

Archaeologies
OF
TOUCH

*Interfacing
with Haptics
from Electricity
to Computing*

**DAVID
PARISI**

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Interfacing with Haptics from
Electricity to Computing

David Parisi



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For Kristen

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What men make, men may also unmake; but what nature makes no man may dispute. To identify the role of human agency in the making of an item of knowledge is to identify the possibility of its being otherwise. To shift the agency onto natural reality is to stipulate the grounds for universal and irrevocable assent.

— Stephen Shapin and Simon Schaffer,
The Leviathan and the Air-Pump

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Preface

Interrupting the Networked Body

The idea animating *Archaeologies of Touch* emerged at the intersection of two collisions. The first collision took place on December 27, 1990, when my sister—five years old at the time—was involved in a car accident that fractured her spine. The resulting swelling compacted a portion of her spinal column, leaving her paralyzed from the waist down (these generalizations are always insufficient: we would later learn that it was a level T 10–12 injury, meaning that she retained some sensation in her lower abdomen, but limited use of the muscles in that region). Bruising the spinal cord is different than severing it. In a severing, there is a complete break in the spinal cord—a total cutting off of one portion of the body from the command center of the brain. With bruising, the spinal cord compresses to the point of becoming functionally useless—the connection is still there, but the data channel is effectively compromised.

Though this crucial distinction between bruising and severing had serious implications for her therapy and potential recovery, it was unclear to me at the time. The important fact was the doctors' growing certitude in their diagnosis that her condition would be a permanent rather than a temporary one. Any chance at recovery would be evidenced by her responsiveness to the sensitivity tests they administered when they visited her hospital room; with each passing day that she failed to respond to their cutaneous probes,

the prospects of recovery dimmed. My knowledge about the medical aspects of her condition (it was 1990, there was no WebMD, and I was a science-averse teenager) came in jumbled packets, assembled from whatever hazy conversations with doctors I happened to be present for, or relayed imperfectly by my parents. Regardless, I gradually came to understand it as a problem of information transmission: the vital connection between the brain and body had been damaged, impeding the successful reception of sensory data from the extremities and making the transmission of commands impossible.

The second collision had taken place a year earlier in the pages of the comic book *Iron Man*, when a bullet fired by a jilted ex-lover collided with Tony Stark's spine.¹ As with my sister's injury, Stark's spinal cord was not severed—the bullet's hit had not been a direct one—but it did leave Stark, like my sister, without the use of his legs. Prior to the injury, when not wearing his Iron Man armor, Stark had inhabited the stereotype of a billionaire playboy, image-obsessed and a tabloid celebrity. But after the injury, he struggled with his new identity as a paraplegic, quickly falling into a reclusive depression. Stark's adjustments to his chair over the subsequent months prefigured those my sister faced when she returned home from her three-month stay in the hospital. The reactions she received mirrored Stark's. In addition to having to navigate the constraints of a body with an imperfect sensorimotor system, she also had to confront the infrastructural impediments and social stigmatizations that accompanied the wheelchair. Stark, however, quickly rigged the Iron Man armor with "microcircuits" that allowed him the use of his legs. Though the writer never explained how the mechanism worked, Iron Man was back on his feet and in action, telling his friend "I never realized how much I'd miss walking, even after just a few weeks."² The solution, however, further bifurcated his identity: while in the armor, he had full use of his legs, but upon exiting it, he returned to his chair, where he once again faced both his physical limits and the steady stream of tabloid stories that presented the wheelchair-bound Stark as a pitiable and tragic figure.

With Stark's paralysis as a vehicle, the plot allowed writer David Michelinie to soberly confront some of the realities that those in wheelchairs face every day (though Stark's use of a \$1.2 million *hoverchair* exempted him from some of these struggles). But, wary of losing action-hungry readers, Stark's time in the chair was confined to a few panels each issue. After six short issues, the situation had become untenable, and Stark doggedly set himself to work leveraging his vast wealth to ameliorate his injury. The solution came in the form of an experimental chip implanted in his spine—"an organic computer"—that regrew the damaged nerve tissue, effectively restoring the connection between his brain and his lower extremities. The healing process, though miraculous, had not been instantaneous.³ It required Stark to undergo an extensive rehabilitation routine that mirrored my sister's: both relearned to walk with the assistance of parallel bars. Kristen's rehabilitation required the further help of a custom-fitted brace that allowed her to be locked into a standing position—but this cruel exoskeleton, forced on her at a doctor's insistence, served more as a reminder of what had been lost than a promise of what could be regained.

