Reverse engineering may also result in the creation of abstract models or specifications rather than a working copy. Software reverse engineering would involve deconstructing or decompiling a finished application to produce human readable source code and identify its basic algorithms. In the WTL's case, the human being is the object to be reverse engineered, and its behaviors provide the data with which an analysis of its functions can be conducted.

The reverse engineering approach to understanding human beings is not unique to the WTL. The inventor and transhumanist Ray Kurzweil (2005), for instance, also argues that the human being needs to be reverse engineered to create intelligent machines. For Kurzweil, this involves opening up the brain using high resolution imaging technologies to render the brain's internal structure visible and reproducible. The WTL however, uses a more limited notion of reverse engineering, which we may call "black box" engineering (see Hayles 1999). In conventional reverse engineering, one may disassemble an original in order to directly understand its internal mechanisms. In black box engineering, the original cannot be opened; its operation must be understood only by observing its external behaviors.

The WTL's emphasis on the human as a black box can be understood in part as a result of the lab's disciplinary position. It is equipped with neither the tools nor the expertise that would be required to undertake a direct analysis of the internal mechanisms of a human being. Terada's claim about reverse engineering is stronger however; in his view, the body *need not be opened* to obtain reliable knowledge about human behavior. Its behaviors and essential functions can be understood and reproduced using only inferences based on observations of its external behaviors.

Most of the WTL's experiments were based on psychophysical premises, a branch of psychology focused on the quantitative study of perception. Psychophysics began as an attempt to establish "mathematical relations between physical magnitudes and subjective experiences of magnitudes" (Banks and Farber 2003, 5). Based on an analogy between more conventional physical systems and the human mind, psychophysics operated on the assumption that "the human perceptual system is a measuring instrument yielding results […] that may be systematically analyzed" (Kubovy et al. 2003, 96). Psychophysics relies on the assumption that, given the repeated input of a specific stimulus, the human being will reliably respond with the same behavior.

Psychophysics is an outgrowth of the behaviorist paradigm in psychology, which was central to the establishment of cybernetics. Behaviorism, dominant in experimental psychology for forty years following the publication of John Watson's *Behaviorism* in 1925, treated the human mind and brain as a black box to which no privileged access was possible, and took introspection and subjective reports of perception as questionable sources of data. The mind and brain were areas "closed to investigation, and all theories were to be based on examination of observation stimuli and responses." (Banks and Farber 2003, 5)

Behaviorism became foundational to the cybernetics of human behavior in an influential "cybernetic manifesto" written by Norbert Wiener, Julian Bigelow, and Arturo Rosenblueth in 1943. The authors begin by defining behaviorism as concerned with an organism's relationship with its environment, not the organism's internal structure (Hayles 1999, 94). In contrast to a "functionalist" approach, which would attempt to understand an organism's future behaviors by analyzing its internal structure, this behaviorist approach only takes the organism's past behavior as a guide.[36] Cybernetics went further, and extended this into claims about the nature of organisms and machines. By eliding the significance of internal structure to behavior, cybernetics put biological organisms and artificial machines on the same ontological footing. If input-output relationships were all that needed to be grasped to characterize a system, then an organic system and a mechanical system that behaved in the same way were essentially equivalent systems.

In spite of early cyberneticists' claims that cybernetics assigned no significance to accounting for the internal mechanism of a system, cybernetics tended to imagine organic and mechanical systems as equivalent by assuming that organic systems were essentially mechanical. This is because cybernetics came in two versions: "structure-free" and "structure-rich"

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[36] As Galison points out, the behaviorism defined in this cybernetic manifesto partook of a broader field of behaviorist approaches that included, but was not limited to behaviorist psychology (1994, 243 n. 38).

cybernetics (Hayles 1999). "Structure-free" cybernetics is the behaviorist, black-box version that claims that no account of internal structure is necessary to characterize a system. As such, it can be generalized to any system that can be figured in terms of inputs and outputs. The "structure-rich" version of cybernetics is ostensibly limited in its scope to electro-mechanical systems, but makes claims about internal mechanism. For instance, the servomechanisms for anti-aircraft targeting or the seemingly purposeful behaviors demonstrated by homeostats were understood in early cybernetics in terms of negative feedback loops and flows of information. While structure-free and structure-rich cybernetics were functionally distinct, cyberneticists rhetorically glossed over the difference between them. Thus, cybernetics came to be understood as a universal science, potentially applicable to all systems, while smuggling in the assumption that they all were at root, systems that processed information based on a mechanical model (Hayles 1999, 96. See also Bowker 1993).[37]

Terada effects a similar rhetorical slippage in his description of human beings. "Humans have a brain, and they have sensors, and they have motors," he explained to me, as he drew a series of boxes and arrows on a notepad, illustrating the process of input, output and feedback between the three parts. Sensors (e.g. the eyes, ears or skin) receive information that is passed on to the brain, which manipulates the motors (the body) to create an output. He pointed to the brain: "This is a black box [with] sensors and motors." He continued, "in order to understand [the brain], all that needs to be understood is this and this" as he gestured to the motors and sensors. "It reduces to an ordinary 'black box' problem. We need tools to deal with the sensors and the motors." This, he says, remains his basic approach to understanding human beings: by building technologies that measure and mediate information passing through human sensors and motors, it should be possible to understand what operations the black box of the brain performs on that information, and to create artificial mechanisms that perform these same operations.

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[37] Hayles (1999) highlights an exchange between Rosenblueth et al. and philosopher Richard Taylor regarding the 1943 paper as a representative example in which Rosenblueth et al. deftly moved between structure-free and structure-rich cybernetics. While asserting a behaviorism that took all systems as defined by their inputs and outputs, the force of their argument came from their assumption that organisms and machines were organized internally so that would tend to maintain a particular overall state, what they called "negative feedback." Such systems are self-correcting, and this self-correcting behavior was key to producing machine behaviors that could appear "positively "uncanny"." (Galison 1994, 263)

4.4 The Brain is a Digital Computer

What is inside the black box? Terada had a clear hypothesis about how the black box was internally structured, which was even more direct in drawing equivalences between the human and the machine. According to Terada, the simplest possible explanation of the brain's mechanisms is one that emphasizes the primacy of the "functions" of memorization and recall. The most basic action performed on physical stimuli received by a human's sensors is segmentation or discretization—the creation of discrete segments of information out of a continuous physical change. This can be understood through an analogy with language. The sounds heard by the ear at any given moment are a mess of frequencies and sonic intensities. Out of this mess, the human brain picks out phonemes, which it recognizes as parts of language that other parts of the brain can then manipulate. This is the process of turning physical difference into an informatic difference that makes a difference. Once manipulated, these units are transmitted to muscles that vibrate to produce a verbal utterance as a physical sound. Terada's view was that all sensory stimuli and motion must also be processed as discrete segments. This process of segmentation is equivalent to what Terada understands as "memorization" or "storage": breaking up physical data into packets of information is concurrent with the temporary storage of that information. Terada described this process as "cutting [something] away from [the flow of] time" so that it can be stored. The opposite process, in which packets are reconstituted into a continuous flow of bodily motion ("continualization"), he terms "recall". These are the two basic *functions* of the brain.

From this perspective, consciousness is secondary to storage and recall. "People talk about consciousness as though it's an amazing *function*," Terada said, "but it's nothing more than a *state*"— consciousness was the "state" of having recalled a memory. Consciousness is the information that people receive from their brains about their own actions and sensations, which is only available to them after information is already processed and stored. This means that one's conscious intent when performing an action is not the cause of that action, but a brain state produced with the action, or after the action has taken place. This is a hypothesis, Terada allowed, but it is one for which he said he had not yet discovered contrary evidence.

This explanation of the brain in terms of functions and states uses vocabulary from theoretical descriptions of computers and automata, such as the finite state machine, a theoretical construct that Japanese students learn in the first or second year of undergraduate coursework in the sciences and engineering. The finite state machine can be regarded as a black box with a limited number of possible internal states that determine how a set of input signals is transformed into a particular output (Minsky 1967). The inputs depend on the machine's environment. The state of the machine and the outputs of the machine at any given point in time, $t+1$, are only dependent on the state of the machine and the inputs at t. In other words, a finite state machine has a set of functions that determine its subsequent states and outputs, based on current inputs and earlier states. Like Terada, the computer scientist Marvin Minsky points out that "The user [of the black box] doesn't normally need to know just what really takes place *inside* the box. That is, unless he is particularly interested in understanding the "works" of the machine, or in modifying it, he needs to know only what are its "input-output" properties." (Minsky 1967, 13) For Minsky, the particular physical character of the input and output signals does not matter. They might be chemical, electrical, or mechanical signals. In this model, all of these are treated equivalently.

What does matter to Minsky is that the machine is *digital*. By this, he means that the inputs and outputs can be characterized in terms of a finite set of distinguishable states or in terms of a limited number of discrete symbols, an "alphabet" (1967, 13).[38] This finiteness means that a digital machine can be completely and unambiguously described algorithmically. While finite, when dealing with physical quantities such as time, position and so on, which vary continuously over a range of non-discrete values and therefore cannot be completely represented by a finite symbol set, Minsky points out that such a machine can suffice as a powerful approximation of more complex and continuous physical systems (11).[39]

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38 "Digital" is commonly understood to refer to binary machines that process input and outputs cast as 1s and 0s, as in modern computer processors. Minsky uses digital here to mean a system based on a finite set of defined symbols, an alphabet, one type of which is the binary system.

39 This is essentially how analog/digital converters of the type found in audio systems work. Microphones pick up continuous variations in air vibrations and transduce these into continuously varying electrical signals which are quantized or transformed into a series of numbers that represents the level of the electrical signal based on a predefined symbol system. When this series of numbers is played back, they are converted back into continously varying electric signals which vibrate a physical membrane to reproduce a sound. In the process, the full complexity of the original physical vibration is lost, but the digital approximation can be accurate enough that a human being cannot readily distinguish between it and the original sound.

In specifying "segmentation" (or "discretization") as a basic function of the brain, and the requirement that information be rendered into discrete packets for the brain to process it, Terada cast the brain as a digital machine. Like a digital computer, which depends on the precise specification of states and functions in terms of an alphabet of symbols, the brain according to Terada produces packets of information and transforms them based on a set of internal functions, which are then turned back into continuous physical output. What can be known about the brain's functions can then be extracted by analyzing how it transforms input signals into outputs.

This model of the human allows us to clarify the lab's distinction between ito and tsumori. Ito, as Terada explained it, requires being able to consciously and linguistically give an account of the goal that one had in mind when performing an action. If one is asked what one's ito was, then one should be able to answer unequivocally about what one was intending. This implies that ito exists as a "state" that is produced as a result of the function of "recall," concurrently with or after the action to which that ito is being assigned. Insofar as ito is considered a conscious and linguistic act, then it can only be a further state that has resulted from a function operating on a previous state. On the other hand, if one is asked what one's tsumori was, Terada argues that more than one answer is possible. Even if one is being asked about a specific action, there are many possible interpretations of that action depending on how one is asked. Was one intending to grasp a cup, gently close one's hand, quench one's thirst, or participate in a toast? All of these are possible answers. Nevertheless, there must have been some kind of impetus for that action, and if it cannot be singularly articulated at the conscious level, then it must exist at a sub-conscious level. The state of the brain which leads to the action in question corresponds to tsumori.[40]

With the black box of the brain understood in this way, the gap between the tsumori of the human user and the behaviors of the machine can begin to be bridged. The brain's responses can be mapped to a set of known input signals. Given that the internal mechanisms of the brain

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[40] The subconscious aspect of tsumori can also be thought of as the "intention" that motivates behaviors that pass through only low order systems, in the terms of Nishida's dissertation. The information that passes through low order systems does not become consciously perceived, but "simply and linearly" produces an output behavior. Subsequently, if one is asked about that behavior, one's attention would be drawn to it, and use high order systems to perform a conscious interpretive act in which one's observation of that behavior would be the input. The result of this subsequent process is the conscious aspect of tsumori. See section 3.4.)

consist of functions operating on discrete packets of information, a computer should be able to effect the same mapping of inputs to outputs as the brain. After this task is performed, then the mechanisms of the machine can operate on them, resulting in the same output behavior.

Casting the brain thusly only establishes the potential that the gap between human and machine can be bridged. In order to traverse the gap, the “alphabet” that the human uses in its processing, which mediates the mapping between inputs and outputs, must be translated with that which is native to the machine. As Minsky points out, each state in the machine is encoded in a finite set of distinguishable states (13) —an “alphabet”. As a finite set of states, an alphabet does not simply define what state a machine is in, but also all of the states that the machine is not in. An alphabet therefore defines the relationship between signal and noise characteristic to a machine. The problem of reverse engineering the human then can be understood as the problem of translating between the alphabet used by the human and that used by the machine, which is equivalent to the problem of translating their forms of signal and noise.

What defines the human alphabet? I address this question in the following section by analyzing the formal schema of the tsumori experiments. My analysis gives further support to the notion that, through reverse engineering, the human becomes understood as a cybernetic system, but it also shows how the alphabet that is native to human beings is determined in significant part by its physiological characteristics.

4.5 Human-Machine Symmetry

One of the most persuasive tsumori experiments is known in the lab as the “Tamura” experiment, after the student who performed it. The aim of the Tamura experiment was to establish the existence of tsumori as a meaningful scientific object by showing that the hand movements a person produced in response to a specific visual stimulus were consistent and reproducible.

Like Toyoda’s experiment, which came after it, the experiment had a structure that mimicked the examples of Tetsujin 28-gou and the boy watching a robot cartoon. It consisted of a small toy humanoid robot standing in front of a set of joysticks. In the Tamura experiment, the robot had 17 degrees of freedom, while the joysticks had 12. Thus, for a person to be able to access the full range of the robot's movements, extra information had to be extracted from the joystick inputs.

In the first mode, the robot would perform a series of pre-programmed movements, each marked by a timed tone separating the robot's movements into discrete segments. Subjects were directed to observe the robot's movements and move the controls, as if they were controlling the robot—"*soujyuu shiteiru tsumori ni nattekudasai*"—just as Toyoda had done to me repeatedly during his experiment. The movements were programmed and randomized so that the subjects would not be able to memorize or anticipate them. For the experimenter, this meant that the subject would not be able to consciously reflect on what movements to perform, but would simply react intuitively. The movements of the joysticks were recorded and compared to the movements of the robot, in order to determine whether specific sequences of joystick commands could be associated with particular robot movements.

When the system is then switched to the second mode, the human becomes the source of motions, which are interpreted by the controller into movements for the robot. The results of the experiment showed that if joystick commands were analyzed in bundles of two segments, then the intended motion could be extrapolated and presented through the robot, with an accuracy of 60% to 70%. The robot control system could interpret with significant success what a person intended with a particular command by also taking the preceding command into account. On the lab's website, the outcome of this experiment is dramatically demonstrated in a video, which shows a lab member giggling as she moves the control sticks and watches the robot's arms move around. A text overlay on the video reads, "The intention of the user is not visible, but from her delight, we can imagine that she is able to move the robot as she intends." This experiment is used as evidence for the existence of tsumori as a unit of intention that contains consistent information, and is prominently cited by all subsequent student tsumori experiments.[41]

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[41] Toyoda's experiment was an extension of the Tamura experiment. It replaced the robot's preprogrammed movements with a recording of Toyoda's bodily movements, but the main difference between the two was that the Toyoda experiment focused specifically on how continuous movements were broken up into discrete segments. While the Tamura experiment had resulted in a moderately successful control scheme, its value for understanding the how the brain processed bodily movement was limited because it imposed strict start and end points for each movement. Toyoda's experiment was aimed at removing this constraint to identify how the brain itself breaks up a continuous motion into discrete units of tsumori.

Schematically, the flow of actions in the tsumori experiments is illustrated as in Figure 10, drawn from a lab presentation. The figure depicts the human subject successfully controlling a robot with a tsumori system. The human generates a tsumori, x, which is transformed by the continualization function F_m into the bodily input operation, y. The robot's discretization function, G_c takes y and transforms it into a robotic tsumori unit, x′. The continualization function, G_r, takes x′ and transforms it into the bodily motion of the robot, z. This is the "Voluntariy Controll [sic]" (Voluntary Control) mode.

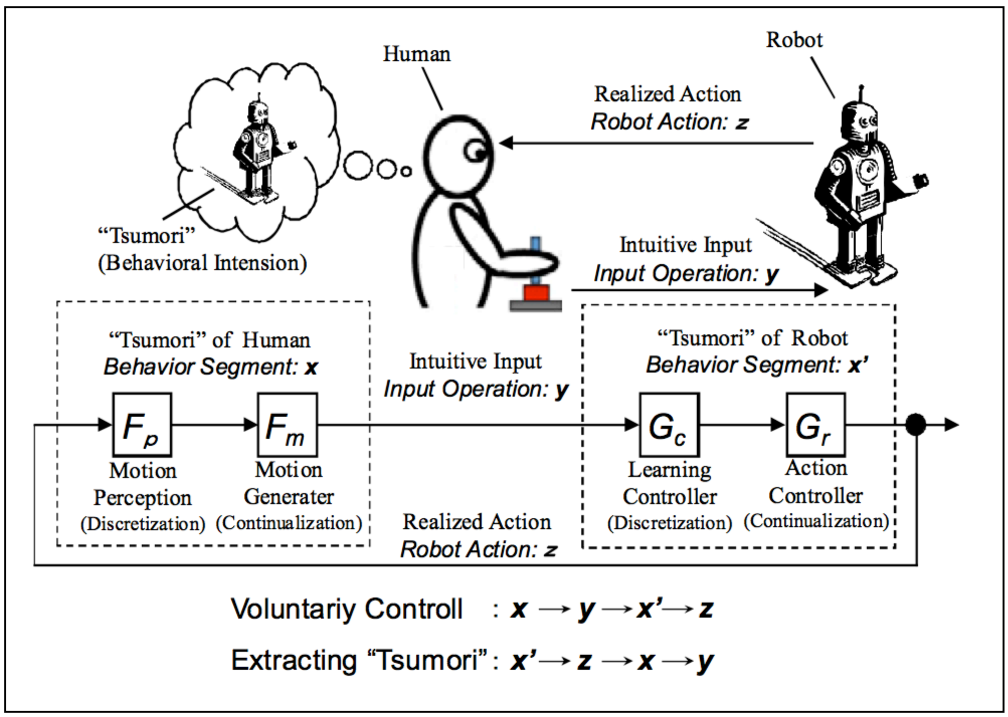

Figure 10. Schematic diagram of tsumori experiment.

The "Extracting Tsumori" mode corresponds to Toyoda's experiment. This mode begins with a tsumori state in the robot (a set of software instructions defining the robot's physical movements) x′, which is converted into robot movement z, which the human being converts into a human tsumori x, resulting in a joystick motion (y). In Toyoda's experiment, the role of the robot is played by the video recording of Toyoda's movements, but the process under investigation is the same, which is to establish a correspondence relation between x′ and y, in order to identify the process by which z becomes y through the mediation of x.

In this figure, note the correspondence between x and x′. Both of these “tsumori” are positioned between the human and robot’s respective “discretization” and “continualization” functions. They mediate the transformation of an observed motion into a corresponding bodily motion. Discretization and continualization are performed on the information flowing to and from what Terada referred to above as the human’s “sensors” and “motors” respectively. Depending on the mode of the experimental system, either x or x′ is also the origin of a particular motion. In the Voluntary Control mode, the human’s tsumori x begins the feedback loop, while in Extracting Tsumori it begins with x′.

From the perspective of the experimenter, x, F_p, and F_m are unobservable in isolation of each other. Only the movements of the human, y, in response to the robot’s movements can be observed. Thus, the rectangle on the left is a black box, whose functions can be characterized only in terms of its observable responses to a known input. Nevertheless, the figure presents the human subject as structurally identical to the robotic system on the right, because as a reverse engineered black box, its basic internal structure must match that of its electro-mechanical twin in order to be amenable to further analysis.

Furthermore, the symmetry of “Extracting Tsumori” and “Voluntary Control” modes illustrates the isomorphism of the human and robot. The two modes are identical save for the point of origin of the initial tsumori. In “Extracting Tsumori” it originates in the pre-programmed movement sequences of the robot; in “Voluntary Control” it is in the human being’s tsumori. “Voluntary control” mode is simply “extracting tsumori” mode from the perspective of the robot. When combined with the representation of the internal structure of human black box, this symmetry makes it possible to imagine the correspondence between joystick movements and the robot’s movements acquired by the computer in the “Extracting Tsumori” mode to imply a correspondence of the internal tsumori states, x and x′, in the human and robot, when the “Voluntary Control” mode works successfully. The paired, symmetrical modes of interaction between the human and robot, along with the assumed equivalence of their internal structures, implies that the human’s tsumori corresponds to the robot’s programming. When x and x′ correspond, then the behaviors of the human have become predictable to the machine.

The successful correspondence of x and x′ can only occur when the conditions surrounding them are held constant, otherwise any difference in the output from the user could not be ascribed solely to the input from the machine. That is, there must be a system of *restraints* that keep the feedback loop stable and producing non-random behaviors (Bateson 1967). We can imagine then, the white space in the diagram surrounding the lines as representing surroundings restraining the interaction, mediating and channeling the flow of messages as it passes between the human and machine. The black lines and arrows tracing the loop of information between user and machine represent the circuits through which behaviors produced from an explicit reading of ambience pass through. The white space signifies the tacit reading of the ambience of the interaction, the ground which must be maintained as constant in order for the interaction depicted to occur predictably and stabilize the loop.

In the next section, I look at the practices through which the constancy of experimental conditions was achieved. How was a tacit reading that could support the experimental tsumori circuit achieved? Through this discussion, I show how a great deal of emphasis is placed on maintaining the experimental subjects' bodily postures and routinizing the experimenters' social behaviors, showing that it is not only the humans' behaviors and surroundings that make up ambience but also their bodies.

4.6 Psychophysical Experiments

Students learned the practical techniques of maintaining experimental conditions from the lab's resident experimental psychologist, the postdoc Kawasaki. Early in the fall, Kawasaki held a seminar introducing psychological experimental methods, which was attended by all of the undergraduate students and one Master's student. She playfully entitled her presentation, "Let's turn humans into experimental platforms! ~ Can you control a person's kokoro? I will show you how!" (*Hito wo jikken dai ni shichaoze ~ Anata wa hito no kokoro wo ayatsuremasuka? Oshiemasuyo~.*) She described the seminar as an introduction to methods for measuring "human functions and the structure of the brain" (*hito no kinou to nou no shikumi wo hakaru*), based on psychophysical methods. Kawasaki contrasted invasive techniques, such as autopsies, with non-invasive techniques such as yes-no questions, and clarified that the lab's psychological experiments and psychophysical experiments in general, dealt only with non-invasive techniques that observed the measurable effects a given input had on a person's behavior.

Her seminar also addressed the practical problems presented by treating the human as a black box. In Minsky's simplified model, the inputs and outputs can all be completely and totally specified. Even if the inside of the black box is unknown, one can be sure of knowing exactly what is going in and coming out. For a human being with a range of sensory organs and muscles and an incomplete account of how each part is connected with the others, total knowledge of the system's signal environment is not guaranteed. Thus, students were trained in ways to design their experiments to isolate specific senses and bodily responses. This was achieved by immobilizing the body in various ways, and was validated by the presentation of a clean graph.

Kawasaki instructed her students to think of their experiments as extracting a "*shin no atai*" or true value being produced by their human subjects. In order to do so, they were taught about different kinds of experimental error, how to design experiments to remove factors such as individual variation, and maintain consistent conditions in their experiments. The goal of the WTL, she explained, was to create interfaces that can help people, and for this to be possible, one had to understand the principles (*genri*) upon which a human's functions operated. These principles could be isolated through psychophysical experiments, which investigate the correspondence relation (*taioukankei*) between a person's perceptions and the external world.

The most important part of designing an experiment was isolating and specifying independent and dependent variables (*dokuritsu hensuu* and *jyuuzoku hensuu*) that would accurately capture a correspondence between an input stimuli from the external world and the output response in a person's perceptions and behaviors, in accordance with the lab's psychophysical approach. This correspondence reflected the principle of a human's function. Experiments in the lab mapped the function in question to a relationship between two distinct sensory organs or body parts, or the human's sensors and motors, as Terada had referred to them. Most tsumori experiments examined the effects of visual stimuli on hand motion, while one investigated visual stimuli and brain activity. Other experiments looked at the link of hearing to torso motion, of visual stimulus to touch, sound to walking direction, and the sense of equilibrium to eye movement.

The researchers would become increasingly confident that they had indeed isolated an essential human function or principle when a particular result became reproducible. Reproducibility was recognized by the close clustering of data points around a single line, which reflected that a specific correspondence between an input stimuli or independent variable and an output or dependent variable was being maintained throughout the experiment.

For a reproducible result to emerge, experiments had to be designed so that their conditions were as invariant as possible across all trials. External disturbances were reduced and stabilized in Toyoda's experiment by having subjects listen to white noise, which masked out other sounds in the lab, and to direct subjects to look only at the screen from the first countdown until the end of the video clip, so that they would focus only on the presented visual stimuli. The sign on the door that Toyoda had flipped indicating that the room was in use prevented most people from entering, and made those who did need to enter careful and quiet as they did so. In some experiments, the entire room was darkened in order to shut out unwanted outside visual stimulation, which can affect, for instance, eye movements or readings of brain waves.

Experimenters also went to great pains to stabilize unwanted sources of noise by restricting subjects' motions, so that only the parts of their bodies that were under investigation would be activated by an experiment's stimuli. During Toyoda's experiment, I was verbally instructed to maintain the position of my body on their chair and the focus of my eyes on the screen. The repetitive motion of my hands and arms (from my lap to the control sticks and back) was to engage only my eyes, brain, and arms in the experiment. In an earlier tsumori experiment, belts and supporting bars was used to maintain the position of the subject's body in relation to the controls and screen. For eye movement and brain wave experiments, the body was often immobilized, either partially, by placing subjects' heads against a padded frame to ensure that they did not move, or completely, by having subjects' sit partially reclined in a long chair with instructions not to move their bodies and eyes at all, and to relax until their brain waves entered a calm state. In an experiment involving the performance of CPR on a dummy, subjects were all told to kneel at a specific position in relation to the dummy before each round of the experiment.

The demand for the invariance of experimental conditions also regimented the social interactions researchers had with their subjects during an experiment. Terada would often emphasize to his students that the way that tasks and questions were presented to subjects would influence the way that a subject experienced a stimulus and shape their responses. This was the reason that in all experiments, the tasks were tightly structured and the instructions scripted. Toyoda's use of formal forms of address during the course of the experiment is also an expression of this. His level of politeness of his statements was consistent across all subjects, assuming a modest register, regardless of his actual status relative to the subject.

Experimental results could also be influenced if the subjects' had prior knowledge of the experiment, so the researchers did their best to keep their subjects "naïve." In the terms of psychological experimentation, a naïve subject is one to whom the actual aims of the experiment they are participating in and/or the procedure he or she must perform in the experiment are previously unknown. The use of naïve subjects is an attempt to minimize the intrusion of unwanted behaviors and intentions into the experiment. Naïve subjects are defined in opposition to "sophisticated" or "guessing" subjects (Kubovy et al. 2003, 97), who have previous experience with the experiment, or attempt to guess the true goals of an experiment during their participation. In general, it is understood that a subject's performance of a task will differ depending on how naïve a subject he or she is.

In Toyoda's experiment, his attempts to keep me naïve were in hiding the true aims of his experiment, which of my behaviors were being measured, and the precise type of stimuli I would be presented with. Toyoda also avoided selecting other people from his own Tsumori squad as subjects for his experiments, because they would have heard presentations of his work in the past, and discussed with him ways to execute his experiment effectively. Students would generally avoid discussing the details of their experiments in lab-wide seminars to prevent unnecessarily shrinking their pool of subjects. For large-scale experiments requiring many participants, people were hired from outside of the lab to ensure a sufficient supply of naïve subjects.

How these strategies were used depended on the participants, the goal of the experiment, and the level of familiarity with the expectations for behavior that the experimenters could assume on the part of their subjects. When an experiment used only lab members as subjects, basic precautions to keep them naïve, the use of a rough script, and polite speech sufficed, since lab members were already expected to know what being a subject involved. When external subjects were used, the measures were more explicit and formalized. During a large-scale experiment involving more than a dozen external volunteers, it was always Kawasaki who greeted the subject at the door of the experiment room. She would explain the experiment according to a script, have them sign and stamp a waiver form, perform the tasks for the experiment, and conduct the debriefing, moving them from predetermined place to place in the experiment room for each task. She would ensure that the subject was comfortable throughout and that there was a glass of iced tea waiting for them on the table afterwards. Other members of the lab responsible for preparing the experimental apparatus were always in the room, but it was only ever Kawasaki who spoke directly to subjects. During these experiments, each participating lab member performed specific and routinized social roles, setting an ambience that would induce the subjects to behave in reproducible ways.[42]

In the previous chapter, I showed that students had to read the lab's ambience to know how to behave in expected ways. They did this in part by producing both tacit and explicit readings of ambience that defined the relationship between the signal and noise of their actions. In the context of psychophysical experiments, a similar need to read ambience is evident. Insofar as the experiments must elicit reproducible and clean output signals, they must be designed to create and maintain a stable system. The less familiar with the behavioral expectations of experiments that the experimenters assumed subjects to be, the more structured they made their own behaviors and the more explicit were the directions and cues to subjects.

In the same vein, the restrictions placed on the movement and positioning of subjects' bodies to elicit reproducibility suggest that the bodies themselves are part of experiment's system of communication. Bodies were kept the same posture from trial to trial and from subject to subject. They were also shaped in a way that would keep the feedback loop between the body and the measuring instrument symmetrical. Recall the schematic diagram for the tsumori experiments above. In order to maintain the symmetry of this loop, the subjects' bodies were oriented so only that the brain and one set of motors and sensors (arms and eyes) would participate in the experiment. The rest of the body was not to move. In a tsumori experiment by the M2 student Sato, which measured brain wave responses to visual stimuli, subjects' entire bodies were supported in a long reclining seat and were instructed to relax and only look at the screen in front of them. As described above, similar measures were employed in other experiments. In each case, the subjects' bodies were placed in states so internal and external stimuli and subjects' responses not under investigation would be masked, muted, and maintained as constant as possible. The bodies could then be imagined to operate as black boxes which only

[42] It is notable that in the tsumori experiments, it was not considered necessary for the subjects to respond in the same manner as the others. The subjects only needed to respond predictably in relation to their own past responses; the predictions derived from one subject's results did not need to be predictive of another subject's behaviors to be considered valid.

had inputs and outputs that corresponded to those of the experiment's measuring devices. This shows that for a human subject to behave reproducibly vis-à-vis a machine, the conditions for their interaction had to be shared both inside and outside of their respective bodies.

If readings of ambience guide and mediate the behaviors of the people within it, then when the interactive participants come to include human-centered technologies—machines that read ambience—the bodies of the participants also become part of the reading. In cases where the only active participants are human, shared embodiment can be assumed and the act of reading ambience emphasizes elements located outside of the body. Where a shared embodiment cannot be assumed, such as when machines and humans are interacting, then it must be achieved. The various experimental control methods that the lab members used held the tacit aspects of ambience steady, so that a close one-to-one relationship between the relevant human circuits and the measuring machine could be maintained. This is necessary to ensure a clean signal from which the internal mechanisms of human tsumori can be inferred. In the next section, I bring how the human body is involved in ambience into further relief through a discussion of the lab's version of the Turing Test.

4.7 The Turing Tests

The original Turing Test was a thought experiment proposed by Alan Turing, which posited an experimental basis on which the question, "Can a machine think?" could be answered (Hayles 1999, xi). In the Turing Test, a human judge sits facing a computer screen, typing statements into a computer, and reads the responses from the entity on the other side. The judge does not know whether the respondent is a human being or an artificial intelligence beforehand. From the viewpoint of the judge, the conversation partner is a black box to which he or she can provide some symbolic input. The resulting output is the only way by which the judge can decide whether the partner is a human or a machine. A machine that can pass the Turing Test by fooling a human judge into believing that he or she is interacting with a human being is understood to be thinking like a human being.

The conventional Turing Test assumes that the manipulation and exchange of a pre-determined set of symbols should be sufficient to encode humanness. In this test, what is most natural and intuitive to humans is the ability to hold an adult conversation through what amounts to a computer chat window. The Turing Test tends to emphasize the separation and autonomy of the machine's agency vis-à-vis the human (see Fujimura 2005, 213-214; Suchman 2007, 213). For artificial life or intelligence scientists, the risk of this separation between humans and machines is that machines may become "lifeless" and thus they must design machines so as to "revitalize" them and "restore them to humanness" (Suchman 2007, 214.) In doing so, AI and Alife researchers endow machines with characteristics that they define as lively and "human" (Fujimura 2005, 213). In this test, this liveliness is demonstrated through the mastery of human language and the capacity for symbolic cognition. Both human and machine bodies become irrelevant to thought and seem to vanish, reinscribing a rational and autonomous "liberal humanist, post-Enlightenment" subject as a normative human subjectivity (Hayles 1999; see also Galison 1994, Suchman 2007.) The main task of translation occurs at the symbolic level, between computer code and human language. The machines' particular materiality plays little to no role in whether the human can receive the machine's message.

The lab had its own version of the test developed by Shinagawa, which was called the Embodied or Non-verbal Turing Test. The Embodied Turing Test similarly entangles the human and machine participants in cybernetic circuits, but in Shinagawa's version of the Test, the exchange between the judge and respondent takes place through touch or "embodied communication." Rather than reading and responding to text on screen through a keyboard, the human participants in the test each have a small vibrating coil attached to the fingernail of an index finger. In front of each user is a 20-cm long metal track, along which they will move their index fingers in one dimension. At one end of each track is a laser which is used to quickly and accurately measure the position of the index finger on the track. Neither of the participants are aware of each other, and can only interact through the track: When their respective fingers are at the same position on the track, then both of their coils vibrate to simulate their fingers touching each other. The users are asked to judge whether the partner they are virtually touching is a human being or not. In this experiment, a human judge can be paired up with one of three possible partners: another human being, a computer program, or a recording of a previous human's movements.

Touch was chosen, because as a 2009 paper by Shinagawa, Nishida, and Terada explains, "there is no need for humanness to reside in interactions mediated by language." Rather than assume that the essence of humanness exists solely or primarily in a symbolically or linguistically mediated conversation, the embodied Turing Test "takes as its basis an environment of highly restricted bodily inputs and outputs," namely touch interactions between subjects' index fingers. Shinagawa further pointed out to me that even spoken language is, at root, a set of muscle movements. In the lab, what defines a human before it can speak or type is whether it can touch and be touched.

As it turns out, humans are quite good at distinguishing real human partners from non-humans, just from the rhythm and duration with which they touch fingertips. In the Embodied Turing Test, the primary difference observed between human-human and human-machine interactions was the emergence of turn-taking behaviors. When the partner was another human being, the subjects would sense the other human in the pattern of pauses and activity (e.g. one subject keeps his finger still while the other scrubs her finger back and forth over it, and vice versa.) When a partner failed to respond and participate in the creation of the turn-taking structure, it tended to be recognized as non-human.

Whereas in the conventional Turing Test, the language or alphabet of interaction is predetermined, in the Embodied Turing Test, the alphabet appears to be spontaneously emergent. Without any advance coaching or experience with the experimental apparatus, naïve subjects were able to distinguish human and machine partners with a high degree of accuracy. In later experiments, it was further shown that two human participants were even able to jointly develop a simple code to transmit limited semantic content.

From where does this system emerge? The causes of its features were explained in two ways. The first was that each participant anticipated the intention of the other.[43] The emergence of a turn-taking structure implies the two participants' awareness of each other as beings intending to communicate, and their willingness to co-create the turn-taking structure by trying to predict the other's behavior. One partner would move and then wait for the other two respond, and so on. As the time that two partners interact with each other increases, they become better able to anticipate each other, producing a more robust and regular structure. For one subject,

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[43] This point was also argued in a different article that describes similar experiments with artificial life simulations. The analysis of that article suggests that the emergence of turn-taking behavior between two software agents also requires that they predict and anticipate each others' responses and suggests this is analogous to an infant's anticipation of its mother's responses to its behavior and vice versa. The article argues, "Interactions in social behavior, including turn taking, can be established when these anticipations are formed dynamically."

their rate of success in discerning human from non-human improved over the course of 80 trials, reaching between 80% and 100% from 50% initially. Once the turn-taking structure had emerged, it tended to be resilient, becoming quickly re-established between human partners even when significant amounts of noise (such as a reversal in the touching and non-touching states) were introduced, which would, at least initially, destroy the structure. The tendency to anticipate and eventually expect certain behaviors from one's partner was necessary to the emergence of an embodied communication.

Second, the lab members hypothesized that it was particular (but unknown) features of the human body that defined the characteristics of the interactions (how long and how quickly to move or pause in relation to the other party) which made the recognition of humans versus non-humans possible. Even if each subject was willing to communicate by anticipating the behaviors of the other, mutual recognition requires the received signals to be structured so that they could be recognized as attempts to communicate. As the lab members speculate in one paper, the specific turn-taking structure that emerges may be due to constraints imposed by the human body on how long motor movements can be maintained and how quickly one movement can be switched for another. Deviation from these embodied, incorporated habits of communication was a signal of non-humanness. Similarly, the simple semantic system developed in the later experiments was hypothesized to emerge out of a kind of synesthesia, in which the visual appearance of a symbol was associated through the body with a particular tactile pattern. These associations too seemed to the researchers to be dependent on the specific features of human embodiment.

If, in the conventional Turing Test, the risk of a "lifeless" machine is addressed by revitalizing it with the capacity for human language, then the Embodied Turing Test suggests that it is not life but a human body that a machine lacks. The machine's vitality does not originate in its ability to carry on a conversation, but in the circuits through which it channels messages. Just as was the case in the tsumori experiments, a certain degree of shared embodiment, defined by similarities in the aspects of the body involved in structuring and chanelling information, is a necessary prerequisite for natural human interactions.

4.8 Conclusion

As we saw from the analysis of the tsumori experiments, in order for a human and machine to communicate in an intuitive manner their "alphabets" must be translatable with each other. They have alphabets because they are both imagined and analyzed as cybernetic systems, and the alphabets are translatable when the systems are both subject to similar social and material restraints. The information encoded by the alphabet results from an explicit reading of ambience, while information about the alphabet itself emerges from a tacit reading of ambience. Both must be shared between the human and machine for a message to be successfully exchanged, and stabilize a feedback loop between them.

Within the limited kinds of human-machine interaction I have considered above, this requires that the participants share some aspects of their material bodies, which is defined by the sensory and bodily modalities involved in the interaction. By sharing "aspects of material bodies," I mean their bodies must be configured to restrain and channel the flow of information through them—cast them into commensurable alphabets—to maintain the feedback loop. This means that the body is an essential part of the human system of communication. Ultimately, to read ambience is to participate in the collective enactment of social and bodily restraints on the flow of information that stabilize a particular set of feedback loops. These restraints make the signal that passes through the circuit as clear and clean as possible, simultaneously establishing a shared substrate of noise against which they become meaningful.

The circuits under investigation in the tsumori experiments as the Embodied Turing Test are simple and limited, but as they deal with intention and minimal forms of communication, they are also seen as basic to human behavior. Given the way that the human body and brain are imagined in the lab, it is necessary to constrain the body's movement and stabilize the surrounding social situation so that these basic feedback mechanisms can be identified. The symmetry imposed on human and machine in the tsumori experiments ensures that the reverse engineering process can be carried out, and the machine that results can share the constrained human's reading of ambience.

This challenges the conventional view of human communication which requires positing the mind as the origin of communication. As Alessandro Duranti has pointed out, anthropologists and social scientists have understood human interactions to be based on "reading others' minds"

(Duranti 2008). That is, each of the participants was thought to require an understanding of others' conscious intentions and meanings for them to interact. Interpretation was therefore a process that "focuses on an individual's mind as a meaning-making organism and on an individual's acts as the reflections or consequences of his or her states of mind" (Duranti 1993, 221).

The HCT view of the human does not place states of mind as the origin of behaviors, but turns it into the output produced at one point in a feedback loop of messages. As Terada pointed out, consciousness is nothing more than a "state" of the human computer. To truly understand how a human produces intentional behaviors, his lab's experiments focus on its "functions"—how the body transforms input messages into outputs. Interacting with a human does not require "reading their mind" but reading their bodies and surroundings as systems of communication.

Chapter 5
Human-Centered Technology

5 Acting under Remote Control

The first time my head was shocked with pulses of electricity was the day I introduced myself in person to the Wearable Technology Lab. I had arrived in Osaka the night before. My eyes were still heavy with jet lag, and my skin was moist from the already intense and humid heat of the late August morning. After searching the campus for an hour, I found the lab within a plain, grey six-story building made of reinforced concrete.

Upon my arrival, I was quickly greeted by Aya-san, one of the three women who worked in the lab's administrative office. She had been expecting my arrival. Shinagawa, who was my main contact at the lab, had yet to arrive. He would be here soon, she assured me, as she led me to the lab's meeting room and introduced me to a group of students. The students had prepared an array of devices on the long conference table. Wada, who had been put in charge of demoing one of the lab's interface devices, handed me a cotton pad soaked in rubbing alcohol and asked me to carefully clean the skin on the bony protrusions called the mastoid processes behind each ear. Meanwhile, he prepared a device that resembled a large bulky pair of headphones.

I applied the pad while nervously eyeing the waiver form that Wada had placed in front of me. The paper demanded my signature, and carried an ominous declaration in its header: "Save YourSelf! [sic]." It was a "No-Lawsuit Waiver Agreement" printed in English. By signing the form, I was agreeing that I was a "willing participant", and would take no legal action against the university or anybody else connected to the device, "regardless of the consequences of the experiment." Wada said that nobody had ever been harmed from wearing the device. I would later learn that this was a half-truth, but at the time I was eager to try the device, so I signed the waiver.

Wada received the cotton pad from me, and handed me the bulky headphones. He gestured with both hands, lowering one over each ear, to show me how to put them on. The headphones were part of the Galvanic Vestibular Stimulation (GVS) device. Instead of cups to cover the ears, these headphones had padded rings that encircled each ear, leaving the ear itself exposed. On each ring was a small metal electrode, fixed with translucent waterproof adhesive tape. Wada had moistened each electrode with water. I felt wetness dripping onto my shoulders as I put the device on my head. When I lowered the rings over my ears, the electrodes came into contact with my freshly cleaned mastoids.

The headphones were one of three parts of the GVS device; they were linked by a thick, coiled black cable to a box contained in a small hip pack, which I was told to hang over my shoulder. The box contained a rechargeable battery, control circuitry, and a radio receiver. The third part of the device was a repurposed wireless remote control from a toy car. It had two joysticks on the front, but Wada's thumb was poised over only one.

Once the headphones were in place, Wada asked me to stand in the center of the room. The three other students who had been watching the preparations stepped back. I stood in the middle of a ring they formed, unsure of what was about to happen. Wada warned me that he was about to start, and slowly tilted the joystick to the side. I felt a gentle tingling behind my ears, and my body lurched, as though the entire room had tilted. There was no sound or evidence that anything had changed in the room, except the corresponding angles of my head, my body, and the joystick under Wada's thumb. He centered the joystick slowly, and pushed it to the other side, causing my body to lean in the opposite direction. I let out a laugh. The students with me responded with smiles and laughter, perhaps recalling their own first times with the GVS.

For some, the GVS can be extremely painful and uncomfortable. The device delivers rapid pulses of electricity behind the ears that can feel like sharp pin pricks on the surface of the skin, especially if the electrodes are not adequately moistened. The kind of sensation a person experiences also depends on the characteristics of their skin and tolerance to pain: for some, no amount of moisture prevents the stimulation from being unbearable.

For me, the main sensation was one of motion. When Wada activated the control, I felt like I suddenly had been placed on a steep ramp, and had to right myself to stay balanced. I knew that the room had not moved, but I still leaned and stepped to the side as though it had. In addition, my eyes felt as though they were being gently nudged and twisted in their sockets.

I was guided out of the meeting room and into the narrow corridor that bisected the laboratory, lined by bookshelves, research presentation posters, and administrative bulletin boards. Wada asked me to walk down the hall. I took careful and tentative steps, intending to move in a straight line down the hall. Standing behind me, Wada pushed the joystick. I veered towards one wall and then the other. Although I felt some degree of control of my own body, I also experienced the incursion of the GVS. Using the remote control, Wada was able to nudge me in a direction of his choosing. As I became accustomed to the sensation, I became able to correct slightly for its effect. Others in the lab, with time, had become used to the GVS, some to an extent that they began to feel an influence on their sense of balance even when they were not wearing it.

Standing in the lab with my body partially under Wada's control, it was easy for me to imagine the GVS device as a rudimentary but definite step towards the reduction of the human body to a mere automaton, subject to the demands of whoever happened to be holding the controls. This feeling was echoed in a 2005 Associated Press article, written by a reporter who visited Terada at a private research institute before he established his current lab. The author expresses wonder and astonishment at the sensation produced by the GVS, but quickly turns to its fearsome potential as a non-lethal weapon, mentioning that a similar technology is under development in the U.S. for use in crowd control. While acknowledging the researchers' desire to turn the GVS towards uses in virtual reality and entertainment, the article ends: "But from my experience, if the currents persist, you'd probably be persuaded to follow their orders. And I didn't like that sensation. At all." (Kageyama 2005) I encountered similar reactions from friends outside the WTL, who expressed fear and surprise that such a technology actually existed in reality and not just in dystopian science fiction.

Though it was crude in its current incarnation, the members of the lab saw the potential for the GVS to become a more "human" and "intuitive" interface between humans and machines than the ones that many people are familiar with today, such as a keyboard or mouse. It required its wearer to learn no new skills. Operating as it did on the body's sense of balance, its signal needed essentially no interpretation: I simply reacted to what felt like a change in my surroundings. It seemed to ask nothing of me except for what I was.

What was it about me that the GVS linked with that made it a "human" interface? My analysis of the WTL's tsumori experiments showed that what characterizes the human as a system of communication distinct from other ones was the body. The experiments showed that the researchers had to contend with the human body as an essential part of the human system of communication if they wanted their technologies to be able to predict and understand human intentions.

But their experiments also seemed to reveal that the human body does not matter at all. Once the human has been reverse engineered and its circuits have been recreated in technological form, then the material body does not seem to matter, just the structure of its circuits. This implies that if a truly human-centered technology were created, one that had successfully copied all of the circuits in a human body, then machines could simply replace human beings.

HCT researchers do indeed foresee situations in which a machine could replace a human, in some cases without anyone even noticing. But they do not see it as being possible in all situations. In other cases, the creation of a human-centered technology cannot lead to the replacement or disappearance of the human and its body. The material human body must remain at the center of these technologies. To understand why both of these outcomes are possible requires a closer understanding of how HCT researchers understand the human body.