In Stark's case, an impossible machine had solved an intractable problem: the chip overcame the data transfer interruption by regrowing the nerves, by hacking the body so that it would heal itself.⁴ Given the rapid forward progress in computing and medicine, what his doctors did on the page seemed like it should have at least been plausible to replicate in the real-life lab. Deluded and desperate for hope, the ease of the solution ate at me as I watched my sister acclimate to her body's new parameters. If only we could find some way to restore the damaged connection between her brain and her limbs, all these struggles would melt away. If only someone at the Spinal Cord Injury Research Lab had been reading *Iron Man*, they could have set themselves to work on the project, treating paralysis, as Stark's doctors had, through an alchemic mixture of electrical engineering, computer science, and molecular biology.

The plotline that played out in *Iron Man*—comic book time proceeds according to the commercial logic of a monthly release cycle—mapped onto my embodied relationship with Kristen's new

disability. When she returned home from the hospital after months of treatment and rehab, our rural home was unprepared to accommodate her limited mobility. A short flight of steep stairs loomed between the driveway and the doorway to the house. To get to her shared bedroom on the second floor of the house required ascending yet another flight of stairs. My role in all of this was to carry her up the stairs to the bedroom at night and then down the stairs in the morning, playing the part of Hodor to her Bran. My encounter with her disability, punctuated each month by a new issue of *Iron Man*, was very much an embodied one, as we struggled to adjust our living situation to her body's limits. Problems invisible to those who enjoy what we now call "ableist privilege" became impossible to ignore. The height of drinking fountains, the width of doors, and the pitch of ramps were suddenly reordered as unfair obstacles. And while my parents, buoyed by Congress's passing of the Americans with Disabilities Act the same year as my sister's injury, fought valiantly for these infrastructures to be made accommodating, *Iron Man's* chip lingered in my imagination, promising a way to circumvent the lifetime of hardships that lay ahead for Kristen.

Nearly ten years later, I learned of McLuhan's formulation of media as imperfect extensions of the human nervous system, functioning as fragmented, selective, and necessarily imperfect externalizations of the senses. Languages, as "stuttering extensions of our five senses" that vary in "ratios and wavelengths," had a particularly disruptive effect on the body.⁵ McLuhan's metaphor seemed to be literalized in my sister's condition. The body's fragile internal communication network—the nervous system McLuhan thought to be "outered" by media technologies—frequently stutters. And sometimes it does not just stutter. Sometimes it breaks altogether. But as much as I found McLuhan's work to be revelatory, his discussions of touch were often maddeningly immaterial and metaphorical. Touch—as an ongoing feedback loop of action and reaction, of sensing and movement—was not a *mental* process of synesthetically translating between sense modalities, as McLuhan frequently claimed. Instead it was a fundamentally embodied and

mechanistic process, involving the stimulation of dense and variegated mechanoreceptors, the exertion of muscles distributed in the joints, and the transmission of complex signals across nerves akin but irreducible to electrical networks.

In 1999, while still grappling with McLuhan's theories, I had the opportunity to attend a performance and lecture by the artist Stelarc. On stage, he invited participants to have their bodies taken over by an electrical keyboard that he wired to their muscles. With a simple key press, he passed current through the participant's muscles, allowing him to act as a puppeteer as he raised their arm over their head. They squirmed in discomfort as their body was taken over by the artist's crude machine. When we spoke after the performance, I asked him about the potential of such techniques to restore function to paralyzed limbs. He explained that even his primitive mechanism could effectively solve the control portion of the sensorimotor problem—routing control over the muscles in the paralyzed region of the body to a computer or to a functioning set of muscles was a relatively simple operation. Feeding the complex and variegated data of touch back from the disconnected limbs to the brain, however, proved nearly impossible. The haptic system resisted translation into a machine-legible code.