In this chapter, I argue that HCT researchers see the human body as *human* not because it is a communication system with a structure that is unique to human beings. Rather, it is human because it produces illusions of humanness as its outputs. While in both Japanese and English, the word “illusion” connotes deception or misperception, the WTL defines illusion as a result of the processes that the human communication system performs. Therefore, in the WTL, all human perceptions are illusions.

As in the tsumori experiments, the WTL reverse engineers the circuits in human beings that result in illusions. To produce technologies that more comprehensively capture the human’s circuits, the lab develops several technologies that address a greater range of senses and behaviors in more situations to produce a large variety of illusions. These technologies are developed with the aim of creating a future system that would be able to observe and intervene in all areas of human life. This system is known as the Parasitic Humanoid (PH). The HCT researchers’ work on the PH shows that illusions are not the result of a human communication system. Instead, the ability to induce sensory illusions defines a system of communication as human.

The answer to the question of whether or not the material human body can be replaced completely by a machine depends upon the type of system in which that body is placed. Specifically, in a “closed” system, one which is tightly controlled and bounded like the systems in the tsumori experiments, the input-output relationships defined by the human body can be nearly completely reproduced. Two examples of robots developed at Ishiguro Hiroshi’s labs show that for HCT researchers, a technology can replace a human provided that the setting into which it is introduced is tightly controlled.

In contrast, the WTL envisions the PH “riding” its human user out into more unpredictable and open systems. In these open systems, the PH cannot finally or definitively capture all of the circuits that a human uses. The PH therefore maintains the body as a point of reference against which it can continuously refine its own understanding of the human. In other words, in closed systems, the human body can be ignored because the process of reverse engineering can be completed and the original removed from the system; in open systems, the reverse engineering process never comes to completion, and human-centered technologies must maintain their relationship with the original.

If the last chapter showed that the conscious mind is not primarily what defines the human, then this chapter shows that the body does not either. The variability in the importance of the human body between different kinds of human-centered technology demonstrates that the human is defined not as an object but as a set of characteristic relations between input and output messages.

5.1 The Parasitic Humanoid

The Parasitic Humanoid (PH) is a system of sensors, interfaces, information processing algorithms, and wearable computers that Terada has been working on in some form since he was an undergraduate student at the University of Tokyo. The system as Terada envisions it has yet to be completed; it exists now as a set of nascent technologies including the GVS and the tsumori control system, joined together by the image of the complete future system.

Terada coined the name "Parasitic Humanoid"[44] or *Parasaito Hyuman* ("Parasite Human") during the first period of his professional career, as he was beginning to establish himself as a researcher at a prestigious corporate research institute. The name, he said, was partly inspired by the title of the novel *Parasite Eve* by Sena Hideaki, a pharmacologist who lectures at Tohoku University. *Parasite Eve* was a popular science fiction horror novel from 1996 about the awakening and struggle for embodiment of a distributed life form that exists across the mitochondria of many human bodies. During this time, the expression "Parasite Single" was also popular in Japan to refer to young working people, who continue to live with their parents into their 20s and 30s. Spending their income on hobbies, recreation, and fashion with the basic necessities of life provided by their parents, this group of young adults was portrayed as being parasites to their parents. Though he was cautioned against using "parasitic" because of these kinds of negative connotations, Terada felt that the most suitable alternative—"symbiotic"—was much less commonly heard in Japan, and did not evoke the right images and feelings among people who knew the word, because it suggested two separate beings living in collaboration. The word "parasite" had a different "impact" that he appreciated and wanted to exploit.

The practical goal of the PH is to provide its wearer with "behavioral assistance" (*kodo shien*). In situations where humans find it increasingly difficult to adapt to the demands that complex technologies place on them, the PH is intended to lighten the mental load on its user by taking over tasks that would have demanded his or her conscious attention. The PH would effectively transfer tasks that would otherwise have to be handled by high-order systems, and free up the limited resource of "attention."

Concretely, the WTL foresaw situations in which the PH would guide and alter a human user's actions to accelerate the achievement of a task, or improve the safety or comfort of the user. One possibility of particular interest in the WTL was for the PH to aid in the acquisition of manual tasks, what was called "skill transfer." For example, combining visual and tactile feedback, the head mounted display (HMD, see section 5.3) was used in experiments to help people learn the techniques of laparoscopic surgery, medical ultrasound diagnosis, and CPR, as well as more familiar tasks such as juggling, tying a knot, or playing a musical instrument.

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44 "Parasitic Humanoid" is the lab's translation.

Another possibility was that the PH might help keep a person safe from a sudden and unexpected threat: one lab video showed a possible use of the GVS along with sensors on the wearer's body and the surrounding environment, which might detect a quickly approaching motorcycle and induce the wearer to step out of the way by altering her sense of equilibrium. In these articulations of the PH, its human-centeredness seemed straightforwardly about maintaining the coherence and enhancing the productivity of the individual body.

The PH was being designed with the idea that if it could have the same experiences as a person (*kojin to onaji taiken wo suru*) or see the world from the perspective of its wearer (*souchakusha to douitsu shiten*) then it would be able to provide behavioral assistance appropriate to the situations that a person found herself in. Terada explains in an early research description (dated 2000-2002) that the ideal assistant would be an artificial intelligence that has experienced the same things as you from the moment you were born. It would know you better than any other person, and be able to suggest useful courses of action. Such a partner could be like a "*bunshin*" ("partial body" or "other self" (Tachi 2010)), taking over common, repetitive tasks so that the user would be freer to direct his or her attention to matters that demanded closer human attention.

At a technical level, this was to be achieved by including a "forecasting model" in the PH. This model, like the tsumori control system, would work in two modes. In the first mode, the system would passively observe the actions, behaviors, and surroundings of its user, gradually building an understanding of what kinds of situations resulted in which behaviors. Once a sufficient amount of data had been gathered for the model to make accurate predictions of its user's behavior, it would enter an active mode, in which it would use various interfaces to suggest courses of action, whenever it observed the user deviating from its predictions. The user may perform the suggested action or a different one. Observations of the user's actual behaviors would be fed back into the model to improve its predictive abilities.

To gather the appropriate kinds of information for this intervention, the PH was to be designed to approximate the sensory perspective of its human user. That is, it had to match the human body. But the most peculiar thing about the PH was that in spite of its being called a "humanoid", at first glance it seemed to resemble nothing like a human. When I first walked into the meeting room to try the lab's interfaces, I was presented with an array of devices strewn about the surface of a table. Even though many of the constituent components were there, I could recognize nothing particularly humanoid about them, neither individually nor collectively. For me, the word humanoid was associated with something that looked more like the Geminoid (see Introduction and section 5.4) than the bits and pieces that were before me.

It was only later, when I saw photos and drawings of the PH in use that I understood that it became a humanoid when a person wore it. The PH is a "wearable robot" that is supported by the human body: it is a "humanoid without muscles and skeletons." The complete PH is expected to include refined versions of many of the lab's devices, each of which operates on a different sensory modality. When supported by the human body, the device's sensors would be positioned at the same points as the user's corresponding sensors.

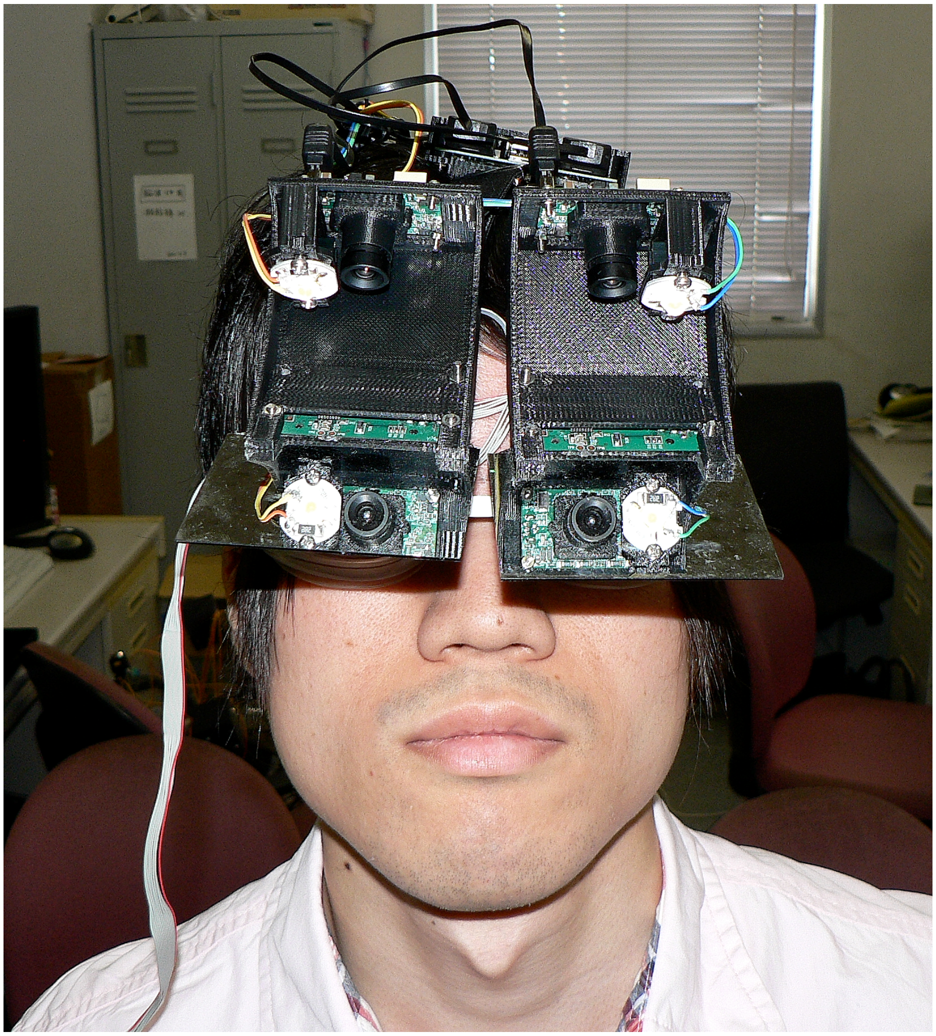

Figure 11. One version of the WTL's Head Mounted Display (HMD).

The head mounted display, or HMD, is a case in point. The HMD is the major component of the existing PH. It is a large pair of goggles mounted on a 3-D printed plastic headset, which is secured to a user's head with an elastic strip or set of belts. It resembles virtual reality goggles, but its main purpose is not to immerse users in artificial environments. It is to augment their engagements with their immediate surroundings. All versions of the HMD contained two small cameras, corresponding to each of the human eyes. Each HMD was also equipped with small liquid crystal displays (LCDs) that sat 1-2 centimeters in front of each eye, which usually display images from each camera to the corresponding eye. This was to enable the viewer to experience stereoscopic vision similar to their usual viewpoints, and allow for a slightly wider field of view than would a single camera.

The same principle guided the development of a fingernail-mounted haptic device called the "Smart Finger." Haptic devices produce sensations in the body to simulate the feeling of physicality or texture of a virtual object. Haptic devices can simulate texture or solidity by applying force feedback directly against the body, as in some video game controls, which vibrate or provide resistance to the user's movements corresponding to what is being on screen. The Smart Finger is used to simulate textures at the fingertips without impeding direct contact between the fingertip and another object. It consists of a vibrating coil mounted on top of the fingernail. In some versions of the Smart Finger, a small sensor is positioned at the fingertip but out of the way of the pad of the actual finger, so that it can sense what the human is touching from the same points as the human. A variety of other interfaces have been created which correspond to other of the body's senses, including balance, hand and head position, gaze direction, and so on. In these ways, the PH would be able to observe the world with the same scale and dimensionality (*dou jigen, dou suke-ru*) as a human being.

In addition to providing the PH with a perspective that approached that of its human user, the fact that it would be mounted on the user gave it a great deal of potential mobility and versatility to physically dwell in the same spaces as a human does. If, for instance, the PH was encumbered by a body that could not climb the stairs in a house or sit in a chair in a café, then it would be unable to observe its wearer's behavior in those situations or offer assistance in them. For this reason, Terada considered the Parasitic Humanoid as a robot "riding" a human being in the way that a human rides a horse.

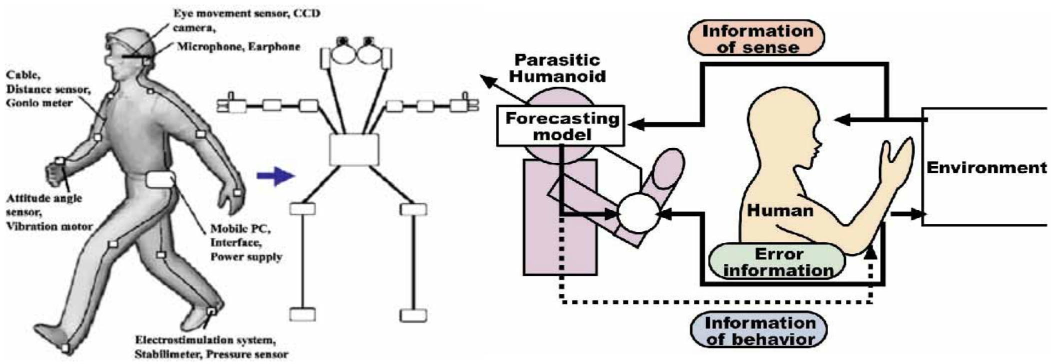

図１　PH の構成と行動モデルの獲得過程

Figure 12. Parasitic Humanoid diagram from a 2000 paper by Terada.

As was the case for the tsumori control system, for the PH it is considered sufficient to observe the stimuli the user receives and their responses to understand his or her behavior. Drawing from psychophysics and the view of the human as a black box, Terada emphasizes in the research description that a person's conscious free will plays a much smaller role in determining that person's behaviors than is ordinarily believed. It is the perceptions that a person has at one moment that determine how that person will act next. A machine with the correct human-like embodiment, as the PH and its subsystems had been designed to have, can perceive and experience the world in a way similar to its users, and because grasping perception is to grasp behavior, then an appropriately embodied machine can understand human behavior.

From the above, it should be apparent how the PH can match the human's "sensors," but given its construction as a humanoid "without a skeleton or muscles" and lacking "motors" of its own, how does the PH affect a user's behavior? As I show in the next section, the PH can guide its user's behavior through the careful use of sensory illusions. If the perceptions that a person has determine their subsequent behavior, then illusions alter those perceptions to guide them in a new direction.

5.2 Illusions and Information

To understand the importance of illusions in relation to the body, it is first necessary to examine how information is imagined in the WTL. Terada referred to this embodiment with the metaphor of "monosashi" or "measuring stick." Monosashi are literally rulers of the kind one may have used in school geometry lessons. They transform continuous physical extension into discontinuous units, which can be communicated, converted, and calculated with other measurements. As a metaphor for the body, monosashi suggests the role of the body itself in transforming the physical world into units, what I called in Chapter 4 an alphabet, or what is more conventionally called information.

In interviews with me and in many of his texts, Terada stated that the idea that the world is "overflowing with information" is "a lie"; there are only physical phenomena (*butsuri gensho*).[45] Here, "physical phenomena" encompasses all possible forms of interaction. Light shining off of a wooden surface is one form, but so are the vibrations in the air produced by a person's throat that constitute spoken language. Information does not exist until it is measured or observed, and the body is the human's measurement device. The body is a set of "measuring sticks" that generate information and convert information back into physical action.

This contrasts with many accounts of contemporary "information societies," which take "information" to be a monolithic entity, disembodied, intangible, and infinitely circulable. As the standard account goes, the increasing pervasiveness of computers and electronic communication networks has produced a world in which "a numerical flux […] is central to activities rather than incidental" (Thrift 2004, 590; cf. Winner 1986, 113-114), which configures space as abstract, in which one "assumes that there are fixed reference points, cardinal dimensions and the like." (Thrift 2004, 590) Hardt argues that even where computers are not in use, "the manipulation of symbols and information along the model of the computer is widespread." (1999, 94; cf. Yanagisako 2012).

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[45] Terada contrasted his perspective with that of the "connectionists." He writes, "[I] think the way that the "connectionists" use psychophysics is a bit reckless. They look at the brain, see how it is acting, and assume that they just need a neural network that can perform the same calculations, while leaving aside [how what the brain is doing] corresponds to something physiological." Connectionists tend to view human consciousness and mental processes as independent of its materiality in the brain, but captured in the pattern of connections among neurons. This is known as the assumption of "substrate independence" (Bostrom 2005).

In this viewpoint, there are no essential ontological incompatibilities between humans and machines, since at root, they are both made of information, interacting with each other through its free exchange, an extension of the individual with natural rights that underlies the Western modern social imaginary (Taylor 2002). The problem of interfacing humans and machines is one of creating a common protocol or code, an imagined space for the meeting of distinct souls or spirits. As Sherry Turkle writes, "Once we see life through the cyborg prism, becoming one with a machine is reduced to a technical problem of finding the right operating system to make it (that is, us) run smoothly." (Turkle 2007, 326)[46]

In comparison, Terada's view of information as produced by monosashi insists upon the material specificity of its forms. Information is not automatically commensurable with other information by virtue of its being information; commensurability must be achieved through the material act of matching monosashi. The imaginary that guarantees the ultimate commensurability of different forms of information is not one which imagines the dissolution of bodies to reveal a common space in which information flows, but one in which a shared form of information is the outcome of the creation of a common infrastructure of material connections.

While Terada's emphasis was on the distinctiveness of human and machine monosashi, it is important to note that this view also extends within the human body. Each human sensory modality is imagined to produce its own distinctive form of information to which human beings are evolutionarily and physiologically adapted to managing and commensurating. Terada explained that this is a question of the optimization of the body for certain kinds of feedback loops between brain, body, and environment. For instance, one may imagine a person picking up a cup using his or her own hand or a robotic arm controlled by joysticks. A person may be capable of accomplishing the task with either interface, but the hand is more "natural" because the circuits for controlling the hand have developed over evolutionary time along with the hand itself, whereas the joystick is a relatively new and unfamiliar mechanism. The particular configuration of hand, arm, eye, and tactile nerve endings that make it possible for a person to grasp a cup without effort are each their own monosashi, converting physical stimuli to

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[46] Note the similarity between these views and Galison's interpretation of Wiener in Chapter 2.

information and back. The human body, considered as a whole, is an assemblage of these circuits, held together by evolutionary circumstance.

This assemblage the lab calls *shintaisei* ("embodiment" in their translation.) In its most basic definition, shintaisei makes up the "conditions of physical constraint" imposed by the body. In a paper co-written by Terada, Nishida, and Shinagawa published in the *Transactions of the Virtual Reality Society of Japan*, it is elaborated that "[embodiment's] basis is that [humans have] 'one head and torso, two arms and two legs, two eyes and two ears, and walk upright without a tail.'" This body mediates interactions between the brain and the environment outside of the body. The sensations, perceptions, behaviors that a human being can have are dependent upon shintaisei, just as a camera is constrained in what it can record based on its optical and electronic characteristics. The body itself then acts like a commensurating structure that establishes relationships among the different forms of information produced by the body's monosashi.

Out of the assemblage of circuits, different subsets are activated depending on the task being performed, which each only provide a partial perspective on physical reality. Their products are compared and weighed somewhere in the body according to a process that was compared by one student to weighted voting. Moreover, a human may be engaged in multiple tasks at once, each activating a different subset of circuits simultaneously, some high order systems and others low order ones, which may operate somewhat autonomously, as in a person who is speaking on the phone and walking at the same time. As described in Chapter 4, the outcomes of these processes are both conscious perceptions and motor responses.

Action and perception are generated not only by external stimuli, but also internal processes. The lab argues that a perception often consists of predictions of the likely state of the world at any given time rather than a direct reflection of it. One paper produced by the lab discusses how, owing to the large size and complexity of the human body, signals conveying sensory information from one part of the body can no longer travel to the brain and be processed quickly enough to respond adequately to changes in the organism's surroundings. As an adaptive strategy, the paper argues that the brain therefore does not act directly on information from the body, but on predictive models it constructs of itself and the world. These are the "body image" and "world image." Acting based on the predictions of these models reduces the time and “processing load” of perception. These models are built on past sensory information. When the brain receives conflicting information from different senses, its perceptual systems make a judgement about the most likely external state, which it uses to update its models based on new sensory data. A conscious perception of the world is therefore in part a prediction.

As discussed in Chapter 4, if there exists a soul, spirit, or mind in this viewpoint, it is as the outcome of these embodied processes, not as its prime mover. “Free will,” as Terada said, is relatively unimportant in understanding a person’s future behaviors; it is the sensations he or she receives that will determine what they do next. Conscious awareness is an outcome of embodied process that make up the human’s *shiten* or point of view, not its cause. As Viveiros de Castro writes for Amerindian perspectivism, “*the point of view creates the subject*; whatever is activated or “agented” by the point of view will be a subject.” (2012, 99. Emphasis in original.) In this case however, one may be able to speak meaningfully about multiple subjects, given that the acting body is a collection of multiple subsets of circuits.

Illusion, or sakkaku, enters as a way of speaking about the perceptual experience of this agented subject. As the lab’s web page explains:

> ‘Sakkaku’ are “phenomena that you perceive differently from their actuality”, but they are different from hallucinations (genkaku) or perceptual abnormalities (chikaku ijyo), because they occur for everyone as a result of the normal operation of the brain.

Illusions, as this excerpt implies, are universal to all human beings because they are a result of the specific means in which the human body turns physical stimuli into sensory information into perception. As Terada put it to me, illusions are the “bugs” and the “special characteristics” (*tokusei*) that all humans have because of their common *shintaisei*.

While in both Japanese and English, the word “illusion” connotes deception or misperception, the WTL’s definition of illusion takes it as a type of message characteristic to the human body. All human perceptions are therefore species of illusion. I was reminded of this fact every morning when I walked through the lab to my desk: a magazine in a display case in the corridor carried on its cover the declaration “Perception is an Illusion” (*Chikaku wa maboroshi.*) For example, Terada and Nishida were fond of pointing out to people that humans’ visual experience of the world as a single and uninterrupted picture is an illusion. When producing a visual perception, our eyes are in almost constant motion, called saccadic motion, picking up slivers of light that are stitched together into one picture somewhere between the retina and the brain.[47] Such information is full of seams (*hokorobi darake*) that do not draw our attention.

The technological induction of illusions is a goal for the WTL for two reasons. First, insofar as the mechanisms that give rise to illusions are specific to human shintaisei, the successful induction of an illusion is an indicator that a technology has indeed approached some relevant aspect of human embodiment, and is therefore capable of sharing human perspective. It is in this way that the GVS described above can be experienced as a human-centered technology: its successful induction of the illusion of lost equilibrium is evidence that it has matched an aspect of human embodiment. Accordingly, the expression "illusion-based interface" is a frequent synonym for "human-centered technology."

Second, since illusions are stitched together from multiple forms of information, and because there may be more than one at work at any given moment, they also allow the possibility that an appropriately designed interface can induce new behaviors by modifying the illusions a person perceives. The above excerpt on sakkaku continues:

> A method for using sakkaku in the guidance of behavior will use a [person's] initial state to predict [his or her] perceptions, and produce a new perception. Based on this new perception, the person will spontaneously and voluntarily alter his or her own behavior. [...] It is an interface that does not oppose your intentions, but when you realize it, your body will have moved.

For the WTL, illusions can be exploited to change a person's behavior in a "subtle" way, by modifying how a person perceives the world so that he or she responds differently in it. For instance, a person can maintain the illusion that permits him to work on one task, while an interface operates on a set of circuits involved in another. The video of the future application of the GVS illustrates this: it works on the circuits involved in the person's walk, without changing his engagement with his handheld device. By using illusions, these human-centered technologies make it possible for events and stimuli that might otherwise demand the user's attention to be addressed without passing through his or her "high level systems", effectively making something that was part of an explicit reading of ambience into an element of a tacit reading.

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47 Another of the lab's devices, called a "saccade-based display," used this characteristic of human vision to produce the illusion of a two-dimensional image from a single row of flashing LEDs. This device was featured in Nishida's art exhibit, discussed in Chapter 6.

In the WTL's view, conventional technologies failed to do this, and in fact demanded more attention from their user, because their monosashi did not match those of humans. As Terada explained, conventional human-machine interfaces do not pay attention to the body as humans' unique monosashi for sensing the world. The information produced by these interfaces is based on the radically different monosashi characteristic to machines. Their use therefore requires conscious interpretive acts, long periods of adjustment and training, or the imposition of physical and mental constraints on the human user. In contrast, by "riding" the human, the PH matches its monosashi with those of the human, permitting it to share the human's perspective. Illusions can then be manipulated to effect "subtle" and "gentle" forms of behavior modification, because they can selectively activate and alter certain aspects of a person's body and perspective while leaving others relatively stable. A good illusion-based interface makes the human's overall perspective persist while using the affordances of shintaisei to alter behavior.

5.3 Illusion-based Interfaces

The WTL uses the following diagram, which appears in nearly every one of the texts introducing the PH, to compare illusion-based interfaces with more conventional ways of intervening in human behavior. The human in grey is being "ridden" by the PH system, shown by the network of white shapes and black lines that runs along the person's body. The blue loop shows the feedback process which occurs when a person acts in the world: the person's body moves with its muscles and receives information from the world through its senses, which then shapes the person's subsequent actions.

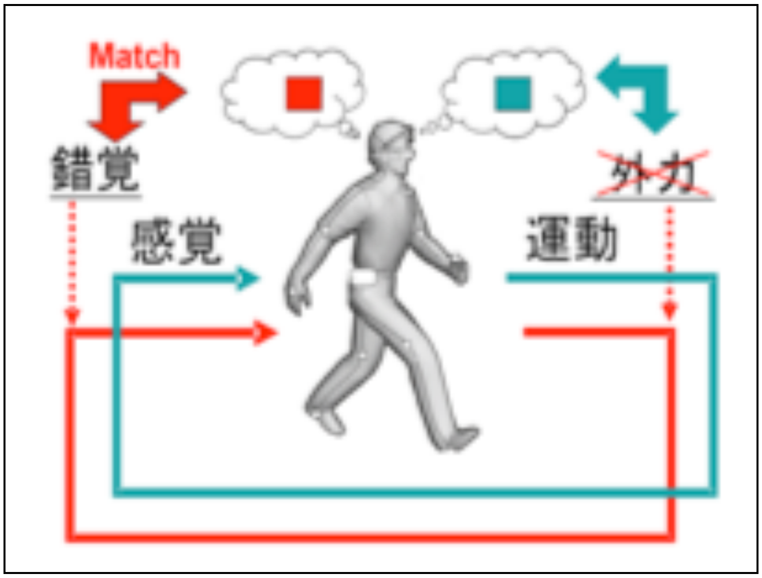

Figure 13. WTL diagram showing the two possible ways of altering human behavior.

The red loop represents an altered perceptual feedback loop, which can be modified in two ways to shape the person's behavior. One way is to induce a change in behavior by applying an "external force" ("*gairyoku*", crossed out by red in the diagram) to the person's body. An example would be if one were walking in a square in an unfamiliar city as the guest of a local resident. You have told your host that you want to eat at a Japanese restaurant. As you walk across the square, you become engrossed in conversation, but when the host sees a suitable restaurant, he or she interrupts the conversation to draw your attention to your destination, or perhaps more forcefully, grabs your arm and pulls you into the shop. Terada suggests in one paper that the discomfort is a result of the gap between what you were expecting to do (keep walking forward) and what you were made to do (stop in front of the restaurant by force), created by external modification of the person's behavior or body. While such a method may be effective, it may cause an awkward and uncomfortable interaction with your friend, or at the very least break the flow of your conversation so that you can process your friend's message.

The PH is conceived to guide behavior in a less invasive way, of which the user may not be consciously aware. Instead of grabbing your arm to pull you into the shop, your host might see the restaurant from a distance, and slowly adjust the direction that he or she is walking towards the restaurant, while continuing your conversation. Though you may not realize it at the time, you may also begin moving towards the restaurant as you try to maintain an appropriate distance to your friend as you walk. Eventually, your friend would stop walking, causing you to stop as well, and you would look up to find that you are in front of an appealing restaurant. In this case, no external force needed to be applied. Your own intention to keep walking forward was never explicitly contravened (indicated on the diagram by the word "Match"), but due to your friend's subtle intervention, your sense of what it meant to keep walking forward shifted slightly, producing an outcome that you had not foreseen but may have chosen had you been aware that the restaurant was ahead. The friend has, in effect, maintained the illusion that you have kept walking in a consistent way in order to redirect your behaviors to reach a desired destination.

The friend's second role is analogous to the one that would be played by the PH. In the video mentioned above depicting a future application of the PH, a man walks down a street with his attention consumed by the screen on a handheld device. He does not notice a motorcycle quickly approaching him from behind, but the sensors to which he is connected do. The PH activates the GVS interface, which causes him to perceive himself as losing balance or the ground as having tilted, making him step out of the way of the threat without diverting his attention from his current task. With such non-verbal interfaces the PH would not explicitly command or suggest courses of action to a user, but alter their perceptions of their surroundings so as to induce a person towards new behaviors.

The most frequently used illusion-based interface in the lab was the head-mounted display system. Over the last four years, several versions of the HMD had been developed. They differed from each other in several respects, but all were designed to give their wearers as close to a "natural" viewpoint as possible. Early versions had rigid frames that kept the cameras on each HMD parallel to each other, while in a later version, the cameras were mounted to a pair of swim goggles that let the cameras move independently, letting the HMD more closely conform to the curves of each individual's face. However, all versions of the HMD maintained the basic correspondence of cameras to LCDs to eyes. The cameras and displays in each HMD were combined with mirrors to form an "optical conjugation" system, which positions the viewpoint of each camera so that they very nearly match the natural line of sight of the wearer. Mirrors positioned on the headset in front of each eye reflected light from in front of the viewer into the cameras, which were situated above the forehead, or to the sides of the user's face. When looking straight at a person wearing the HMD from the front, the reflected images of the cameras correspond closely to the positions of the wearer's eyes, making it appear as though they have been perfectly replaced by the tiny cameras. A post-doc in the lab compared this appearance to "Bato-san," the cyborg crime investigator with ocular implants who appears in the *Ghost in the Shell* series.

The system's basic mode of operation is "video see-through," in which images from the pair of cameras mounted on the front of the device are captured and displayed on the corresponding pair of LCDs positioned directly in front of each of the user's eyes. In this mode, the user sees on the screens what he or she would see without the PH device on, albeit with diminished resolution, color, frame rate, and a narrower field of view owing to technical limitations of the cameras and displays used. Pairs of HMDs are also commonly linked together for "view-sharing," which feeds one wearer's headset the view from the other's cameras, giving them the other wearer's first-person view. In view-sharing mode, the images from the two HMDs can be combined in a number of different ways to facilitate different interactions between the wearers. Whatever the mode, the HMD was intended to present visual information that wearers could treat as equivalent to their usual vision.

While the view through the HMD was a pale digital version of ordinary vision, the experience was incredibly immersive. When the HMDs were in video see-through mode, people would have little trouble orienting themselves in their surroundings, as long as the thick cables that connected it to the computers on the floor were out of the way. During CPR experiments, subjects would often forget for a moment that they were looking through an HMD, and collide with the dummy when they had to bring their faces near its mouth. Because the HMDs added considerable bulk to the wearer's face, the lab was always looking for ways to miniaturize the system of mirrors and cameras though this would involve a trade-off with the field of view.

Wearers would take the minutes before an experiment to look around the room and see their familiar surroundings through eyes that were nearly but not quite like their own. Invariably, they would look down at their hands, as if to confirm that they were indeed still inside their own bodies. When the HMDs were paired and their views swapped, it was very easy to believe that the world one was seeing was still from the perspective of one's own body. On more than one occasion, I looked at a person across the room wearing an HMD for a few moments before realizing I was looking at myself. Such "out of body experiences" are reported frequently among people who have worn the HMDs and similar devices (Tachi 2010, 160-161).

When wearing the HMD, the ordinary feeling that I was present in my own body was strongest when the movements I saw my hands making corresponded closely to the movements I felt them making. This feeling was difficult to maintain in skill transfer experiments, which swapped or combined the views from a pair of HMDs (or when one HMD displayed a recording from another) to permit a "Beginner" to learn a manual skill from the first person perspective of a "Master," as the two HMDs were labeled. It was common for people in the student role to become confused and disoriented when the view that they saw diverged greatly from the body movements they felt, or, when the views were combined, they became unable to distinguish their own hands from the master's.

Techniques such as "time stabilization" and "space stabilization" (*jikan sutabiraizu, kuukan sutaburaizu*) generated visual illusions that minimized this disorientation. Consider the skill transfer of knot tying. When two users are linked in real-time, the master will often wait for the student to catch up after performing a step, but the master is not always able to wait for this to occur. If the master gets too far ahead of the beginner in the performance of a task, then the beginner can become disoriented and unable to catch up, since he may not be able to see the current state of his own hands and rope. This problem is exacerbated when a user is attempting to follow a recording, which will not know to wait for the beginner.

To avoid this disorientation, the lab created time stabilization and space stabilization, which were both at a very early stage of development during my fieldwork. Both process the image that the beginner sees so that if a significant spatial or temporal gap develops between the beginner's motion and the master's motion, the beginner will be presented not with images that directly correspond to what the master is doing, but which "wait" for the beginner. In the conventional view-sharing system, if the master looks away to the right suddenly to see the far end of a rope she is tying and the beginner does not perform the same movement quickly, then the beginner may be left facing forward while his or her view shows the end of the rope. If the beginner tries to reach out for that end, then he or she will be unable to find it, and moreover will not have the visual information to be able to re-orient himself correctly. Space stabilization tracks the current head orientation of the beginner so that he sees what the master would be seeing if the master were still facing forward. Then the beginner will be better able to see where the master's attention has now turned, and move himself accordingly.

Time stabilization is similar except that it slows down or pauses the image that the beginner sees so that if the master is performing a complex multi-step task, the beginner need not be able to perform the task at the same pace in order to maintain a correspondence between what she sees and what she feels with her hands. For instance, if the master goes through the steps of tying a rope quickly, the beginner who becomes confused at an early step will become increasingly disoriented as her view shows the knot being tied, but her hands still hold a rope in an untied state. Time stabilization would slow the image she sees so that she is able to follow and eventually catch up to the master's movements. In either case, the beginner need not be aware that she is no longer exactly matching the master's actions. The HMD system does the job of translating the information from the master so that the time and space transmitted visually from the master better match what the beginner is experiencing with her hands. In this case, the HMD paints an illusory visual world in order to allow the beginner to maintain the expected relationship between her sight and proprioception, and focus on the actual task at hand.

The illusions produced by the HMD and other devices work because they preserve what the user expects should be happening during their performance of a task by monitoring and, when necessary, modifying one form of sensory information to maintain the relationship between it and another sense. For instance, when the time stabilization function is activated, the HMD alters the visual information a person receives to maintain the illusion that what she is seeing corresponds to what she feels through her hands. The effect of this is to allow the relationship between the beginner and her master to be maintained without disrupting the master or requiring the beginner to initiate a disruption. The example of the GVS user threatened by a motorcycle mentioned above is similar; the GVS nudges the user out of the way to prevent injury, without disrupting his interaction with is handheld device, all the while preserving the user's sense that he is simply walking down the street.

Note the similarity between how illusions intervene in human sensation and how students were expected to interact with their professors in Chapter 3. The students were required to read the lab's ambience so that their actions were predictable to the professors, reducing the professors' mental loads. The situation here is analogous. If we take the master-beginner interaction in the skill transfer experiment to define a shared reading of ambience, then the beginner must similarly work towards minimizing the mental load placed on the master. Where the beginner might become unable to follow the master without, for instance, asking him or her to stop for a moment, the illusion intervenes to help the beginner catch up, avoiding drawing the master's attention, permitting the master to continue without disruption. The illusion intervenes when the coherence of the shared reading is threatened, holding together two elements of its when they are at risk of growing apart.

Whereas in social situations, mental load had to be minimized, illusions reduced a corresponding quantity called *cognitive load* or *ninchi fuka*. The "goodness" or "human-centeredness" of an illusion-based interface is indexed by cognitive load.[48] Like mental load, cognitive load is not an objective quantity that can be directly measured. It can be observed indirectly by comparing quantities such as the time to needed to acquire a manual skill using HMDs or the accuracy of bodily movement effected by a GVS, but it exists primarily as the general cause of relative differences in such quantities (e.g. the time taken to acquire a task may have been longer because the student experienced a high cognitive load.) It also permits the relative comparison of the comfort and quality of the sensorial experience of different kinds of interface. It is often invoked along with the term *iwakan* (discomfort or strangeness), which refers to the sensory experience of an unpersuasive illusion that imposes a high cognitive load. The effect of reduced cognitive load is described with terms such as "increased reality" (*riariti koujyou*) and "immersion" (*botsunyuu-kan*).

Cognitive load also applies more generally in the lab beyond its significance to illusion-based interfaces, because it is associated with the degree that the body's predictive perceptual mechanisms have failed to work. In an e-mail to lab's mailing list Terada sent while he was away at a research seminar, Terada describes how a high cognitive load is what results when the unconsciously generated predictions that a person has about the state of their surroundings begins to deviate greatly from the actual state of things. The variance increases the need for a person to make observations and use them to correct the prediction, to the point where an unconscious process becomes the object of conscious reasoning and interpretation, raising the cognitive load of the task they may have been performing. Similarly, if the information that a person receives from two different senses is in conflict, then the person experiences a higher

[48] In the lab, what I am calling "cognitive load" also is called "processing load" (shori fuka), "work load" (sagyou fuka), "decision load" (handan fuka), "movement load" (undou fuka), or "perception load" (chikaku fuka), among others, depending on the kind of task being performed.

cognitive load as a result of having to alter its predictions by gathering more sensory data and performing the effort of judging which is most reliable. In general, the "natural" forms of behavior a human performs in the course of everyday life, those to which the body is evolutionarily adapted, are considered to impose a low cognitive load, and therefore "intuitive."[49]

Illusion-based interfaces therefore work because they maintain the kind of "signal" that would ordinarily be produced by the human body; it maintains its explicit reading of ambience and therefore minimizes cognitive load. The PH can guide its wearers' behaviors because it alters the noise, similar to how the students in the WTL used PowerPoints to convey potentially problematic messages. As I discussed there, the students were able to present these messages because they did so in a way that did not affect the kinds of signals that were demanded in the lab; they conveyed their information through tacit circuits. In general, a node in a communication system can operate through a message's noise to subtly change the character of the system as a whole, without disrupting the stability of the system. Here, the PH maintains a persuasive conscious perception—the signal—while subtly altering the noise to push its wearer to perform new actions. Because only the signal component of a message draws conscious attention, the PH can insert a message that alters the system's behavior without disrupting the stability of that system.

This shows that what characterizes a body as human for the researchers therefore lies in the kinds of signals it creates in each situation. These signals embody the relative importance of different sensory modalities or forms of information in the context of a given interaction. In its normal operation, the ranks and synthesizes these different messages, discarding some as irrelevant and amplifying and combining others, to arrive at a reckoning of the state of the body and its surroundings, which it presents as an illusion. Thus, while the PH appears at first glance to be matching the form of the human body, it is actually structured to be able to observe the specific relations of input and output that the body enacts. These relationships are what define a system as human.

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[49] See also the discussion of cogntivie load from Nishida in Chapter 4.

In principle, a human body can be replaced by a machine and still be considered human, provided that the relationships that the machine enacts correspond to those that a human would enact in that situation. In practice, this can only occur when the situation in which the machine is placed is controlled and stabilized to a degree that the input-output relations that characterize a human can be completely reproduced. In "open" systems, these relationships cannot be completely defined, because the human remains a black box, and any unexpected input may set off a previously unknown circuit. Thus, the PH is structured to constantly observe its wearer's behavior so that it can keep reverse engineering its system over a long period of time. Only in closed systems, in which no unexpected inputs are likely to take place, can the "human" can be displaced from its original location in the human body and reside in a machine.

Two technologies from Ishiguro Hiroshi's robotics labs illustrate this point. During a visit to his lab on the Osaka University campus, one of his colleagues introduced me to a small robot called M-3 Synchy which was being used to study the role of robots in improving the quality of social interactions between multiple human conversation partners. Its purpose was to study the use of "non-verbal modalities" to improve the "satisfaction (manzokukan)" and "feeling of oneness (ittai kan)" felt by the human participants. It stood only about 30 centimeters high. Its hands, head, torso, and circular base were light beige, and its eyes were white circles with large and distinct black irises. Synchy's face and proportions made it look like a tiny infant with impeccable posture.

The lab's webpage cites proverbs like "bozu nikukerya kesa made nikui" (to hate even the ground somebody treads on. Literally, "If the monk is hated, then even his garments (stole) are hated") and "the enemy of my enemy is my friend" to introduce the idea that the relationship between two people can be influenced by each of their relationships to a third party. Synchy acted as this third party. Tracking the exchange of roles in a conversation, it would turn to face the active partner with its polite, permanent smile, and nod.

Synchy itself does not speak, and its human-like but very robotic appearance and movements make it impossible for anyone to mistake for an actual human being. Beyond the function to identify the current human speaker, Synchy had no capacity to understand the content of a conversation. However, the researcher explained to me that people still react at an unconscious level to the robot's non-verbal gestures. He hypothesized that when a person sees a robot nodding at them in response to a statement, the person can become “biased” towards having positive feelings. When the robot nods at another person’s words, a person may even unconsciously mimic the nodding response, which may also bias their feelings about the conversation.

This research is based on the premise that even when humans consciously recognize the robot as a non-human, they treat and react to the robot at an unconscious level as though it were indeed human. In some of his preliminary experiments, Ishiguro’s colleague told me that people generally report more satisfaction from a conversation when the robot is present, even perceiving their human interlocutor to have nodded when it was only the robot that had done so. The robot, within a limited role as the silent participant in a three-person conversational setting, can effectively replace a human being, or at least a nodding silent conversant. It does not need to completely reproduce a human being’s appearance or range of behaviors to have a similar effect. The Synchy example suggests that its human partners can apprehend it as non-human at the same time as some other aspect of their engagement with it treats it as though it were human within the limited context of a three-party conversation.

In the final section, I offer an extended ethnographic description from Ishiguro’s lab, which demonstrates the dependence of humanness on the shared reading of ambience. In this case, I and many other visitors to the lab failed to perceive the presence of a robot in our midst, because the combination of its embodiment and behavior was matched to our readings of the ambience of the space we shared, making it a human like any other.

5.4 Invisible Android

I stepped out of the cramped back seat through the suicide doors of Omoto’s black Mazda RX-8 roadster. After more than an hour of sometimes harrowing driving through rural roads under drizzling skies, Omoto, Nishiwaki, Sato and I arrived at ATR, a public-private research facility in an area called Keihanna, at the intersection of Kyoto (Kei), Osaka (Han), and Nara (Na) prefectures. The area is populated by many private and public corporations, a major science and engineering research university, research institutes like ATR, and the imposing monolithic glass and steel structure of the Kansai location of the National Diet Library. Omoto spent his childhood nearby, and he pointed out the grassy valley where his parents still live in an old and modest house as we approached ATR. None of these research buildings were here in the past, but now the area has become a “science city”[50]—we were in the middle of a regional center of the most advanced technological research in Japan, surrounded by the new residences, shopping centers, and roads that support it.

Though Omoto spent some of his pre-doctoral career at ATR as a research associate, the WTL did not then have any formal connections with the various labs that populate the sprawling structure. However, the WTL’s postdocs and professors were well acquainted with many of the people there doing interface and virtual reality-related research. Moreover, ATR housed one of the robotics research labs established under Hiroshi Ishiguro.

The four of us were there for the annual ATR Open House, when all of the labs set up demonstrations, posters, and talks to introduce their research to the general public. The technologies on display addressed the full gamut of human sensation from sight to hearing, and smell to touch. I passed by demonstrations of a three-dimensional holographic display, a haptic system to impart the sensation of touching a virtual object, and a curious sound processing system which simulated the experience of hearing through differently shaped ears—another person’s, a rabbit’s or a bat’s. The crowd flowing through the building’s halls and rooms was large and diverse. In addition to many university students and researchers like us, there were groups of uniform-clad junior high-school students on short school excursions, and a few elderly men and women who decided to take advantage of this opportunity to explore this usually closed space.

Terada had encouraged all of the WTL students to make use of the Open House to learn about the breadth of research being performed at other institutions. Some of the other students would come on its second day to see the demonstrations, but today, only Sato was here; she was interested in ATR as a possible next step in her research career, and intended to spend the day experiencing the different technologies and become acquainted with other researchers. Omoto and Nishiwaki had come to catch up with colleagues. I came to take in the demonstrations, and also to meet Ishiguro’s colleagues, after having spoken to him a few weeks earlier at his lab at Osaka University.

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50 Keihanna is one of three “science cities” developed since the 1960s near major metropolitan areas in Japan, where public and private research and education organizations have been concentrated.

As we entered ATR, each of us received a map and small information booklet that showed where each lab had set up their demonstrations. My eye went directly to a large room on the ground floor marked on the map as a special demonstration by the Ishiguro lab. After exchanging phone numbers with the others to make sure we would be able to find each other at the end of the day, the four of us split up and I made my way to the Ishiguro lab's demonstration area. Arriving at the point designated on the map, I found a small lecture room that had been converted into a cafe. I peeked inside to see two waiters dressed in black and white uniforms standing at one end behind large brown plastic tanks of hot coffee and tea, and stacks of small paper cups. The rest of the room contained metal bistro tables, each with two chairs and small glowing orbs as centerpieces. The room was quiet and dimly lit: a handful of people sat drinking coffee while looking at their booklets and maps, but it was only the two women at a table near the far end who seemed to be in conversation. At first, I assumed that the cafe had been set up by the Ishiguro lab as a courtesy to visitors of the open house, but its atmosphere felt out of place for the venue and occasion. From the uniforms of the waiters to the style and layout of the tables and the dim lighting, it was clear to me that a great deal of thought has gone into evoking the feeling of a café patio at twilight. Confused, I walked past this room several times expecting to find a brightly lit, bustling demonstration area somewhere nearby where different robots from the Ishiguro lab would be standing for visitors' inspection. Eventually, I decided to partake of the free coffee while reorienting myself in the building.

I chose a table near the center of the room and seated myself as a waiter took my order, quickly bringing me a cup of strong, dark coffee. With my notebook open, I began to look around the room and noticed that there were a dozen small video cameras mounted high on the walls, all targeting different tables and areas of the room. Wondering why they might be recording patrons of the cafe, I looked towards each table in turn and my attention settled again on the pair of women sitting at the table behind me. I adjusted my seat to be able to see them more easily. They were young, both in their late 20s. One had her back turned to me, but I could see the face of the other. Each was dressed similarly in skirts that ended below their knees and light knit cardigans, not unlike what Kawasaki (the PD in the WTL) wore to the lab each day.