Our conversation simultaneously reawakened and dashed the hopes of my teenage years, but more significantly, it prompted me to begin kinetically reading about the emerging wave technologies that attempted to transmit tactile sensations over electrical networks. With the impending spike in computer processing power, their engineers promised, these machines would soon work perfectly, allowing a high-fidelity touch to flow effortlessly over the Internet. After several years of following this research, it became clear to me that the technology could not cash the checks written on its behalf. But the narrative being crafted around what I soon came to know as haptic interfaces seemed to echo McLuhan's utopian hopes for touch's elevation by the new electronic media in the 1960s. I soon invested myself in mapping the similarities between the two, what would be the first step in the project that eventually became *Archaeologies of Touch*.

Like superheroes, books have origin stories. The intersection between these two collisions—one fictional and the other, inescapably real—provided the inciting event for my eventual research into the antagonistic relationship between technology and touch. And although the disabling of my sister’s body sparked my initial thinking, this is not a book about the social and infrastructural constructions of disability, though it could have been. It is not a chronicling of the efforts made at restoring the connections between the brain and its complex network of nerves broken by collisions, though that, too, provided a tempting pathway for this expedition. Instead, this is a book about touch’s impossible complexity: about the dreams of connecting bodies seamlessly through networks, and about the recurrent efforts to unleash a touch transformed by technoscience as a positive, productive, and liberatory force. This Preface, then, serves very much as an acknowledgment that, without vicariously encountering touch’s absence through Kristen’s condition, this book might never have been written.

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As psychologists, haptic interface designers, and academics have lamented for generations, investigating touch can be a lonely and isolating affair, with collaborators few and far between. I was fortunate to exchange ideas with Mark Paterson and Jason Archer during our work on the Haptic Media Studies issue of *New Media & Society*. My appreciation also goes to Susan Lederman and Mandayam Srinivasan, who generously detailed their experiences working on computer haptics during the field's early years.

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Introduction

Haptic Interfaces and the Quest to Reinscribe Tactility

Within the next five years, your mobile device will let you touch what you're shopping for online. It will distinguish fabrics, textures, and weaves so that you can feel a sweater, jacket, or upholstery—right through the screen.

—Robyn Schwartz, "IBM 5 in 5 2012: Touch"

How is one to believe that touch cannot be virtualized?

—Jacques Derrida, *On Touching*—Jean-Luc Nancy

In a 1965 address to the International Federation for Information Processing, computing pioneer engineer Ivan Sutherland detailed his vision for an immersive, computer-controlled “ultimate display” that would present information for “as many senses as possible.”¹ Sutherland’s talk famously provided the blueprint for what would later be termed “virtual reality,” prompting investigations into immersive stereoscopic displays, motion-tracking input systems, along with a host of other human–computer interaction schematics. Assessing the impact of Sutherland’s address in a 2009 retrospective, science fiction writer-cum-media historian Bruce Sterling referred to it as “a seed bomb of emergent technologies,”² and proceeded to annotate the text of Sutherland’s talk with repeated examples of computing devices that had effectively

realized Sutherland's immense vision. In the category of "still doesn't exist yet," Sterling placed the most radical component of the imagined display: a complex mechanism to render computational data for tactual senses that Sutherland termed the "kinesthetic display." The kinesthetic display, as he envisioned it, would capture the movements of the human body, and in response, project forces back onto it, effectively simulating the body's physical interactions with matter. Using this "force feedback" system—rudimentary versions of which were already employed in the 1960s to allow for the dexterous remote manipulation of hazardous material—the computer could display complex objects to the user's sense of touch. In its ideal form, the objects presented by the display would have such a high degree of haptic fidelity that "a chair would be good enough to sit in" and "handcuffs . . . would be confining." Even more striking, however, was Sutherland's suggestion that a bullet presented by the display "would be fatal."³