The two women seemed to be friends. They updated each other about everyday matters: what their families have been up to recently, the acquaintances they have seen, the jobs that they struggle with. Theirs was an ordinary conversation that one might overhear at a café, but it felt out of place when, outside this room, everyone else was concerned with haptics, olfactory interfaces, and ultra high definition displays. Then I noticed the voice of the woman whose back was turned to me. It was strangely compressed, cutting through the dull murmur of the room with its narrower dynamic range. It also seemed to be emanating not from her, but from just outside of her body, near her legs. My eyes followed my ears to see a black speaker on the floor I recognized from my earlier encounters with the Geminoids. I realized the woman with her back to me was a robot. I quickly looked around the room at the other cafe patrons, but none were paying any special attention to the table with the two women.

I was seated in the midst of a techno-social experiment. After my coffee, I met with Yukawa, a young associate professor in the Ishiguro lab involved with Geminoid research, who explained the cafe to me. The cameras were targeted to record the reactions of the cafe patrons in the room and to give the operator of the Geminoid views of her conversation partner and immediate surroundings. In addition, the lit centerpiece in the middle of each table contained a microphone to record the cafegoers' conversations. One of Ishiguro's students told me that he had gone to great trouble to hide the microphone cables. I told him that I had not suspected anything amiss with the tables, and he looked very pleased. Upon leaving the cafe, patrons were stopped by students of the lab who were dressed up for the day in business formal outfits to facilitate their momentary impositions on visitors. Each person was asked to fill out a brief survey to see if he or she had noticed the robot in the cafe. Some visitors were taken aside and asked to participate in video recorded interviews. All of these post-café activities took place around the corner from the cafe's entrance, so that new visitors to the cafe would remain naïve to the experiment.

Figure 14. The Geminoid F.

Although I did not realize immediately that one of Ishiguro's robots was hidden in plain sight, I knew that similar experiments had been performed in the past. One took place in 2009 at the Ars Electronica show in Austria. That year, the Geminoid modeled on Ishiguro himself was placed in a cafe in Linz, while Ishiguro controlled it from Osaka. In that case, the Geminoid's presence turned out to be less of an experiment than a public display: a student told me that in Austria, the Geminoid was almost immediately recognized as non-human by passersby, not necessarily because it was a robot. The presence of a Japanese man in that setting drew increased attention.

The students who hovered outside of the cafe peeked in from time to time, and whispered to each other about who in the cafe had noticed the robot before they were shooed away by Yukawa. They wondered if the crowd that had begun to gather outside of the cafe had come because they had heard about the Geminoid or were after the free coffee. I was caught up in the excitement that they seemed to be feeling as more and more people crowded into the cafe, and fewer of them seemed to realize that they were sharing the space with an extremely human-like machine.

When I visited the lab again a few weeks later, they were not ready to reveal the results of the experiment to me, except to say that the majority of people did not realize that the robot was there. Indeed, even Omoto, who avidly followed the development of the Geminoid, told me he entered the cafe expecting a robot to be there, but did not realize who the robot was until a few moments before finishing his coffee. Neither would I have guessed a robot was there, if I had not noticed the cameras in the room and known before arriving that the lab had done similar experiments in the past.

The success of this experiment was gauged in terms of the failure of nearby people to recognize the robot's unique presence. Her humanness was measured through the quality of the conversations or explicit social interactions of which the robot was capable, but through the extent of its disappearance into a crowd of humans. Its disappearance does not imply invisibility however: the researchers understand it as a partial visibility. Different robots can be differently human, depending on the context and nature of the interactions through which the engage human beings. One way of differentiating these ways of humanness is through the context: a human-like robot sitting in an audience of a play, for instance, does not need to behave in the same way that a robotic conversation partner does, as Ishiguro is often known to point out. Its appearance might simply need to be realistic enough to be mistaken for one through a person's peripheral vision, and laugh, clap, and be silent at the appropriate times; while the other would need to access a wide range of knowledges and interactional modalities, and be more detailed in its appearance to be convincingly human. As shorthand, one of the lab members referred to these in terms of the time duration of the expected successful interactions: a “five-second” human is not the same as a “five-minute” human or “five-hour” human. In the cafe experiment, the robot passed the “five-second” test with flying colors: at a glance, of the kind you might give other patrons at a Starbucks, the robot is human.

On one hand, the statement that the robot is human might refer to the persuasiveness of its deception. Viewed in terms of its internal mechanisms—its software algorithms, mechanical actuators, cameras, and so on—the robot is unambiguously non-human. If it appears to be human, it is because its true nature is effectively hidden behind a facade created to deceive human beings. The statement implies a gap between what a human subject can know or see of the robot, and the robot’s actual being. The robot’s skin is the boundary across which the electro-mechanical truth of its being is concealed by a partial but convincing representation of humanness.

However, when this statement was uttered in the Ishiguro lab, it was often used with a different meaning: the robot does not simply appear to be human; it truly is human. For example, a “five-second” human is not just a robot whose deception remains effective for five seconds, but a robot who in those five seconds, is the same as a human perceived for five seconds. While five seconds shared in a queue at a cafe is not equivalent to five seconds under a surgeon’s scalpel at an operating table, the point is that if it acts as a human would be expected to act in a given situation, then it is human.

That the Geminoid should meld with the atmosphere of the cafe expressed the researchers’ view that a good android is one that can seamlessly integrate itself into ordinary human social situations. It should melt into the ambience. The Geminoid can go unnoticed not only because it looks like another human being, but also because it is doing what a human would be expected to do in a café after a day of work over coffee. It embodies the social and material character of a human being who would occupy such a space, and by doing so it becomes human, nothing less than what a person sitting in the café would expect of any other human sharing that space.

5.5 Conclusion

In this chapter, I have delved into how HCT researchers understand a body as "human." I have shown through an analysis of how they understand illusions that a body is defined as human because it produces characteristic kinds of messages in various situations. This idea is reflected in the designs of illusion-based technologies. For a system like the PH, which is designed to follow its human users through a range of situations, the PH cannot completely reproduce the circuits that might be activated in its user across the full range of its activities. As a result, it is built to share its user's perspectives by matching the contours of the user's body. This allows it to continuously observe how the user responds to different situations, and refine a forecasting model that will allow it to produce persuasive illusions in similar future situations.

In contrast, the Synchy and Geminoid robots also produce illusions, but they can mimic far fewer of the outputs that an actual human is capable of producing compared to the PH. Nevertheless, they can also induce extremely persuasive illusions for the people with them, provided that they are placed in a controlled situation, in which the corresponding actions of an actual human would be similarly simple.

Together, these systems show that for HCT researchers, that the material body itself is not important to how they understand a human. Rather, it is the particular relationships between input and output messages that the body enacts that define its system as human. Where these relationships can be completely reproduced by a machine, then that machine can replace a human. But in cases where they cannot, then the body must retain its place at the center of human-centered technology, where it serves as the target system in a process of reverse engineering without a definite end. In general, the human is enacted as a particular kind of system through its relationship with its surrounding systems. When these surroundings are closed, then the body's importance to humanness dissolves, but when they are open, the human body must remain at the center of human-centered technology.

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Chapter 6
Ambient Information Societies

6 Imagining a Societies with HCTs

In this chapter, I ask how HCT researchers understand the social necessity and value of human-centered technologies. The view that the human is a system of communication holds the key to understanding how the researchers create technologies that are "human-centered" and that humans can interact with naturally. These machines can even replace humans, depending on what kinds of larger systems they are introduced into. This raises the question of the purpose of creating HCTs. If their society is the larger system into which HCTs will be introduced, then what do they envision HCTs doing to society? Why do these researchers see HCTs as so necessary?

This question returns our attention to the ambivalent place that technology has occupied in postwar Japan. Following the war, technology was to be used to create a democratic society that would not fall back into militarism and totalitarianism. However, there were two competing visions of what kind of society technology could create. Would it be a technocratic one in which humans would use technology economic growth and the establishment of a consumer society? Or, would it be a utopian one, in which humans and technology would shape each other to found a more radically democratic society?

While the question has been answered in favor of technocracy in postwar Japan, the emergence of human-centered technology re-establishes this debate on a new basis. By casting the human as a system of communication, HCT translates the question of what kind of society technology should support into a question of what kind of communication system humans exist within. The question becomes, should human-centered technologies work to reinforce existing systems, including existing forms of the human, or should they work to explore and redefine these systems? In Deleuze and Guattari's (1987) terms, should human-centered technology be made as a "royal science" that works to "prop up the state" as it exists (Pickering 2010, 11), or as a "nomad science" that can reveal ways to subvert state order.

In this chapter, I examine how HCT researchers answer this question to show that the HCT view of humans as systems of communication can reproduce existing imaginaries of society, but it can also reveal potentials for new kinds of relationality. HCTs can support human beings as they try to adapt to the intensification of technocracy, or they can help humans to establish new forms of relationality that challenge technocracy.

An analysis of how HCT researchers articulate these two possibilities shows that the kinds of societies that the researchers imagine their technologies fostering depends on the kind of communication system they imagine the human to be. In the former case, they view the human communication system as one structured first by the fact that it is a form of life. This limits the kind of system that the human is to resemble existing forms, making HCT into a royal science. On the other hand, when they suspend the assumption that the human is a form of life, and focus on it first as a form of communication, they articulate a view of HCT that is nomadic. In this nomadic view, the existence of unexpected human circuits becomes tangible and perceivable with the help of human-centered technologies.

This chapter shows that for HCT researchers, "life" is extremely easy to conflate with "communication," but ultimately life for them is no more than a form of communication. The assumption that humans are a form of life imposes strong constraints on the kinds of systems they can imagine as human. In contrast, taking communication as more fundamental to humanness than life reveals for them the possibility that humans embody connections that can be felt but not yet made explicit. That both these views are possible simultaneously shows that communication is the "meta-value" that undergirds their notion of the human.

6.1 The Ambient Revolution

> "Ambient." In the dictionary, the word is defined as "the encircling and encompassing" [*gururi to torimaku*]. The entirety of an encircling and encompassing environment, a world designed as if to your order. The "Ambient Information Society" is one in which ICTs have naturally melted into the environment; they approach humans from every angle, as though they were organisms living in symbiosis with humans. Without one's awareness, the barriers between human and ICTs disappear, flexibly intersecting with each other [*shinayaka-ni kousa shite*], creating a new ecosystem. The model for this symbiosis is found in the workings of life itself.
>
> —from *The Ambient Revolution: The Evolution of ICT from "Use" to "Feel"*

In 2009, the WTL was featured in a booklet produced by Osaka University and the "Founding of the Ambient Information Society Infrastructure" Global Center for Excellence

(AIS-GCOE). This publication, entitled *The Ambient Revolution: The Evolution of ICT from "Use" to "Feel"*, served as a public introduction to the activities of the nationally-funded research program. The booklet describes an astounding vision of a society in which information and communication technologies (ICTs) have "dissolved" (*tokekomu*) into the environment, essentially creating a "new ecosystem" ordered by ICTs as though it were designed for each individual. It contains dozens of vivid color illustrations that traverse the scales of the nation, the city, the household, the street, and the petri dish. Dogs and cats, men and women, buildings and motorbikes, and trees and satellites are all marked with colored points from which emanate lines and concentric circles signifying wireless connections. On another page, an illustration shows the systems in a house that detect the departure of the (male) breadwinner from work, activating a rice cooker and filling the bathtub in preparation for his return home. A woman reclining in a chair watching television with a cat in her lap is notified of his approach via her mobile phone. It is a vision of utter convenience for modern middle class human beings, and of total integration and transparency among an array of heterogeneous agents made possible through ICTs.

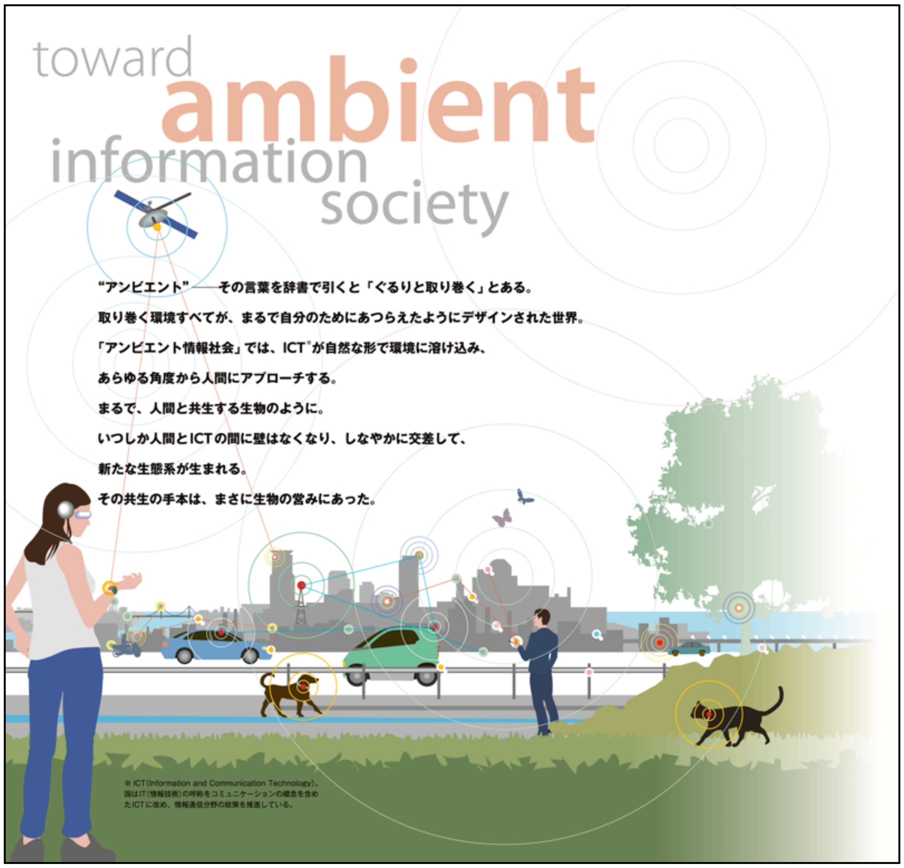

Figure 15. Representation of the Ambient Information Society from the AIS-GCOE booklet.

What is striking about this image of a future “ambient information society” is how, in spite of its integration of technologies that are new or yet to exist, the kind of life they support is utterly familiar and traditional. Jennifer Robertson calls this “reactionary postmodernism,” in which the humanoid robots are conjured into the imagination to erase the existence of ““‘something”—whether that “something” be wartime memories, history, immigrants, individualism, privacy, autonomy, and so forth”—that might threaten the status quo rather than deal with the difficulties and transformative potentials that “something” presents (2010, 394). Instead they participate in the reinvention of the timeless, traditional family, and project it into a posthuman future in which the Japanese population may have shrunk and grayed, but life continues as it has because the productive work of robots without culture or historical memory ensures Japan’s social and economic survival. Like the domestic robots that Robertson discusses, the broader category of human-centered technologies seems to participate in this same erasure, making robots into adopted members of traditional families, enlisting them into a state project that joins technological progress with “an ethos of revanchism.” (381) Human-centered technologies are enlisted to make up for the loss of human beings created by the country’s declining birthrate and aging population. The system embodied in this image of the ambient information society is one that has hardened to support the reproduction of a reactionary ideology.

The AIS-GCOE shared this hardened image of society with its predecessor. The AIS-GCOE was proposed as the next step beyond the project of “ubiquitous information” that had characterized Japanese ICT policy in the mid-2000s. The Japanese Ministry of Internal Affairs and Communications implemented a broad program of ICT research and development called the “u-Japan” project, whose aim was to realize a “ubiquitous network society” by 2010. Such a society would have network technologies that allow easy connection “anytime, anywhere, by anything and anyone.” The policy envisioned the close integration of wired and wireless networks, authentication systems and information servers, and various kinds of terminals to allow constant and universal access to information services across Japan.

These aspects of the policy have largely been fulfilled, but the u-Japan policy also promised solutions to a “mountain” of problems facing Japan that would be made even more urgent by *shoshi koreika*—a declining birth rate and aging population. u-Japan’s two broad goals were to promote economic revitalization and improvements in the safety and security of society, which were divided into ten problem areas that ubiquitous access to information might address (Figure 16). The u-Japan policy ended without concrete solutions to these problems.

Structuring these concrete problem areas were two ideological goals that the u-Japan policy had as its overall desired outcomes. By 2010, the policy sought to make “80% of the population appreciate the role of ICT in resolving social problems” and “feel comfortable with ICT.” These goals were formulated on the premise that ICTs are a “magic bullet” (*kiri fuda*) for solving the mountain of social issues, and sought to instill this attitude in the Japanese population. As Robertson (2007) argues for humanoid robots, by framing ICTs as the solution to all of Japan’s social and economic issues, the u-Japan policy obscures the role of the state and politics in improving the safety and security of society, and transforms population decline and economic stagnation into conditions that demand a technological response.

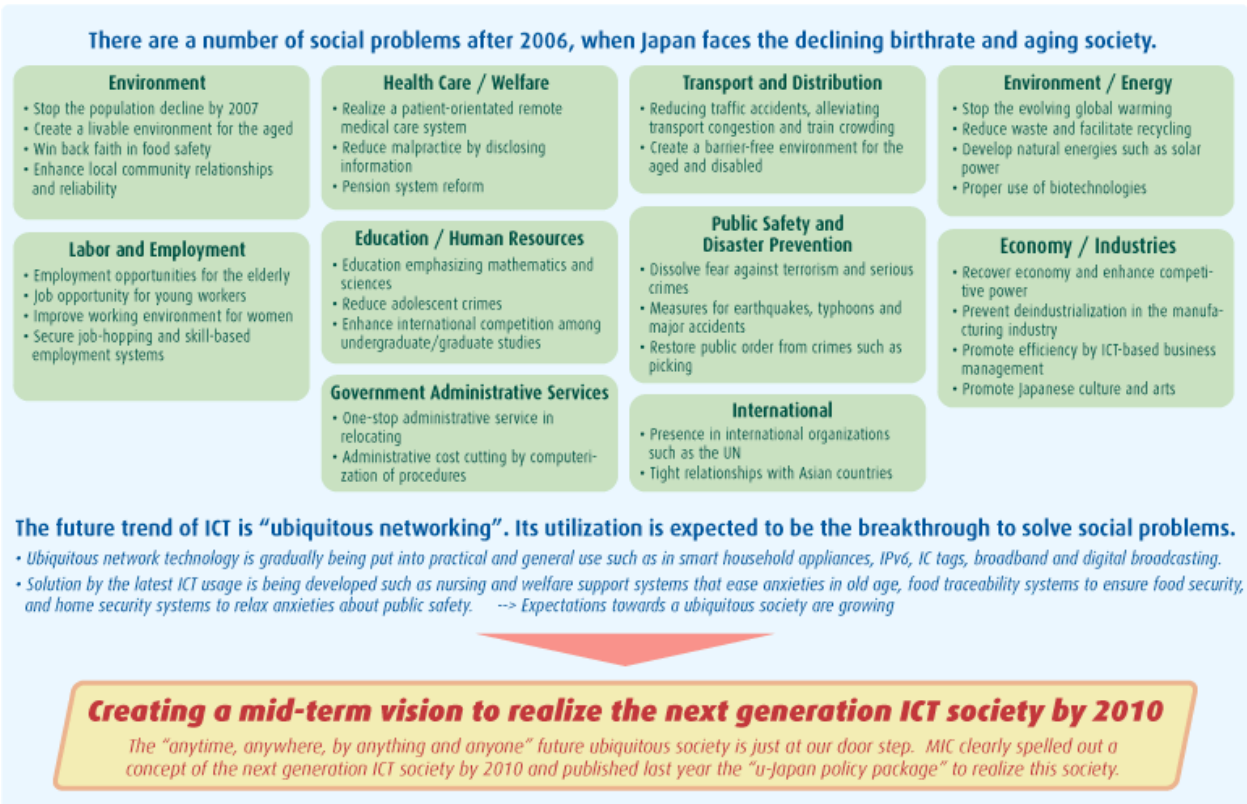

Figure 16. u-Japan problem areas. From Ministry of Internal Affairs and Communications (2007).

The AIS-GCOE proposed to extend the ubiquitous vision into a new, more personalized age, but leaves the "technological fix" approach in place. Rather than the ubiquitous information society, in which technologies are available to "anytime, anywhere, by anything and anyone," the ambient information society would have technologies that are for "you [individually], where you are, and when you need it [*ima, kokode, anata ni*]." One goal of transitioning from ubiquity to ambience is to remedy the social exclusions produced by the existing ubiquitous information society. The exclusions were described in the AIS-GCOE booklet as follows:

> There is an idea known as the "Digital Divide". The words refer to the problem of the gap that emerges between people who can use ICTs and those who cannot. No matter how powerful a computer is, it has no meaning if people cannot use it. What can be done to ensure this gap does not arise? What is needed is an environment that provides services that would not require people to control machines. If this can be

achieved, then even infants and the elderly can receive the benefits of ICTs.

This vision for the ambient information society points towards a future in which everyone can participate in society through ICT by making them easier to use, while hiding the social or economic structural issues that may be responsible for preventing access to them. Ambient information technologies will include not only the elderly, of whom there is a growing number, but also children, of whom there are too few. The integration of a greater proportion of the population into the ambient information society will create a system in which "[e]ach individual element contributes to the working of the entirety, creating a great dynamism, and a society that is balanced as a whole. This can also contribute to energy conservation and increases in productivity." The AIS-GCOE thus shifts from the perspective of ubiquity, which addresses the society or the population as the subject with which machines must interface, to ambience in which it is the individual, with whom machines interact in ways specific to time, setting, and person to integrate them into "a great dynamism." The relationship of human to machine is not one of the "user" to the "used" but of partnership among beings that "feel" each other.

6.2 Symbiosis

The model for this relationship is biological symbiosis. The use of biological models for understanding human-machine relationships is the major point of divergence between the "ubiquitous" and "ambient" approaches. It reflects a greater reliance across many areas of information science and technology on biology to provide insights into problems of system design and interconnection, an approach known as biologically-inspired engineering.[51]

While the introduction of biological metaphors such as symbiosis provides creates a persuasive framework in which to understand human society, it also reintroduces the assumption that humans are a form of life, prior to their being systems of communication. The reinscription of life to define humans constrains the kinds of communication that can be imagined, and limits the human relationalities that researchers can imagine to those that resemble the contemporary technocratic society.

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[51] See Karen Barad's discussion of "biomimicry" in science and technology (2007, 364-369).

The use of biological metaphors in HCT reflects a history of exchanges between engineering and biology that has taken place among the AIS-GCOE researchers. The studies of biological symbiosis that inspired the AIS-GCOE originate with the lab of Yomo Tetsuya, a biophysicist at Osaka University. Though their specializations differ, Yomo and Terada have been colleagues since before Terada came to Osaka University. In 2000, they were both selected as the first recipients of the Precursory Research for Embryonic Science and Technology (PRESTO) program, operated by the Japan Science and Technology Agency to fund basic research and collaborative meetings into strategic sectors identified by the Ministry of Education, Culture, Sports, Science and Technology. The theme during the year of their selection was "Intelligent Cooperation and Control" (*Kyouchou to Seigyou*). (The Japanese title is also presented as "Interaction and Communication: Towards [an] Objective Science of Subjectivity" (*Intarakushon to komyunikeshon: Shukan no kyakkankagaku wo mezashite.*)

Theoretical insights from Yomo's lab regarding the mechanisms that lead to symbiotic relationships were central to the conceptual apparatus that drove the technical work of the AIS-GCOE. A 2006 paper from Yomo's lab analyzed the responses of *E. coli* bacteria when confronted with new and unfamiliar environments, laying the groundwork for understandings of how symbiosis emerges. In many cases, the response of cells to environmental stimuli are mediated through a process called "signal transduction," which uses complex signaling networks within the organism in order to activate a specific response encoded on its genome. These signal transduction pathways evolve over time in response to frequent and familiar conditions.

When the organism encounters an unfamiliar environment change, such as the sudden approach of a new species, pathways for generating an appropriate response do not exist. However, organisms are nevertheless able to respond in ways that allow them to survive. These responses may not have been evolved specifically for the conditions, but often there will be one existing response pathway that is more adaptive than other possible ones. The question the paper addresses is, how does an organism select the most adaptive response to an unfamiliar stimulus in the absence of an established response pathway?

The paper explores this question using genetically engineered varieties of *E. coli* bacteria placed in conditions in which they were deprived of one of two essential nutrients. It was observed that the bacteria would flexibly switch between two states in which they could produce the missing nutrient, and return to a normal state when normal environmental conditions were established. In a series of experiments, the researchers excluded the possibility that this behavior was due to the selection of random genetic mutations present in a small number of bacteria and the presence of "hidden" signal pathways that may encode the adaptive behavior. The paper investigates the mechanism of "attractor selection" in order to explain how these cells produce adaptive behavior.

The idea of attractor selection is illustrated by a series of diagrams in the AIS-GCOE booklet, which represents a biological state with a spatial visual metaphor. In one diagram, the range of an organism's possible behavior is represented by a curved plane (Figure 17.) A sphere represents the current state of the organism, and the wells represent "attractors," the various states that the organism can assume. The sphere falls into one of the "wells," signifying that the organism has entered one physiological state over other possibilities. The depths and positions of each well represent the likelihood of the organism entering a given state. Such diagrams are frequently used to represent the behavior of physical bodies in gravitational or electromagnetic fields. For a gravitational field, the configuration of wells corresponds to the presence of massive bodies, while the sphere would be the body that ambles between them, pulled into unpredictable and chaotic paths by the fields it encounters. Here, the plane corresponds not to an external plane of possible spatial states but an internal plane of possible behavioral states.

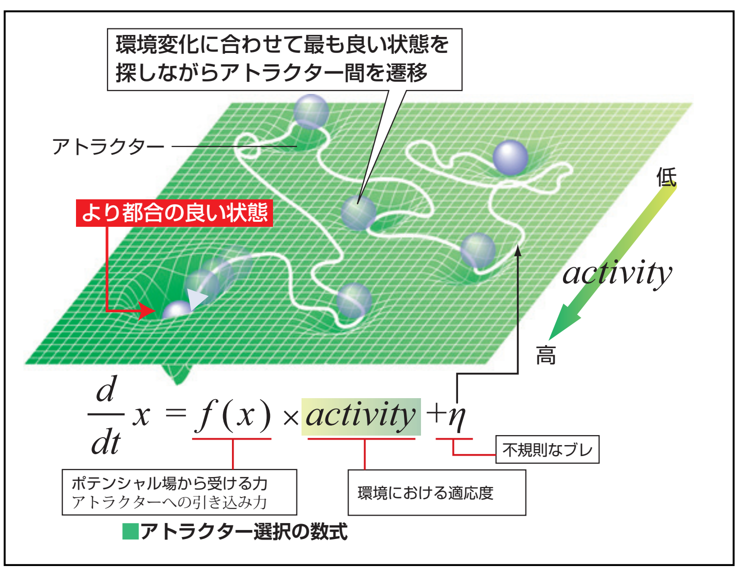

Figure 17. Graphical representation and equation of attractor selection.

The diagram visually represents the "attractor selection" formula, which relates the state of an organism at any given time to the range of available states:

$$dx/dt = f(x) \times \text{activity} + \eta$$

where dx/dt is the change in the state of the organism, x, over time, f(x) is the "force" experienced by the organisms by its position on the plane (or the "attractiveness" of each of the wells), "activity" indicates the "level of adaptivity to the environment", and η is noise or an unpredictable flux. As the environment around the organism changes, its "activity" increases. This, along with the "unpredictable flux" inherent in the behavior of the organism, works to push the organism out of one stable state, towards another that is deeper, more "attractive," and more adaptive to the new environment.

The meandering, looping path of the sphere represents how the most "adaptive" state that the organism ends up taking is not the result of a hard-wired response to stimuli, but of a flexible mechanism that permits the best of all available states to be selected when confronted with a previously unknown situation. Through attractor selection, signaling pathways and behaviors that may have evolved for other purposes can be used to produce responses that allow it to survive. The mechanism of attractor selection represents the organism with an innate capacity to deal with unpredictability.

Later research from Yomo's lab used this model to understand the emergence of symbiotic relationships between two species of bacteria. A 2008 paper (Yamada et al. 2008) describes the operation of the attractor selection mechanism in the emergence of mutualistic or symbiotic relationships between two species of bacteria, *Dictyostelium discoideum* (*D. discoideum*) and *E. coli*. Ordinarily, these species exist in a predator-prey relationship. Left on its own, the D. discoideum will consume all of the E. coli, condemning itself to die of eventual starvation in the process. However, Yomo's lab was able to induce these species to exist in a symbiotic relationship in which they form stable colonies containing both species, by placing them in nutrient-poor conditions. The paper describes how reversible, physiological changes, as opposed to evolved, genetic changes, were responsible for modifications in each of the species' behaviors which permit the emergence of a symbiotic relationship, in which both species can survive for a longer period of time, each doing for the other what it needs but cannot do for itself.

In this symbiotic relationship, neither of the bacteria have any agency to act on the conditions in which they live. The "nutrient-poor" conditions to which they adapt are externally imposed. The environment is like a third party in the symbiotic relationship, and it is one that bears none of the burden to change. It is unperturbed by its bacterial constituents, which must use their cellular creativity to devise new ways of living "less stressfully" in harsh conditions. The focus of these representations always remains on the quality of the interaction between the two organisms in symbiosis.

In the AIS-GCOE booklet, the symbiotic interaction is illustrated in an additional set of diagrams. The first two diagrams depict two bacteria—"*E. coli* A" and "*E. coli* B"—in their independent states as orange and blue planes, each with a distinct pattern of wells. When they mutually interact, their planes combine to create a new configuration of wells, and the creation of a new preferred attractor state, which they both assume, acting as though are a single organism. This is what a junior professor in Yomo's lab calls "the smallest model of the Ambient Society."

This diagram is where a crucial translation between bacterial relationships and human-machine interactions takes place. Alongside "*E. coli* A" and "*E. coli* B" appear a "sensor robot" and "human," respectively. The graphical representations of bacterial attractor states are also used to represent the possible behaviors of human and machine. In the third diagram, the plane depicting bacterial symbiosis becomes that of the "Parasite Human" or Parasitic Humanoid, the imagined future human-machine system of the WTL, described in Chapter 5. Each sphere/plane diagram is thus a graphical representation of the bodily perspectives of human and machine which combine to form a third perspective that belongs to the Parasitic Humanoid.

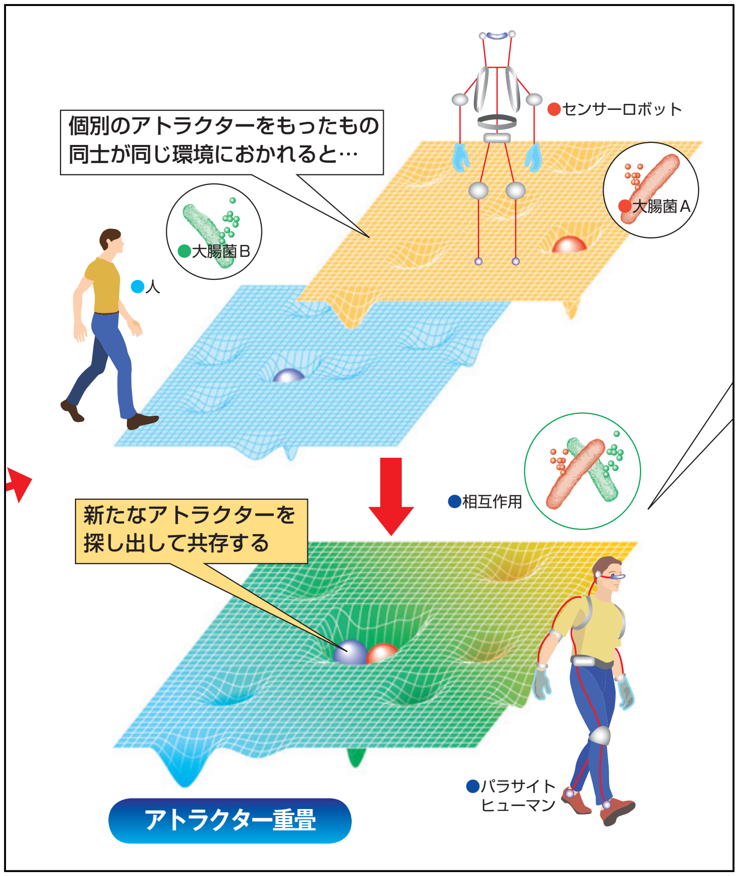

Figure 18. Depiction of E. coli and the Parasitic Humanoid.

Such relationships are described linguistically in terms usually reserved for comfortable or caring human relationships. They must be *shinayaka* (smooth, flexible) and produce *chouwa* (harmony), *kyousei ga naku* (without coercion). Humans, machines, and bacteria all "communicate" or "converse"—*taiwa* suru—to gently approach (*yorisou*) each other. These terms focus attention on the interaction between bacteria, between human and machine, or between human and human as the primary locus of intervention and improvement in the making of an Ambient Information Society.

By equating bacterial symbiosis with the Parasitic Humanoid, the diagram erases their respective specificity. It implies that the human and machine can become symbiotic because bacteria can. This translation can occur because all of these actors, human, bacteria, and machine, are considered forms of life, and as life they can communicate in similar ways regardless of differences in their size, composition or structure.

The scope of the "great dynamism" and the "balanced society" sought first by the u-Japan policy and extended by the AIS-GCOE remains one in which human and machines are organisms living within a world that is beyond their control. Though they may actively engage each other in creating new ways of life, they are both utterly passive with regard to the conditions that demand adaptation. This is not unlike the world that Galison interpreted from Wiener of cybernetic monads, fighting each other on a flat plain of a World War II battlefield. Society appears less like an open ecosystem that an array of human and non-human entities construct and live within together, and more like soldiers devising tactics to survive on the battlefield, but without any agency to declare an end to the war. Human and machine interactions become "stabilizing system feedback" within a larger system (Fisch 2013, 340). While the rhetoric of the AIS-GCOE is to eliminate the "master-slave relationship" between humans and machines (*shujuu kankei*), the actual effect is to make both human and machine slave to a master whose presence has dissolved into the environment.

What is presented in the diagrams discussed above as a smooth plane over which possible states are distributed is therefore actually more like the local view of a much more expansive space warped at a large scale by the presence of a massive "attractor"—namely "life—but whose influence is so broad that the space local to any given observer appears flat. It is in extending such a view of organismic interaction that human-centered technology becomes a "royal science" in Deleuze and Guattari's sense. As they write, "royal science only tolerates and appropriates perspective if it is static, subjected to a central black hole, divesting it of its heuristic and ambulatory capacities." (Deleuze and Guattari 1987, 365) In the perspective of the AIS-GCOE, both human and machine appear to share a flat space of behavioral possibility, upon which they articulate and blend their perspectives, but they are under the influence of the black hole of life whose existence lies beyond the reach of the human-machine perspective, and the effects of which become barely visible in the flatness of local space. By maintaining this illusion of flatness, the AIS-GCOE articulates itself as a royal science, which functions as part of "a stable social and political order—which prop up the state." (Pickering 2010, 11)

Yomo himself gave this royal viewpoint a voice in a talk at the closing symposium of the AIS-GCOE project. After having discussed the findings of his research into the emergence of biological symbiosis, he spoke of the need for engineers to move away from thinking of systems in terms of achieving higher efficiency, and towards systems that were “friendly” to and symbiotic with human beings. If in the next twenty years, he said, the speed of computers is projected to increase 100 times, then perhaps we should devote just 10% of this capacity to exploring ways of increasing efficiency, and use the remaining 90% to try and discover how networks and robots should evolve to ensure safety. Humans and machines needed to work symbiotically to ensure their own safety through changing and unpredictable conditions. Altering the dynamics of the whole organism is not explicitly on the table.

Pressed by an audience question, Yomo connected this to the notion of human comfort. The audience member who had posed the question to Yomo began by saying that engineers had been trained to think in terms of maximizing efficiency, and that it was difficult to turn away from that, both as a matter of practice and of attitude. Was efficiency really in a trade-off with stability? Were these values at odds? Yomo answered, “It comes down to the issue of when people feel stress, and when they feel comfort and satisfaction. Looking at things since the disasters [of 3.11], it’s clear that things have become vastly more convenient [compared to the past]. But, in fact this makes us feel stress. In a mature society [such as ours], I think it’s more important for us to pursue comfort [than convenience.]” He asked the audience to imagine the level of stress as a curve plotted over time on a graph. In a system that seeks efficiency, the level of stress may be low at times but it will inevitably break down in response to unforeseen circumstances. Efficient systems are brittle systems. Increases in stress will be sharp and high.

A system that seeks comfort and security will be robust and stable. Designed to be better able to cope with unforeseen changes in conditions, its stress dynamics will be muted and rounder. Yomo suggested that if one integrates these graphs, and calculates the total stress in each system over a long span of time, then the system that pursues comfort and stability rather than efficiency will have a lower total amount of stress. “People will get upset if I say this, but we should be more like E. coli; our technologies should learn from these organisms’ moderation (*iikagenppuri*).”

Yomo was saying that humans and technology no longer should pursue efficiency or optimizations to make life more convenient. Such a strategy might have worked when the world was more stable, but if they continued to do so in more constrained conditions, they would become like perfectly voracious bacteria, eating themselves out of house and home. Scientists and engineers can take their inspiration from biology, and develop systems like his symbiotic colonies of E. coli and D. discoideum, prey and predator which, when thrust into new and harsh environments, survive by generating new relationships of co-existence. Yomo invited his audience to imagine comfort in terms of the mutual aid and support that humans and machines could provide each other, huddled together in symbiotic colonies, living in moderation and eschewing competition and efficiency in favor of maintaining the resilience and robustness of their collective lifeway; because unless they did, material sustenance for both of them would quickly run out.

All of this is not to condemn Yomo and his colleagues in the AIS-GCOE as mere instruments of a single-minded state. And it is not to say that these researchers are constrained in the ways they can imagine the improvement of human life by their positions within a royal science. Though there were those who found it difficult to question royal science, such expressions were also the cost of doing research in a Japanese university. Shinagawa, for instance, who was one of the young researchers profiled in the AIS-GCOE booklet, accepted such PR exercises as an unavoidable duty that comes with receiving financial and institutional support for his research, but he dismissed the framing of his research in these avenues as an outward posturing (*tatemae*). Like teaching and administration, it was a responsibility that came along with the privilege of being a university researcher. Students and other professors were roped into performing for videos, posing for pictures, or preparing posters and presentations for these PR exercises, which would establish the social and economic utility of their research for the satisfaction of granting agencies and the university. By the time researchers had achieved the security of a permanent position, they were quite adept at displaying deference to these authorities to ensure that their own labs and research would be insulated from them. Researchers often have one eye on the work they actually care about with the other on how to convert this research into a narrative that will attract the right kind of attention from administrators and government funding agencies.[52]

In the time leading up to the closing symposium of the AIS-GCOE, WTL members feverishly worked on picking up projects that they had let languish for months, so that they would have something that they could show at the technical demonstrations that accompanied the symposium. It was as if all of the work I had been observing and participating in up until that point had to be dropped until the symposium passed. Devices that I had seen collecting dust in the elevator lobby were suddenly plucked up and moved to the demonstration sites. On the day of the demonstrations, I was surprised to see Shinagawa manning a booth for a device I had never seen him working on until that moment. I recognized the device from past papers, but I thought that work on it had long ended. Suddenly, but temporarily, the lab seemed to open up into a different space and fill with an unfamiliar air.

The new air carried a hint of the scent of money. Occasionally, in the months leading up to the end of the fiscal year and of the AIS-GCOE, professors discussed ways of spending the remainder of the GCOE money. Buy anything you need, Terada told the other professors and PDs at a staff meeting in September; anything that is left should be diverted to another lab. They are good at using up extra money, Terada said, by stockpiling gene chips. Closer to the GCOE symposium, I went to lunch with Nishida and Shinagawa, who wanted to come to Canada. They wondered if there might be any GCOE money left to pay for a trip. In one conversation, Terada spoke to me about a highly respected senior professor, who I found profiled often in the newspaper and on the web talking about how research into biology at Osaka University might

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[52] This does not necessarily mean that the researchers are engaged in the cynical manipulation of funding agencies and the public in order to secure resources to pursue other ends. For instance, some of the popular writing produced by researchers in the same milieu as the WTL and the AIS-GCOE was unabashedly nationalist. Kaneko Kunihiko, a complex systems scientist at the University of Tokyo and a frequent collaborator and co-author of Yomo's, condemns Japan's obsession with the foreign in a book recommended to me by Yamanaka (Kaneko 2010). In one section, Kaneko laments the disturbing tendency that he has observed in Japanese academia to pay incredible sums of money to attract famous foreign scientists for conferences and workshops (38), which he calls the degradation of morals in science. He ties this to the entrenched idea among the Japanese that foreigners are to be lauded and admired, the Japanese "faith in the foreign-made" (*hakurai mono shinkou.*) Even when it is a Japanese scientist who proposes a radical new idea, it is overseas where it is appropriated and made into an achievement. He calls the misconception that the major breakthroughs of chaos research have been made in America an illusion (*sakkaku*) that he wants to dispel for the Japanese public. Japanese scientists, he points out, have been responsible for significant breakthroughs that are not easily recognized by other Japanese.

reveal the secrets of the origin of life and the universe. Part of why he commanded such high respect from Terada was because of his skill in telling a good story for funding authorities. According to Terada, this professor would tell his colleagues, “I’m not the one to make discoveries. I’ll go say [what I need to say], get some funding, and give it to people who have some talent. They’ll figure it out!” The researchers are “sociocultural entrepreneurs” (Fujimura 2003) who have mastered a rhetoric that couples technological progress to state goals. But, the rhetoric that they have committed to reproducing feeds a vision of a closed world, strengthening the royal scientific dimensions of human-centered technology.

Accounts such as the one I have just given, that emphasize the ideological character of Japanese technology research, have exercised a powerful hold on the popular and scholarly imagination. However, they provide only a partial insight into understanding what drives researchers themselves to imagine and create the technologies that they do, and the wonder and meaning that they derive from their engagements with machines. Jennifer Robertson (2007, 2010), for instance, who has written insightfully about Japanese robotics, has argued correctly that they can serve conservative ideological purposes. While she acknowledges that robot engineers draw on a “dynamic tension” inherent in the self and the other that leaves the self always in “an incomplete or emergent state” (2007, 379), she argues that this openness and creative potential is ultimately “compromised or precluded” by a reactionary and conservative agenda “implicit in applications of robot technology” (380). On one hand, this is because she assumes that the national context of Japan is sufficient on its own for understanding the practices of these researchers.[53] More pertinent to this chapter however, is that she does not ethnographically attend to the nature and quality of relationships between humans and machines. Her analyses therefore do not have anything to say about the socially transgressive or nomadic potentials of technology that might emerge through these close interactions. It is in these close interactions, where the communicative specificities of humans and machines cannot be ignored or abstracted, that the black hole of life can be dislodged to show that communication is what defines their shared universe.

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[53] I discuss how imaginaries of “the West” push WTL researchers to think of ways of altering the human body in Otsuki (2014). I make a similar argument drawing from Japanese popular culture in Otsuki (2013).

In the WTL, these more nomadic movements always ran alongside royal science. These become visible in moments when the researchers found it difficult to say what they were doing or what they hoped to accomplish in the instrumental terms of royal science. Taking the AIS-GCOE's injunction to transition from technologies that people "use" to ones that people "feel," some of the researchers explored other forms of engagement with technology and with other people that pointed to the possibility of human-centered technology as an opening to something new and generative.

6.3 Nomad Science

> State [or royal] science continually imposes its form of sovereignty on the inventions of nomad science. State science retains of nomad science only what it can appropriate; it turns the rest into a set of strictly limited formulas without any real scientific status, or else simply represses and bans it. It is as if the "savants" of nomad science were caught between a rock and a hard place, between the war machine that nourishes and inspires them and the State that imposes upon them an order of reasons. (Deleuze and Guattari 1987, 362)

Nishida struggles with his place in the WTL. He has followed Terada here, through Tachi's lab at the University of Tokyo and corporate research. He is younger, but not that young, and needs to make a name for himself beyond that of the Terada Lab. Nishida never did anything less than was needed, but privately, he would talk about his misgivings about the work that he was involved in.

I sat down with him during the December before the AIS-GCOE closing symposium, and he spoke to me about a meeting of the principals that he had attended. Nearing the end of the multi-year project, Yomo was looking forward. He posed a question to his colleagues to prompt them to think about what their next endeavor should be: What do we need right now? He wanted the discussion to reach beyond research, and have a more "global sensibility." Yomo wanted to "reset" their thinking. Reflecting on the meeting, Nishida told me that he agreed broadly with Yomo's suggestions that engineering should be less about optimization or convenience, and aim more towards robustness and resiliency. However, he was ambivalent about the use of bacterial models to derive ways of organizing human and machine society:

> Even if you discover the systems that make organisms work together well, and turn

> them into rules for the human world… I mean in science, we talk about rules or fixing the parameters of an experiment, but we're always talking about the closed space of the experiment room. For cells, they are in a closed space so that's fine, but you can't assume that the human world is a closed space. If you think in terms of "closed", then the moment that something comes from a place outside the "closed", then everything will break down.

He understood that scientists would work towards making life more stable and comfortable, but he wondered whether their efforts might actually be having the opposite effect. We have created many little bits of safety, he said, so many that they have piled up into a brittle system.

Andrew Pickering writes that in British cybernetics there were two stances that scientists assumed with regard to cybernetic systems—enframing and revealing (2010, 32). Drawing on Heidegger, Pickering writes that enframing is a stance of domination and control, of closing off possibilities in nature and taking it as a "“standing reserve" for circuits of production and consumption" (2010, 3). In contrast, Pickering argues that cybernetics also had a mode of revealing, "of openness to possibility, rather than a closed determination to achieve some preconceived object, come what may" (2010, 32). For Pickering, enframing and revealing correspond to what Deleuze and Guattari called royal and nomad science. One works towards stabilizing nature and using it in service of the state. The other wanders and meanders, pushing on royal science to reveal new flows, dynamics, and phenomena, but is always in danger of being appropriated or effaced by royal science. The ambivalence that Nishida conveyed to me ran along this axis. While recognizing the conveniences and safety that human-centered technologies might afford, he worried that they brought along a view of the world as "closed" or enframed. When I observed Nishida working with machines, he seemed to engage them so that they might reveal.