Fifty years after Sutherland's address, with his employer poised to release the commercial version of its virtual reality headset, Oculus chief scientist Michael Abrash took the stage at Oculus's second annual developers' conference. He tackled the twofold task of simultaneously laying out the current state of the art in virtual reality research, while also projecting a realistic path forward for the technology's future iterations. In dizzying detail, Abrash explained how virtual reality displays merged technical knowledge with perceptual psychology to effectively and convincingly "drive the senses." Imitating Sutherland's 1965 address, Abrash considered the potential of current-generation displays to create convincing illusions for the different sense modalities. When he came to touch—which computer scientists had taken to calling *haptics* in the late 1980s—Abrash noted its centrality to the virtual reality enterprise, telling his audience that "haptics is at the core of the way we interact with our surroundings, and without it, we'll never be fully embodied in a virtual world." But he then made a curious and startling admission: current-generation virtual reality systems—including the Oculus Rift system that would be released for sale a few short months later—were woefully inadequate to the vital task of synthesizing the felt materiality of virtual worlds. "As

important as haptics potentially is for VR,” Abrash explained, “it’s embryonic right now. There’s simply no existing technology or research that has the potential to produce haptic experiences on a par with the real world.” Uttered at an event intended to hype virtual reality’s purported potential to revolutionize human communication, Abrash’s statement seemed an oddly deflating concession. Abrash himself, however, remained upbeat and hopeful, suggesting that the challenge presented by haptics would eventually be solved through “breakthrough research.” He promised his audience that “the first VR haptic interface that really works will be world-changing magic on par with the first mouse-based windowing system.”⁴ Still, the problem seemed insurmountable and enduring.

In the fifty years between Sutherland’s 1965 address and Abrash’s in 2015, computer scientists, roboticists, engineers, and psychologists set themselves to work on the project of writing touch feedback into computing. Contrary to Abrash’s narrative, they have had some significant—and some more modest—successes along the way, formally establishing computer haptics as a new discipline in the 1990s, incorporating vibrating “rumble” motors into more than 500 million videogame controllers distributed around the world, building high-fidelity haptic devices for use in surgical training and remote manipulation, making somewhat effective cybersex machines, developing prosthetic limbs capable of feeding complex tactile sensations back to their wearers, and embedding vibration feedback mechanisms in touchscreen interfaces as a means of approximating the sensations produced by pressing buttons and keys. In spite of the widespread domestication of these haptics applications, the popular and scientific narratives mobilized around haptic interfaces continually portray them as technologies belonging to an imminent but perpetually deferred future, with haptics researchers still questing after an elusive “Holy Grail”⁵ of touch interfacing that is only hinted at by the rudimentary forms of force and vibrational feedback present in current-generation technologies.⁶ As in Abrash’s framing, finding this Holy Grail promises to bring about a drastic upheaval not just in human–computer interaction but also in a whole range of social relationships, consumption habits, labor practices, and aesthetic forms.

Archaeologies of Touch addresses this current technohistorical situation—the consistent efforts made at weaving touch into computing systems, the persistent failures and circumscribed successes of engineers as they attempted to realize this end, and the continued utopian hopes mobilized around touch feedback computing—by describing the gradual emergence, over four centuries, of a formalized technoscientific haptics that provided the groundwork for the twentieth-century project of computer haptics. At the distal pole of this genealogy sits the eighteenth-century cultivation of a practiced epistemology of electric shock, which proved instrumental first to the production of belief in and knowledge about electricity, and shortly thereafter, to the creation of new techniques for studying the functions of the human sense organs. At the proximal pole lies the rapid embedding, beginning in the late twentieth century, of a computational haptics in a range of digital media interfaces, including virtual reality displays, mobile communication devices, video-game controllers, smartphones, scientific visualization machines, wearable computers, and cybersex devices. Between these poles, a new technological *haptic subject* emerged that served to both mark and steer the drastic changes touch underwent as it became increasingly an “object-target”⁷ of scientific knowledge, engineering and design practice, bureaucratic management, therapeutic discourses, and commercial investment. This haptic subject embodies the self-conscious efforts scientists, engineers, and marketers made to transform touch, as they sought to give tactility a new utility in a political economy of sensations vital to a society with a growing dependence on the efficient circulation of information through sensing bodies. In 1999, confronting the implications of digital touch technologies that appeared poised to wash over and transform culture, Cathryn Vasseleu grappled with the fundamental question of “under what terms is touch admitted into cybernetic telecommunications networks?”⁸ *Archaeologies of Touch*, in positing this haptic subject, takes up Vasseleu’s prompt by looking backward to the technohistorical processes and discourses that forged a touch capable of being rendered, if only in selective fragments, through computing machines. In light of this longer history, the

recent attempts at engineering a computerized tactility become only one stage in an overarching project pursued by subsequent generations of researchers—the touch admitted into cybernetic telecommunications networks is one that has already been thoroughly reshaped by its repeated interfacing with science and technology.