The dilemma of the nomadic scientist is that they may find themselves without a stable home. While royal science apprehends its object from a fixed external point, translating it into variables that run along predetermined metrics (Deleuze and Guattari 1987, 372, 374), nomad science must follow singular events as they move, letting its own metrics morph and vary. Nomad science can turn scientists into wanderers because the questions that interest them wander, moving between and out of the institutions of royal science, as was the case for British cyberneticists like Gregory Bateson and R.D. Laing. As Pickering writes, Bateson never had a steady job (2010, 180-181), while Laing established an "antipsychiatry" and a therapeutic community for schizophrenics outside of existing mental health care institutions (190). While Nishida is firmly within an established institution and was a respected engineering researcher, he gave a great deal of his attention and energy to work that was outside of engineering. Job security in a Japanese university requires much strategic and subtle action, but from within these constraints, Nishida seemed to be pushing outwards from conventional science and engineering towards something that he had yet to fully comprehend.[54] This nomadic movement was rooted in moments when he engaged machines directly with his body, letting them activate and trouble his understanding of himself.

6.4 Nishida and the Trochoid

Late one afternoon, I wandered into the meeting room to find Nishida standing over the "Torokoido Sharin" or the "Trochoid Wheel[s]". "Trochoid" is a geometric term referring to the curve traced by a fixed point on a circle rolling along a straight line. (Below, I refer to the "Torokoido Sharin" as the "Trochoid" for simplicity.) The Trochoid is a large robot invented by Terada to test an idea he had for a versatile system for robotic locomotion based on wheels that trace out trochoid curves. The Trochoid was Terada's pet project, its design inspired by the Tachikoma robots in one of Terada's favorite comics, *Ghost in the Shell*. Uncharacteristically for a lab that is mostly concerned with building devices to be worn on the human body, the Trochoid's presence is imposing. When confronted with it at the center of the meeting room, I stepped back to a safe distance. It looks like a large table made of metal standing on three wheeled legs that stands about one meter above the ground. Viewed from above, its chassis is an equilateral triangle of aluminum beams of a little more than a meter on each side. Each of the small wheels below the vertices is mounted at an adjustable angle relative to the floor. The Trochoid can move in any horizontal direction by adjusting the angle of each wheel, and the positions of each wheel relative to the others. When it is operating, it looks like a three-armed cephalopod spinning its appendages in all directions.

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[54] Nishida recognized the nomadic character of his work. In a video interview recorded for a previous art installation in Tokyo, Nishida says that "the reason that researchers can't become artists is that they have a "home" they can return to called "research". If you do work thinking that you can eventually return to this home, then you won't be able to create art." His collaborator on both exhibitions added, arts can play the role of "expanding the borders of research" by revealing new kinds of connections.

The Trochoid had been tested successfully in early 2011, before I arrived at the lab, but some of its parts had failed, and during nearly my entire stay at the lab it sat in a corner of the meeting room unused and mostly uncommented on. Terada had machined the parts himself, while Nishida had designed the control circuitry. Terada told me that nobody else in the lab could have built the machine, let alone operate the required machining tools safely, so it waited until this afternoon, when Terada had suddenly decided that the Trochoid needed some attention. He sent Nishida to try and diagnose its problem. Nishida told me that he didn't know why Terada had chosen today to try and bring the Trochoid back to life. He seemed mildly annoyed, although I could not tell whether it was because of Terada's unexpected request or his inability to see the solution to the Trochoid's issue.

I watched for several minutes as Nishida worked at the machine, barely making a sound except for a few unintelligible words that he occasionally mumbled to himself. He would flip one switch back and forth, and then another. The machine was receiving power, as evidenced by the bark that its motors released when Nishida jostled a stick on the Trochoid's controller. He shook various connectors and bundles of cable. He placed his hands on the motors to test their temperature. He then leaned over the Trochoid and lowered his head to the cables coming out of its on-off switch and sniffed several times. "It smells funny," he said to himself.

We were soon joined by Ikegami, one of the lab's two doctoral students at the time. He stood next to Nishida, and they both looked at the Trochoid in silence. With few words passing between them, they repeated the testing sequence that Nishida had begun. First, they turned the machine on and off. Then they pushed buttons on its controller haphazardly and listened to the Trochoid's motors spin up and halt. Then they spent several moments, each with their arms crossed in front of them, leaning over various parts of the machine, touching the motors, tugging at the drive belts, and pushing connectors together. To my eyes, they seemed to be drawing no closer to diagnosing the problem. Perhaps to theirs as well; after a short while longer, they both left the room to turn to other work.

At the time, I was struck by the absence of tools in their troubleshooting process. Although tools would undoubtedly have made an appearance later on had the repair work proceeded any further, neither Nishida nor Ikegami used anything but their own bodies in their initial attempts to locate the Trochoid's problem. They moved their hands over the metal chassis, on the gears, the wires and connectors, as though the texture and suppleness of the polymer insulators and dead motors would provide them with hints to the underlying problem. They appeared to treat the Trochoid as a living thing in need of care. Indeed, on many occasions, Nishida compared circuits to forms of life and to people, speaking about circuits as “kono hito” (“this person”). He also compared machines to “deities that are nearby” (“chikaku ni iru kamisama”, as opposed to a “deity that is above” or “ue ni iru kamisama”) that lurk in the machines themselves. A very “Japanese” viewpoint, he said.

This was a way of thinking about what kind of relationship and attitude that he should have to care for the machines. If he approached the construction of a device with care and attention, as though it were a deity to be respected, then he would make fewer errors. “There aren’t rules for what you should do, but if you treat it kindly, even a machine will work properly.” There are many cases, he said, in which he “puts his hands on a device” (“te wo ateteageru”), without a specific objective in mind and it starts to work. That such a relationship with a machine is possible feels similar to the machine being alive.

Nishida later related to me how similar cases ideally unfold. Faced with a device that is not working correctly, he will disassemble it to its constituent parts and clean each one carefully. In some instances, he may be able to locate a dead component during this process, but in others he is not able to recognize the specific issue. Still, he will reassemble the device, and often this will result in the device operating normally. He says that when this happens, he is not consciously aware of having fixed anything. He is aware of no explicit rules that can be followed or parameters that can be adjusted. He believes that he has done something unconsciously to effect the repair. Perhaps, he speculated, it is something like tsumori (see Chapter 4), where his body executes an intention in a way that his conscious self does not recognize.

He emphasized this point by comparing his relationship to machines to that which he has with his children. As his children grow up, he said, his brain creates a model of how they will act in a particular situation. This makes him able to predict to some extent what they want and what they need. This model is formed as he spends more time interacting with them. The process is like having one’s brain encroached upon by another person (“nou ga shinshoku sareru”) or, equivalently, to have one’s brain “extended” (“nou o kakuchou suru”). The effect of this modification is the emergence of a tacit sense of that child’s behaviors, a copy of that person’s circuitry embodied in oneself. These pieces of his children that exist in him are what make it possible for him to understand and empathize with them. “Humans cannot get outside of our own brains,” he said. “To empathize with the feelings or understand the thoughts of another person means to have a copy of a model of that person’s behavioral patterns in your own brain, and to interact with it. This happens within your own brain.”

The same is true, Nishida told me, for machines. He has spent as much or more time with machines than he has with his children, who are still relatively young, and so he has a similar but perhaps better model in his head for how they behave and how they might be repaired. This model was what he was attempting to draw upon when he stood above the Trochoid, looking and listening, running his hands over its components, and smelling its connections. He was demonstrating what he understood as a cultivated embodied understanding of the workings of electronic circuitry, which he imagined as materialized in his own brain. To Nishida, the process through which he came to know other human beings through social and embodied interactions was the same as the one through which he has come to know machines: they make part of himself into the other.

Philosopher Vinciane Despret discusses this kind of relationship as “isopraxis” (2004; see also Thompson 2011). In her account, isopraxis is the state of bodily communion between an experienced horse and rider. The subtle, unconscious movements of the rider are sensed by the horse, who then reproduces those movements. The hands of the rider anticipate and reproduce the movements of the horse's legs. A talented rider, she writes, has learned to move like a horse, and the body “has been transformed by and into a horse's body.” (2004, 115) The morphology of the Trochoid precluded such direct correspondence between it and Nishida, but his description of how his brain is reshaped through his long relationships with machines suggests that there was a part of him that was being activated by the Trochoid in the same way.

Isopraxis is also implied in Nishida’s characterization of the machine as a deity that needs to be cared. According to Despret, for such a state to emerge requires a charitable willingness on the part of the both the horse and the rider to activate each other as a subject, “a subject of passions, a subject producing passions, a subject of questions, a subject producing questions” (131). This passion is “an effort to become interested” (131), to try and engage the questions, problems, challenges, and experiences of the activated subject. For Despret, this implies that the rider and horse become entangled in a mutual becoming, in which "Who influences and who is influenced [...] are questions that can no longer receive a clear answer." (115) In carefully disassembling and cleaning a machine's parts, in "laying his hands" upon it, he demonstrates this willingness to engage machines as a subject to be activated.[55] Through such interactions, he seemed to recognize the boundary between him and the machine had blurred, perhaps momentarily, partially, and beneath full conscious awareness.

For Nishida, the possibility of a person acquiring this relationship was contingent upon the specific characteristics of the technologies that he or she encountered. For some technologies, such as the Trochoid, he said it was possible for him to touch, smell, and interact with them to use and develop his embodied experiences and knowledge. For other technologies, such as modern day computers, information networks, and smartphones, he saw this as being impossible. "There are too many black boxes. The technologies are too complex." Their complexity and scale exceeded human capacities, preventing the emergence of an embodied sensitivity. He could not relate to them, because there was little possibility of matching the metrics of the technology with the human's. A technology's "complexity and scale" can be understood, he said, in terms of whether a single person can design and build such a technology on their own, or at least have enough knowledge of the system as a whole to see the mutual interactions of its parts. The example he gave was of Toyota, and the recall of their cars that began in 2009. "It's unthinkable that they would release cars that cannot start," Nishida said, seeming astonished that such basic functions would be littered with critical flaws. These issues were due, he explained, to the fact that no one person could see the car's design and engineering through from beginning to end. The scale and complexity of these technologies prevented the emergence of an embodied sensitivity and relationship with them, precluding the possibility of isopraxis.

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[55] A book that records a conversation between Ishiguro Hiroshi, the creator of the Geminoids, and the philosopher Washida Kiyokazu expresses a similar idea (2011). In one section, they discuss how robots may have their value precisely in being "useless." Here, Washida elaborates that people may have to learn to treat robots as inherently valuable (that they have value because they exist), rather than instrumentally valuable (they have value for what they can do.) Instead of a robot that performs valuable work, they discuss one that is more like an infant trying to take its first steps. If an infant stumbles, Washida notes, the person watching over it is compelled to step forward and help. This ability to induce activity rather than render humans passive in relation to a robot may be where robots' true value lies. This way of thinking, Washida suggests is the "polar opposite" of the neoliberalist, credentialist mindset that has taken over Japan since the Koizumi administration in the late-1990s (122-123).

Nishida's feelings were not his alone. The WTL's devices, particularly the PH, were based on the principle of *jin-robo ittai*, or the oneness of human and robot. The papers of the lab introducing this concept explain that jin-robo ittai draws on the idea of jin-ba ittai, the oneness of horse and rider, with the robot as the rider and the human as the horse. Terada clarified to me that the human-robot relationship was not necessarily so asymmetrical. While public definitions of jin-robo ittai maintained that the robot was the rider, he said that this analogy was in fact an attempt to raise a question. "When a horse and rider are one [*ittai to natta toki*], does the question, "Which is the subject [*shutai*]?" have any meaning? [It's like asking] are our eyes the subject, or our hands? There's no meaning to this question. […] Unless both the eyes and hands are moving, then there is no "I". I think the [robot and human] is the same." This indeterminacy was also demonstrated in the naming of the PH system. Terada coined the English term "Parasitic Humanoid" first, then back-translated this into the romanized Parasaito Hyuman, or Parasite Human, for use in Japanese. In practice, the two terms are used interchangeably with "PH," and each of them can vary in referent. Some times, they may refer to the technological device that "rides" the human; at other times, they referred to the combined human-machine system, a "high-performance organism" and "oneness." Thus, when one spoke of the "PH," "Parasite Human," or "Parasitic Humanoid" doing something, exactly "who" was doing it remained ambiguous.

6.5 Ishiguro and the Geminoid

Further afield, the researchers I spoke with at the Ishiguro lab also often discussed their feelings of oneness with their machines. Hiroshi Ishiguro is as close to an international celebrity as one might find on the campus of Osaka University. He has been interviewed numerous times by Japanese and international media for his research and development of robots, and his greatest fame has come from being the man who created a robotic copy of himself, his Geminoid. A profile of Ishiguro published in *IEEE Spectrum* (Giuzzo 2010) presents Ishiguro as brilliant but eccentric, always dressed from head to toe in black, constantly rumbling down the streets between the different labs he heads in a black Mazda RX-8 roadster. He appeared in the opening montage of the 2009 Bruce Willis movie *Surrogates* as a real life example of the film's fictional future, in which Willis's robotic double goes out in the world to do police work, leaving his body safely contained at home. As an amalgam of the science fictional and factual, the bodily and the imaginary, and the organic and the technological, he seems to be nothing other than Haraway's cyborg.

When I spoke to him in his office, a framed poster for *Surrogates* hung on the wall, signed with a message of gratitude from the director. On the adjacent wall was a Guinness World Records certificate awarded to him for being creator of the world's first "android avatar." There were two large computer screens on two desks arranged in an L around his chair. Small cameras were mounted around one of the screens, which were used to capture his facial expressions and motion when he operated his Geminoid across the internet. Placed on either side of one of the computers screens like speakers were two large black electronic air cleaners, with another on the floor beneath his desk. Each individually appeared to be of a capacity that would have been enough to filter the air of his office. I wondered, what was he trying to clear the air of? What impurity in the atmosphere made these three machines necessary? My nose detected nothing out of the ordinary, but perhaps my body was not as sensitive to the atmosphere as his. When he finally arrived and we began to speak, I realized their true purpose as he proceeded to smoke half a pack of ultra-light cigarettes in quick succession. At Osaka University, smoking is permitted only in designated outdoor areas.

This was my first encounter with Ishiguro, although I would later meet him at a conference and in several joint seminars with the WTL, and see him give public talks several more times. We spoke for an hour about his work before he introduced me to an associate professor in his lab, who introduced me to Synchy (see Chapter 5) and guided me through the rest of the lab's research. What was most notable to me about this meeting was the photo on his business card. At the end of our conversation, I realized that I had neglected to hand him my own card at the beginning of our meeting, when it would have been most appropriate. When I attempted to make up for this at the end, he was prompted to give me his card, which had in its corner a small color photograph of his face. Half in jest, I asked him whether it was he or his Geminoid in the picture. He smiled and declined to answer.

I initially read his refusal as an example of his provocative and playful approach to public engagement. During his talks, he exhibits a wit that is uncommon among the often staid, scripted, and rehearsed performances of other professors. In rooms full of white shirts and striped ties, he wears a black leather vest. Where others are dressed in more casual attire, Ishiguro arrives in the same black leather vest. When others speak in standard Japanese, he uses the informal Kansai dialect. After one public talk in which he demonstrated a miniature android designed to connect with smartphones, he was asked which smartphones it would be compatible with. Without missing a beat, he grinned and quipped, “Android, of course!” to the laughter of the audience.

I wondered later whether a simple answer to my question about the photograph was possible. During our conversation, he told me that the previous year, he had undergone plastic surgery. In the six years since his robot twin had been completed, his human body had aged. The

Figure 19. The Geminoid modeled on Ishiguro.

surgery was to return his physical appearance to better resemble the robot again. It was after all, he said, the robot that people came to see and that had made him famous. He is not him without the robot.

In his 2011 book *How Can We Create a Human Android?*, he describes this process at some length. Troubled by his colleagues' comments that he had gotten fatter than the Geminoid, Ishiguro proceeded to lose ten kilograms doing sit-ups and dieting. Afterwards, a combination of repairs to the robot and cosmetic surgery to his human face was used so that they would better resemble each other again. It was cheaper and quicker, he writes, to perform small modifications to both human and robot than it would have been to overhaul the robot to match his current appearance. Thus, even if the figure in the photo on his business card was the human Ishiguro, it could have been the one whose appearance had been altered to converge with the changing look of the robot.

If his actions seemed difficult to understand for ordinary people, he did not believe this was because he was radically removed from the world of their experience. Rather, he saw himself as more deeply aware of it. One need only look at the titles of his books to receive the impression that he sees himself seeing humans from a perspective that contrasts with the conventional one, which seems to allow him to access some deep truths about what it means to be human.[56] Here, the scientist is at once human and humanoid, a oneness of human and robot who sees the world through slightly shifted eyes, compelled to change his body and the world because of what he has witnessed and felt.

His students and colleagues experienced similar, albeit less physically transformative, relationships with the Geminoids. Yukawa, the associate professor in Ishiguro's lab at ATR, described one such experience to me. During a visit from a television crew from France, Yukawa was operating the female Geminoid while being interviewed. Without warning, he said, the male interviewer leaned in to kiss the robot on the cheek. Yukawa tried to raise his hands and move his body to avoid the kiss, but it was only his actual body that moved. Yukawa told me that he

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[56] His books include, *How Can a Human Be Created: I, Who Became an Android* (*Dousureba "Hito" wo tsukureru ka: Andoroido ni natta watashi*) (2011), *What is a Robot: A Mirror that Displays the Human Soul* (*Robotto to wa nanika: Hito no kokoro wo utsusu kagami*) (2009), *What Does it Mean to Live?* (*Ikirutte nanyaroka?*) (2011, co-written with philosopher Washida Kiyokazu, former president of Osaka University.)

felt an intense panic as his personal space was violated, and felt as though he were being physically constrained or that his body had become temporarily paralyzed. One female student described a similar sensation. During one interview using the Geminoid, the robot's body had suddenly become unbalanced and fell out of its chair. She reflexively tried to move her body to avoid the fall, but panicked when the robot's body did not respond. Such incidents were common enough among operators that they were seen as the mark of experience and true understanding of what it meant to be 'transferred over' (*noriutsutta*) to the Geminoid's body. The operators all know at a conscious level that they are operating a machine through a limited Skype-like interface. But over time, their bodily sensations make them feel like that robot is actually part of their own bodies.

In Nishida's case, close bodily experiences with human-centered technologies had been an opening for him to glimpse the existence of the whole system of which he and HCTs were a part, and motivated him to try and better understand it, driving him towards a new imagining of totality. His experiences demanded a response that carried his attention beyond the organismic closure that was deftly performed by the AIS-GCOE, or could be rendered meaningful within the confines of the lab. He seemed to find meaning in what otherwise might be considered noise. In response, he employed the technologies they had developed to meet the goals of social stability and robustness, and turned them into sensory experiences that would destabilize human senses of self through medium of art, and in the idiom of spirituality.

6.6 Interfaces for Creating Instability and Spiritual Richness

I sat in a darkened corner of the Museum of Osaka University's third floor exhibition space, facing a large video screen at the end of a darkened tunnel formed by large wood panels. The tunnel extended just past me, blocking my peripheral vision. This is a piece of sensory art created by Nishida called "Empathetic Heartbeat." It was installed, along with a dozen other pieces of media art for a special exhibition curated by Nishida called "The "I" in my brain, the "I" in information" (*Nou no naka no 'watashi,' jyouhou no naka no 'watashi'*)(脳の中の「わたし」、情報の中の＜私＞).

The text on the screen guided me to put on the headphones in front of me, and place what looked like one end of a stethoscope over my heart. I began to hear my own heartbeat, amplified to a low throb in my ears. I doubted whether the sound was loud enough to reach my chest, but I felt like it was resonating through me. The instructions said that the program would begin once my heartbeat was detected clearly. I adjusted the position of the stethoscope over my heart until the sound was steady and noise from the friction with my shirt disappeared. The words on the screen faded out, along with the sound of my heartbeat.

The cheers of a crowd of young children bubbled into my ears. The screen slowly brightened to show the face of a young girl. She wore a white t-shirt, dark shorts, and a white cap over her long black hair—she is a primary school student dressed for physical exercise. In the background, other students milled about, preparing for another school sports day event. She dropped her stance, and poised her body to run. Her chest was lowered slightly over one knee, one foot anchored just in front of the other, arms raised in anticipation acceleration. Looking forward, her eyes sharpened, and she waited for the race to start. I noticed a heartbeat return to my ears as the sounds of the schoolchildren faded away. The deep rippling reverberations of the heartbeat intensified, and the video on screen slowed, accentuating the moment when the girl dashed across the starting line.

Other similar scenes followed. A young boy dressed for a kendo match, calmed himself at the sidelines as he waited for his turn. Around him, other children shouted and stuck their bamboo swords against each other. The shadow of a man standing on a diving board loomed over the ripples on the surface of a swimming pool in the moment before he jumped in. Each time, the video would fade in and the sounds from a scene would fill my ears. Near the end of the video, the motion in the video would slow, and the sound of a heartbeat would enter my ears, pounding faster and faster as the climactic moment in each video approached.

When I sat at the Empathetic Heartbeat, the feelings of tension and anticipation were palpable. These were all situations that I could easily imagine myself in, and I heard my heartbeat accelerate and my fingers push into my palms as I sat in the booth listening to the heartbeat. I felt the waves of tension reach into my chest. The description of Empathetic Heartbeat in the exhibition brochure explained that as the video progressed, I would become increasingly unable to distinguish whether I was hearing my own heartbeat or that of the person in the video. By "sharing" our heartbeats in this way, I would be able to "imagine the other person's nervousness and the movement of his or her *kokoro*[57]" ("Tanin no kinchoukan ya kokoro no ugoki wo souzou shimasu.") When I spoke to him later, Nishida revealed that with the exception of the heartbeat at the very beginning, the headphones had been presenting a recorded sound. In terms of the sensations that I experienced, it did not seem to matter whether it was my own heartbeat or a mechanical reproduction. I believed that my heart was pounding, and I felt the tension that the people depicted in the video must have been feeling.

Figure 20. Image from a video on the Empathetic Heartbeat.

The title of the piece in Japanese was "Shin-on Inyuu," a play on the phrase *kanjyou inyuu*, to transfer and accept into oneself another's emotions—empathy. The video of the familiar childhood scenes would have evoked empathy on their own, although the immersive sound of the heartbeat intensified the effect. However, the point of Empathetic Heartbeat was in

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[57] See note 58.

the moment when I took the recording of another person's heartbeat for my own, when something that I believed was inside my body was in fact coming from the outside and I could not feel the difference. The description of Empathetic Heartbeat framed this not as the moment when I was deceived into believing a recording of another person's heartbeat was my own, but as the "sharing" of my heartbeat with the person in the video. The piece was conceived as revealing a relationship between my self that I felt within my body and a self outside.

This was the thought that Nishida had invested in the title of the exhibit: "The "I" in the brain, the "I" in information." In Japanese, the two words for "I"—watashi—are phonetically identical but rendered in different scripts, hiragana for one and kanji for the other, emphasizing both the continuity and discontinuity of the selves in the brain and in information. In his introduction text for the exhibition, he explained the significance of the difference between the two "I"s:

> "What am I?" [わたしとはなにか？] This has been an eternal question for humanity, which has, until now, been addressed by philosophy and theology, art, and today, the brain sciences. If you think that "I" [わたし] resides in the same place as consciousness, then psychology and neuroscience may appear to be the sciences closest to the "I" [わたし].
>
> But in contemporary society, many things including our bodies, thoughts, and actions are being turned into information. Without "my" [わたし] awareness, a new "me" [私] is forming in the world of information. […] This exhibition is an attempt to think new forms of the "I" [わたし] in the brain and the "I" [私] in information from the standpoint of the fusion of human sciences and information science. […] In this exhibition, "わたし" and "私" will be made manifest as two different existences. You will need to create a new human relationship between "わたし" and "私."

In Nishida's introduction, which was posted facing the entrance of the exhibit space, the problem of knowing oneself is equated to the problem of constructing a new "human relationship" between two selves, the self in the brain and the self in information. Where does the truth about oneself lie? It cannot be only in the brain itself: we also have selves that exist scattered across different forms of information, among technologies that watch, represent, and embody our "bodies, thoughts, and actions" and transform them. The point of the exhibit was to give people a new sense of themselves from which they could compare with their usual experiences.

Surrounding visitors to the museum were reminders of these other selves. Posted on walls throughout the exhibit and other areas of the museum were small cards printed with "poetry" created using the predictive text input technology common in mobile phones. Those words, selected out of databases of past inputs based on the messaging habits of their users, captured something about the users of those phones. The sentences were nearly grammatically correct, laden with expressions that could be quirks of a person's speech, and populated by nouns that pointed to some of their recent areas of attention. (E.g. "If it's there it's difficult to write a reply and I'm limping but I'm driving so don't push yourself too hard. I've gathered the responses I'm not biting I'm sorry for the sudden intrusion." [あればね　返信しにくい　メールして　ビッコひいてるけど　運転してますけど　無理なく　ね。返信　集めた　かまない　いきなり　すみませんでした。]) These poems seemed both to be random arrangements of sentence fragments, and seemed to embody something of the phones' owners in the nearly human way that they put words together.

Another piece called "Kageboushi" (shadow figure or silhouette) used digital cameras to capture the outlines of nearby visitors, which were projected in black on a large white screen to appear as though it was the person's shadow cast on a wall. The shadow would follow the person's movements for several seconds, until it stopped and took on a life of its own, walking away from the person who cast it. The description of Kageboushi asked, "How much of a connection do you feel with the shadow that has moved away from your own body?"

One of the most interesting of Nishida's creations, which was not displayed at this exhibit, was called "Save YourSelf!" [sic]. It used the GVS interface (see Chapter 5), which was linked to electro-mechanical sensors on a tiny screen. The screen displayed an image of a person. The display was mounted on a small buoyant platform and placed on top of water in a large bowl, and participants had to carry the bowl through the exhibit area. Each time they jostled the figure or were bumped by another person's careless movements, the GVS transmitted the disturbance to the human participant, causing them to experience a loss of balance as well. Participants protected these avatars as though they were a part of their own bodies. Save YourSelf! was a visceral demonstration of the extension of a bodily sense to a floating computer display. Nishida hoped that this piece, as well as all of his other artistic pieces, would help people experience the relationship that they have with their own bodies and with other people in new ways, relativizing and denaturalizing their ordinary selves. He thought they could engender forms of empathy among humans and non-humans that might help people imagine a differently connected, more prosperous, and "spiritually rich" society.

It was this “spiritual richness” that he sought to inspire through his artwork. Nishida was particularly explicit about this aspect of his work in the first of two lectures on his research he gave to a group of short-term foreign exchange students at Osaka University, for which he asked me to revise the English on his slides for the presentation. This was in preparation for a class visit to his museum exhibition the following week. During his first lecture, he presented the students an opposition between two categories of ideals for the role of technology in human life in the inequality “Convenience item ≠ Necessary item.” In his accompanying comments, he wrote, “Most of the people who live in Japan have all things necessary for life now. Because people in the past did not have items necessary for life, we felt that having things was to be happy. I feel that modern humans have lost the feeling of being satisfied, because there are too many things. Then the problem is, what can I do to make people feel fulfilled? How should I design interfaces in the future?”

One point of reference was what he took to be a general trend in the Japanese population towards feelings of spiritual poverty. Among his slides, he included a graph of results from national surveys conducted by Japan’s Cabinet Office. The survey asked a sample of Japan’s population whether they want to “Place emphasis on spiritual wealth and living with flexibility, now that they have achieved some level of material wealth” or to “Continue to pursue material wealth”. These choices were abbreviated on Nishida’s graph to “Spiritual Richness” and “Material Wealth” and presented as a time series, which showed that since about 1980, more people began to choose “Spiritual Richness” over “Material Wealth.” At the end of the graph in 1999, 57% of people chose “Spiritual Richness” compared to 29.3% who chose “Material Wealth.” Nishida presented this graph to reinforce his argument that technology had now to meet a different social imperative: it should enrich their spiritual lives rather than increase their material wealth or conveniences.

The notion of “spiritual richness” places this graph within a discourse about the loss of meaningful social connection in Japan (Allison 2013). In the original graph, the opposition presented is between “*kokoro no yutakasa*” (spiritual wealth) and “*mono no yutakasa*” (material wealth).[58] In the Cabinet Office graph, the opposition between "mono" and "kokoro" suggests a correspondence with "physical" versus "mental" well being, or between personal satisfaction and material comfort. The graph translates the term as "spiritual comfort," but the term refers less to "spiritual" matters such as religion, but associates it with a shared value system and activities that secure social capital (in Robert Putnam's (2000) sense), such as being with one's family, and participation in one's community. According to the Cabinet Office White Paper in which this graph appeared, there are three areas of life where one experiences spiritual comfort or its lack: the family [*kazoku*], the neighborhood or locality [*chiiki*], and the workplace [*shokuba*].

To these three, Nishida's artwork adds one more: information [*jyouhou*]. Thus, his artwork serves three purposes. The first is to reveal, through technologically induced experiences of instability, how one's sense of self and well being increasingly implicates the self that exists and is experienced through information and information technology. Second, it locates a significant cause of a widespread feeling of spiritual poverty in the failure of information technology to make a relationship with the self in information possible. This is the relationship that he hoped people would experience through his art work, as new and intense forms of empathy with strangers through the Empathetic Heartbeat, or the desire to protect a bundle of plastic and circuits in Save YourSelf!

Third, it reveals the self in information as multiple. By sense and by situation, each work of art engages and reveals a different self in information: the shadow that walks away in *Kageboushi*; the poems that write themselves in your words and with your habits recorded by a phone's predictive input system in "*Oyayubi no kioku*" (the memory of the thumb); the image of your own face fractured into parts projected by saccade-based displays in "Eye Remember You". Each piece gives a different perspective of the self, leaving the work of joining them together to the visitor.

These relationships between self and information are revealing rather than enframing. The pieces encourage speculation, exploration, and nomadism, rather than acceptance, ossification, and closure. Nishida instructs the visitors, whom he has made novices in the same

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[58] *Kokoro* is a notoriously difficult term to translate into English, sometimes rendered as "mind," "center," "soul," "spirit," and "heart" (Katsuno 2011, Traphagan 2002, Yuasa 1987, Yano 1997, Lock 2002).

journey he has undertaken, to forge "new human relationships" with themselves, without telling them that they should be like E. coli. Information is more than a postmodern consumer convenience, but an emerging sensory and relational modality, a different basis for mutual comparison and recognition, in which people must try to understand their connections with other beings, because they have already been thrown in among them by the ubiquitous information society. The task of the exhibition is to reveal to visitors tacit readings of ambience that they did not know they had, though they may have sensed it dimly as an *iwakan*—a discomfort—that issued from the feeling that the world was not turning out how they expected.

The idea that people participated in relationalities that they could "feel" but not "think" had its strongest expression at the entrance to Nishida's exhibition, which was dominated by two giant Matryoshka dolls, each standing more than a meter and a half high. The one to the left was painted in lively, pastel colors and a flowery design. The other was grey and robotic. Where one had flowers and buttons, the other had gauges, indicator lights, and rivets. The tops of both dolls had been cut horizontally and opened to show the inside of each of the dolls' heads.

Figure 21. Entrance to Nishida's media art exhibit.

Each head displayed different aspects of Minakata Kumagusu, a prominent turn of the century biologist, ethnologist, and cultural figure.[59] The doll on the right contained Minakata's

[59] Minakata Kumagusu was born in 1867 in present-day Wakayama prefecture, south of Osaka. He followed an unconventional educational trajectory which brought him to Tokyo to study at a predecessor institution of the present University of Tokyo, alongside future luminaries such as Natsume Soseki. Consumed by his own natural research, he returned to Wakayama, but he eventually travelled the United States and Europe for several years. In spite of his unorthodox education, he was a genius who contributed numerous papers to *Nature* and *Notes and Queries*. Minakata still holds the record for the greatest number of papers published in *Nature* by a single author. In his later life, he settled in the town of Tanabe in Wakayama, a few minutes by car from Shirahama where the lab took its summer trip.

brain, which had been preserved in formaldehyde following his death in 1941. Minakata had suffered from seizures, hallucinations, and out-of-body experiences during his life. He bequeathed his brain to the Medical School of Osaka University so that others could study what had caused them. Now, in the building that had once housed the teaching hospital for the university, his purplish gray brain sat in a glass receptacle mounted on a matryoshka doll and illuminated from below, loaned to Nishida by the university for his exhibition. The other doll contained a set of small LCD screens, upon which digital images of Minakata and his work faded in and out.

When visitors entered the exhibit area, they would stand between the two dolls as they read Nishida's welcome message, which was posted on the wall between them. Visitors were pulled into a position between the two "I"s of Minakata, tacitly making each of them a possible answer to the problem of how to create a new "human relationship" between the I the brain and the I in information.

Minakata's presence here is meaningful because he provides a way to link the peculiar sensory experiences of Nishida's exhibition to the place of humans within a framework in which a new "human relationship" can be understood. It shows that the bodily experiences created by the WTL's technology can reveal a new kind of ambience which serves neither the lab nor the existing "royal" order directly or singularly, but which is part of a larger system that emphasizes humans as what define the totality, instead of convenience, money, or life.

The framework that Nishida presents in this exhibit is based on esoteric Buddhism, and is embodied in Minakata's presence at the entrance of the exhibit space. In several recent English publications regarding the history of ecology in Japan, Minakata's devotion to Shintoism has been highlighted, particularly in relation to his involvement in the "anti-amalgamation of

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Minakata died in 1941, but was unknown by the general public until the late-1980s when he became the focus of a "boom" during which his works were republished, and he was the subject of numerous books, magazine and newspaper articles, and television shows. In 1991, during the year of the 50th anniversary of his death, a special exhibition on Minakata was held at a major department store in Shinjuku, in which members of the public could view writings, artifacts from his life, and purchase slime-mold kits to cultivate the same organisms he had recently become famous for studying (Blacker 2000, 235-246).

shrines" ecological movement in the 1910s (Jensen and Blok 2013; Kato 1999). However, it is his deep and long interest in the esoteric Buddhism of the Shingon sect (*Shingon Mikkyo*) that has been an intense area of study among Japanese scholars of Minakata, particularly since the publication of letters exchanged between Minakata and the Shingon priest Dogi Horyu from 1893 to 1904 (Hashizume 2005; Karasawa 2011). Minakata met Dogi in London in October of 1893. Though they spent several days together, they rarely met in person again. But over more than a decade they exchanged masses of correspondence in which they discussed the nature of the universe, the meaning of human life, and the relationship of Shingon Buddhism and Western science, which had a profound effect on Minakata's thinking. By the end of his life, Minakata had become committed to Shingon Buddhism as a way of understanding the universe beyond what Western science could prove.

One of the characteristic features of Shingon Buddhism, especially when compared with non-esoteric forms of Buddhism, is the central importance placed on two mandalas: the Kongokai (diamond-world or matrix-world) mandala and the Taizokai (womb-world) mandala. The Kongokai mandala symbolizes the "“knower" upon which the "known" is reflected" or "wisdom" ("chi", 智) (Kiyota 1978, 177; Yamasaki et al. 1988, 149). The Taizokai mandala represents the "known" or the "ri" (理) and symbolizes the "repository of truth". (Kiyota 1978, 164) In Shingon Buddhism, these two mandalas represent different aspects of the deeper unity embodied by the *Dainichi Nyorai*, the fundamental light from which all creation is formed. As Yamasaki et al. explain:

> The two mandalas together thus signify the indissoluble unity of Truth and Wisdom, the inseparability of Matter and Mind, the resolution of mystical paradox. The Taizokai symbolizes the totality of all that exists, the oneness of reality, while the Kongokai symbolizes the wisdom that knows truth in all its separate manifestations. […] Both describe real aspects of the universe. Since they are both inseparable from compassion, however, the dual Taizo-Kongokai mandala is an ideal pattern of harmonious activity. It is a unified portrait of the fundamental Buddha, which is none other than the infinite universe. (Yamasaki et al. 1988, 149)

Spatially, the relationship between the two mandalas is displayed by their position in relation to the altar within a Shingon temple. During initiation ceremonies, portraits of the Taizokai and Kongokai mandalas are hung facing each other on either side of the altar, with the Taizokai in the (left) east and the Kongokai facing it from the west (right). At the altar, which becomes a "great mandala platform", the master unites the two mandalas in his body-mind, and transmits the Dharma to the initiate (Yamasaki et al. 1999, 127). Positioned between the two mandalas, the initiate and master experience the "innate Buddha-mind." The area between the two mandalas becomes a sacred space, in which a person can unify with all of the Buddhas, bodhisattvas, and divinities embodied by the two mandalas.

It can be seen that, spatially, the arrangement of Minakata's brain and works (encoded as digital information) reproduces the positions of the Taizokai and Kongokai mandalas that surround the altar of a Buddhist temple. On the left, the position of Minakata's brain corresponds to the position of the Taizokai mandala, which represents the "reality of things as they are" (Yamasaki et al. 1999, 138). The right, where LCD displays and circuits show the Minakata in information, is the position of the Kongokai mandala which embodies the "adamantine and imperishable" wisdom that illuminates the universe (138). Between them is the message from Nishida, the words of the master to the initiate, who does not provide any answer to the initiate, but offers them the experience of encounter between the self in the brain and the self in information, through which they might experience some kind of unification between the two.[60] Nishida has appropriated the basic structural form of the space around the Shingon Buddhist altar to begin the process of public visitors becoming initiated into a new kind of "human relationship" between the selves in their own brains and the selves in information.

This initiation continues the further one ventures into the exhibit. With each piece of art, one encounters a different kind of self that induces yet another possibility for a new relationship with the self. It is an initiation without a determinate end. Nishida was not interested in making people think something, but in making people feel off balance, and in showing them that the disjuncture between the I in the brain and the I in information might be the reason for it. At the end of his message to visitors posted at the entrance, Nishida concludes, "Will the experience [of

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[60] Nishida also performed his "Master" status and skill with electronics in ways that were inflected by Buddhism. Nishida starred in a short video called "The Esoterics of Soldering" (*Handazuke Ougishuu*), in which he demonstrates several of his circuit fabrication techniques, each one named and presented as though it were a secret religious practice. For instance, a scene in which Nishida solders tiny LEDs, each as small as a grain of rice, into a densely packed column is called the "Rice Grain Sutra-Copying Solder" ('kometsubu shakyou zuke'), a reference to the devotional practice of copying Buddhist sutras on to individual grains of rice. The video puts Nishida's incredible manual dexterity on full display. Nishida was quick to point out that the video was 'fake' and made to be 'comical' by the video's producer. He wanted it to be clear that the framing of soldering as a religious practice was invented for the video. Nevertheless, the video was a persuasive expression of his status as a master of circuits, demonstrated through technical skill if not spiritual awareness, in relation to students and others around him.

making a new human relationship] be a painful or joyful one? I [Nishida] cannot help but keep imagining."[61]

Nishida's media art exhibit is a gallery of numinous experiences (Rappaport 1999), bodily experiences of oneness or unification that confirm the truth of certain knowledge through the undeniability of somatic experiences. The gallery has been crafted to focus the visiting public's attention on the possibility of integration or unification with another self that exists in information. Nishida's works induce undeniable sensory experiences within an arrangement of statements and objects that gesture towards a totality. This is a totality that people can ordinarily only dimly perceive behind a veil of ideas handed down by the state and supported by royal science. His work attempts to push against this veil, and reveals it as mere convention. It takes the spiritual poverty that national surveys detect and the disconnection of humans from technology that Nishida senses, and turns them into signs that the ideas of self, humanity, and technology that people carry might be out of sync with the world that they actually live in.

Nishida's choice to use a spiritual idiom here does not necessarily reflect a deep commitment to a Buddhist vision of technology, or that a religious totality is the only one that is plausible (however, see note 60.) A previous exhibition he curated that was held at the National Museum of Emerging Science and Innovation in 2009-2010 cast similar technologies and experiences in an ecological idiom.[62] It does show, however, that explorations of humans in relation to technology can be accompanied by experimentation with imagined totalities in which they are situated, each coupled with the other in a dialectic of mutual unfolding.

In contrast, in the royal scientific discourse of human-centered technology, humans and machines struggle within a harsh and changing environment. Like symbiotic bacteria, they can work together to survive, but the conditions in which they live lie beyond their reach. Humans

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[61] 「それは果たして、楽しいものになるのか、苦しいものになるのか。私（［ニシダ］）の想像は止みません。」

[62] The exhibition was called "Kankaku kairo saishu zukan" (The illustrated book of collected sensation circuits). Allison (2006) translates *zukan* as a "database" to which children can learn about and add the Pokémon that they collect, that refers back to the childhood play activity of collecting insects as "interactions with both nature (exploration, adventure, observation, gathering) and society (exchanges and information-sharing with other kids)." (201)

and machines are both extensible and plastic subsystems of a larger whole that is structured by the assumption that life is the meta-value that joins humans and non-humans. Nishida's work questions the ordering of this system through technologically mediated bodily sensations. It suggests the possibility that modern society is organized along lines that are too ready to limit human beings to a narrow range of possible connections for the sake of the survival of the whole. Rather than a profane sub-system that works to maintain something else that is sacred, his work suggests a desire to position the human being and human-centered technologies as an entangled pair that can asymptotically approach the center of a new world. This human being is not one that enframes the rest of the world or is enframed by it, but which stands towards it with a posture that reveals, and from which people may experience through technology, new "human relationships" between the I in the brain and the I in information.

6.7 Conclusion

In this chapter, I have argued that the HCT view that humans are systems of communication can reproduce existing imaginaries of society, but it can also reveal potentials for new kinds of relationality. In either case, HCTs are viewed as essential to allowing humans to become more strongly and closely integrated with the larger systems that will ensure their survival and progress. The difference between the two lies in what kind of larger system humans are being integrated with.

In the AIS-GCOE, this system is a technocratic one, in which HCTs are imagined to replace humans lost to demographic decline, so that existing ways of human life can be made both more comfortable and resilient. I showed that in the AIS-GCOE, however, this imagining is possible because the version of the human at its center is one that has been constrained by the reintroduction of the assumption that humans and machines are both forms of life. This assumption serves to ground and close the larger system in which humans and machines participate, so that only a subset of their circuits are activated and maintained by the whole.

In contrast, my analysis of Nishida's media art demonstrates how an imagining of the human that suspends the assumption of life opens up an indeterminate but more open space in which new kinds of relationality might be experienced. His art uses HCTs to create experiences that induce people to encounter versions of themselves of which they may not have been consciously aware. In order to frame these experiences, he draws on esoteric Buddhism to stage the visitors' encounters with technology as an initiation into a relationship with the universe that cannot be spoke or thought, but must be felt.

This chapter demonstrates that communication rather than life is the meta-value atop which humans are systems of communication, and which acts as the foundation for connecting humans with machines. It shows that within this context, the assumption that humans are a form of life can re-enter to constrain what kind of human can be imagined. Life becomes a form of communication, and humans become a form of life. At the same time, then other kinds of circuits and connections become possible, and humans' positions as nodes within a different kind of system become tangible.

Chapter 7

7 Conclusion

In this dissertation, I have argued that, for human-centered technology researchers, the human is not a form of life but a form of communication. Communication took the central place of a meta-value for understanding humans through the HCT researchers' adoption of cybernetics as an account of reality, in which humans and machines could both be considered systems of communication. As I showed in Chapter 2, Japanese researchers interpreted cybernetics and the work of Norbert Wiener in a way that gave them an account of the underlying but imperceptible reality of the universe, out of which all forms of being, including humans, emerge as systems of communication.

In the WTL, this view of the human became linked to how they experience and understand their everyday social relations, which are regulated by the requirement to read ambience. In middle-class Japanese society broadly, people are socialized to read ambience, and continuously monitor and observe their surroundings so that they can always perform appropriate behaviors. In the WTL, the act of reading ambience then became linked with the concept of mental load and a theory of conscious and unconscious behavior rooted in communication circuits. In this way, everyday social relations led researchers to place central importance of the act of reading ambience when creating human-machine interfaces. Reading ambience became the way through which one system of communication becomes able to interface with others, and become a node within a larger system of communication.

Through experiments and technological development in tsumori control, illusion-based interfaces, and the Parasitic Humanoid, the WTL refined and further established the view of the human as a communication system defined by its characteristic set of input-output relations. In their work on these technologies, the researchers reveal a contradictory notion of the human body, in which it both seems essential to understanding the human communication system, but which can also be replaced by machines. This contradictions showed that what HCT researchers consider to be most characteristic about humans is the particular way that they map input messages to output messages, such as illusions. This view of the human and its body shows that the human is enacted as a particular kind of system through its relationship with its surrounding systems. When these surroundings are closed, then the body's importance to humanness dissolves, but when they are open, the human body must remain at the center of human-centered technology.

I also showed that HCT researchers have placed so much importance on technology as a way to support human beings in contemporary society, because the cybernetics allows them to view social problems as problems created by poor interfaces between communication systems. This is due in part to the introduction of cybernetics into a postwar context in which social progress was inseparable from technological development. In this context, the central question concerning technology was whether it should be used to support the development of a technocratic and consumerist society, or if it should be made to foster more democratic forms of society. Cybernetics made it possible for HCT researchers to see the difference between these alternatives as difference between systems of communication.

More recent challenges presented by Japan's demographic decline were similarly articulated in terms of communication. This has made the creation of "human-centered" technologies urgent for these researchers, so that machines might be able to do the tasks that humans are no longer available for. Reiterating the postwar technocracy/utopia debate, HCT researchers imagined their technologies as both supporting the survival of society as it is, but also enabling the realization of new forms of relationality. The difference between these possibilities rested on how the researchers imagine the larger communication system in which humans were to be integrated, and showed that the re-introduction of the assumption of life can constrain what they human can be.

With HCT researchers, we can see that far from being approached as a "technical problem of finding the right operating system" (Turkle 2007, 326) to make humans and machines work together, creating interfaces between humans and machines raises questions about society—what is it about our relations with each other through which we recognize the humanity in others and ourself as humans? It raises questions about politics—what kind of society can help people flourish? What means do we have to achieve this? Finally, it presents an ethical challenge—amidst changing global social, political, economic, and technological circumstances, what parts of ourselves, what relationships, and what values must be held without compromise?

The key insight I believe that was necessary for developing my analysis of human-centered technology is that these researchers do not require the assumption that humans are alive in order to understand their world. As I discussed in Chapter 1, the assumption that humans are a form of life and that the notion of life is the basis of human relationality is deeply rooted in anthropology, and even in studies that deal with human–non-human interactions. This study of HCT researchers suggests that life is not essential to humanness in all societies, not even among scientists in Japan, who appear at first glance to have adopted the same knowledges, technologies, scientific practices, and institutional forms as their colleagues in other disciplines and countries. Deep and profound differences in how people imagine themselves as living and as human lie underneath even the appearance of universality that science so easily projects.

The arguments of this dissertation might therefore serve as encouragement to others interested in relationships between humans and non-humans, not just machines and technologies, also animals, plants, cities, and stones to question whether their informants are forms of life, forms of communication, or forms of another meta-value, which has yet to become explicit. Different meta-values cut across the universe in different ways, and redistribute objects, practices, and agencies into different kinds of systems. More comprehensive investigations of the varieties of these foundations may reveal that "human–non-human" is only one way to make this cut.

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