Five Phases of Interfacing

The story I tell of haptic interfacing's technogenesis is organized around a linear chronology that charts touch's passage through five successive phases of interfacing. Each stage entailed a generative contact between touch and a new set of institutionally and materially grounded discourses. By moving through these phases, I show the technoscientific haptics that underpins and animates the rise of computerized touch to be not unique to the age of computing. Instead it is a product that emerged piecemeal out of a gradually cohering body of scientific and technical research aimed self-consciously at producing an objective mapping of the human haptic system. Locating contemporary haptic interfaces in this overarching tradition calls attention to touch's positioning as both a target and source of scientific knowledge, emphasizing the disciplinary techniques and protocols that allowed it to gain expression as a sense capable of serving a utilitarian function in electronic communication networks. Touch was transformed into haptics first by its deployment as an instrument of scientific investigation, then through its enclosure in the framework of an objective, positivist episteme, and later by its articulation in advertising and marketing discourses. These processes allowed touch—via the new haptic subject—to be “made adequate”⁹ to the new demands placed on it in successive epochs.

The first phase, which began with the use of touch to register the charges produced by eighteenth-century electrostatic generators and electrical batteries, involved the cultivation of a practiced tactile sensitivity to electrical shocks. This epistemology of shock underpinned both scientific studies of electrical phenomena

and the growing cultural belief in the new and mysterious force. The electrotactile machines of the eighteenth and nineteenth centuries were built with the expectation that their users' bodies would provide not simply a binary registering of electricity as either present (shock) or not present (no shock), but further, that they would acquire a fine sensitivity to variations in the strength and character of the electrical currents that struck them. Users who came into contact with early electrical machines articulated these gradations in experience by developing a detailed semi-standardized language of shock that allowed for the transcription, circulation, and comparison of experimental encounters. By emphasizing tactility's primacy in experiments with machines like the Leyden jar, electrostatic generator, and voltaic pile, I show how the operation of an electrotactile subjectivity fueled both the spreading interest in electrical machines and the knowledge produced as a result of these shocking human-machine contacts. In contrast to the standard account of psychic shock frequently rehearsed in media theory, this model of shock as embodied, tactile, and epistemic—drawn from both scientific and medical discourses around electrical machines—emphasizes the generative function of shock over and against the formulation of shock as a traumatic effect of encounters between bodies and new technologies.

The second phase of interfacing concerns touch's passage into what I term a tactile modernity, as a new set of knowledge-producing apparatuses were set upon the body with the intent of yielding objective scientific knowledge about the operation of the tactual senses. Touch's isolation in the research laboratories of nineteenth-century psychophysicists facilitated the gradual accumulation of data about touch, culminating in the proposal of the term "haptics"—suggested in 1892 by Max Dessoir and defined in 1901 as the "doctrine of touch"¹⁰—as a response to the accumulating abundance of scientific knowledge that accrued as a product of lab experimentation. Initiated by the "epoch-making"¹¹ two-point threshold experiments Ernst Heinrich Weber carried out in the 1820s, this new epistemological framework captured touch through a structured adherence to experimental protocols. In the lab, experimenters divided touch into isolatable subcomponents, with

pressure, weight, temperature, pain, and movement each sectioned off from one another through the use of increasingly specific laboratory instruments. Where the first interface involved the simple but structured mobilization of touch—a practiced epistemic electrotactility—as a means of producing experimental knowledge about electricity, the second interface turned the gaze of experimentation (with its attendant apparatuses and machines) inward on touch itself. Electricity, which had been an object revealed through tactile investigation, now became a means of investigating touch: applying electrical charges to the skin provided new insights into the mechanisms responsible for tactual perception.

The third interface, dated to the middle decades of the twentieth century, was constituted by a productive contact between touch and technical communication systems, where engineering psychologists designed machines capable of routing data through a touch now reconceived of as a channel for the transmission of information. The overarching aim in this research was to divine what Frank Geldard termed in a 1956 address “the tongue of the skin”: a set of machine-rendered vibrotactile or electrotactile signals that the skin would be able to reliably distinguish between and assemble together as the building blocks for a tactile language. Some of the new machines built in the service of this project could pass speech sounds through the fingers, others functioned by using vibrations to project tactual images onto the torso, while yet another category of devices employed Morse code-like schemes for arbitrarily linking letters to vibrotactile signifiers. The psychologists in this third phase of interfacing employed the data and methods inherited from nineteenth-century psychophysical investigations of touch to provide the foundation for their various communication systems, improving on and repurposing many of the apparatuses developed by the prior generation of researchers. Where the search for knowledge about touch as an end in itself defined the second phase of interfacing, this third phase instrumentalized that knowledge, intent on opening touch up to new flows of data. Through the structured solicitation of artificially generated tactual sensations, nineteenth-century touch machines helped quantify and map touch’s discriminatory capacities, and by doing so, laid bare its hard-coded ability

to register the differences between unnatural sensations. By assigning values to these stimuli (and teaching their experimental subjects to concretize associations between machinic tactile signifiers and linguistic signifieds), touch communication researchers gave the science of touch a utility it previously lacked. Researchers like Geldard formulated the new communication systems as necessary responses to the increasingly taxing burdens that modern media were placing on the visual and aural channels, with touch providing an ameliorative means of “transmitting intelligence.”¹²

In the fourth phase of interfacing, initiated by the blueprint for the ultimate display Sutherland laid out in 1965, computer scientists sought to make touch experiences into something that could be stored, transmitted, and synthesized by computers, building machines capable of simulating the physical materiality of objects that existed only in the electronic realm of computer memory. Appropriating robotic machines used for the remote manipulation of hazardous nuclear materials, these engineers extended touch into computer-generated environments. The new interfaces allowed their users to feel the weight, shape, temperature, and textures of virtual objects. Though they initially proceeded unaware of the previous century’s scientific investigations into touch, the computer scientists and roboticists working on touch feedback computing eventually learned of rich research tradition designated by the term haptics. Owing especially to the efforts of cognitive psychologists like Susan Lederman and Roberta Klatzky, interface designers began partnering with hapticians to build more effective touch feedback interfaces that were informed by the principles of both electrical engineering and haptic perception. In 1990—nearly one hundred years after the Berlin psychologist Max Dessoir had proposed “haptics” as the name for the scientific study of touch—MIT engineer Mandayam Srinivasan dubbed this emerging field of human–computer interaction “computer haptics,” effectively fusing the positivist tradition of studying touch and the practice of building machines that could extend and stimulate the various submodalities of the human haptic system. Consequently, the nineteenth-century model of touch—as one broken down into experimentally isolatable components that could be indepen-

dently stimulated by machines—was inscribed into the design of haptic human–computer interfaces,¹³ with separate mechanisms, dedicated algorithms, and coding languages devoted to each of touch’s constitutive parts. Although their designers aspired to make touch machines that would create holistic and accurate representations (as Sutherland had called for with the ultimate display), in practice, these machines were only able to act on limited subsets of the haptic system. Any reconstruction of touch, then, entailed strategically selecting which body parts the haptic interface system should interact with, and which of the various haptic submodalities (pressure, vibration, temperature, pain, etc.) it should target for stimulation. Where researchers in the third phase had sought to instrumentalize touch as an information-reception channel, translating audio, visual, and linguistic data for transmission through the skin, efforts in this fourth phase represented a self-conscious departure from the prior tradition—or, as Marvin Minsky explained in his famous 1980 essay “Telepresence,” it was time to abandon the goal of transcoding images, sounds, or words for the skin and instead move to the project of “translating feel into *feel*.”¹⁴

The fifth phase of interfacing concerns the efforts made by advertisers in the twenty-first century to produce a demand and desire for touch-based interfaces. In this phase, marketers working for digital technology firms like Nintendo, Apple, Hewlett-Packard, and Immersion Corporation crafted an image of the cultural sensorium in a state of urgent crisis that touch interfaces were uniquely qualified to alleviate. According to the narratives presented in these advertising campaigns—which featured slogans like “Touching is Good,” “Touching is Believing,” and “Touch the Future”—the sense of touch had been forgotten, left behind, and marginalized by a media interfacing schematic overdependent on audiovisual technologies. In a McLuhanesque maneuver, they claimed that the cultural sensorium could be rebalanced through the active embrace of touch interfacing. Collectively, these ads sought to create a new mode of haptic subjectification that would foster a desire in consumers to reconnect with their lost sense of touch. Touch interfacing becomes instrumentalized simultaneously

as a marketing strategy and a means of regaining a lost sense modality. But while these ads portrayed touch as a way to rediscover something ancient, primitive, and pre-rational, they also fetishized touch—in its technologized reincarnation—as a marker of the consumer's passage into a utopic future of fully embodied presence in digital worlds. The attempt to make haptics into a mass-marketed technology involved the ongoing construction and continual reaggregation of a haptic subject—through practices of user-centered design—and the activation of a haptic subjectivity that desired awakening through the adoption of new interface technologies. In the fourth phase, haptics had been confronted primarily as a design problem; in the fifth phase, it became a marketing challenge. At the same time, however, the design challenge persisted, with growing numbers of researchers taking up the task of building more effective haptics applications. By 2010, engineers and developers around the world had established nearly fifty haptics labs spread out across over a dozen countries, with the increasing need to develop new mechanisms for communicating tactile sensations through mobile touchscreens providing fresh infusions of capital into the computer haptics project.¹⁵

Throughout these five phases of interfacing, I am concerned with mapping a range of interrelated developments around touch's technogenesis: the institutionalized and formalized knowledge-production networks that rose up around touch, the new intellectual and financial resources funneled into the study of touch, the training and regimentation of tactility demanded by the new machines, and the motivations—explicit and implicit—of the various researchers who set themselves to work at the immense challenge of bringing touch under the control of scientific and technical apparatuses. I want to understand what can be thought of, borrowing from Hans-Jörg Rheinberger, as the “experimental situation” and “experimental system” that redefined and reconstituted touch—a “reasoning machinery” consisting of “the dynamic body of knowledge, the network of practices structured by laboratories, instruments, and experimental apparatuses.”¹⁶ Through the case studies in each phase, I bring these “materialities of research” and “epistemic practices”¹⁷ into dialogue with the artic-

ulated theoretical and practical aims of investigations into tactility. Each trial in the experimental system yielded not only new data about touch but also prompted the refinement of experimental protocols, the formulation of new research questions, and the development of new apparatuses that, taken together, served to specify touch with increasing detail.

While the structure I am imposing on these phases suggests that each constitutes a distinct moment in touch's history, they exist in continuity with one another, linked by direct intellectual, biographical, and institutional connections among the different actors associated with each phase. When the Italian physicist Alessandro Volta first invented his electrical battery in 1799 he immediately suggested that, by applying its currents to the various organs of the human sensorium, the battery could be a tool for the generation of new knowledge about the nature of sensory perception. To illustrate these possibilities, Volta repeatedly applied the battery to his eyes, ears, nose, tongue, and skin, providing detailed accounts of the sensations produced with each contact. Two decades later, Volta's trials proved inspirational for E. H. Weber in his psychophysical research on tactile perception, as Weber carried out similar investigations on his own body. By doing so, Weber staged the subsequent development of electrical machines specifically designed for the stimulation of the tactile senses. When Geldard began his search for the tongue of the skin in the 1940s, he had at his disposal a whole range of tools and techniques, acquired during his graduate training in psychophysics at Clark University, where he had studied under several of the figures responsible for experimental psychology's migration from Germany to the United States. Joseph Jastrow and G. Stanley Hall, both of whom possessed deft expertise in the ad hoc design of instruments for investigating tactual perception, were among his mentors. Before Geldard's passing in 1984, he had frequent contacts with Lederman, who by the mid-1980s had begun collaborating with roboticists to help build artificial hands that obeyed more closely the principles of haptic perception established by psychophysics research. Both Lederman and computer science luminary Frederick Brooks—whose GROPE-1 in the late 1960s represented one of the first attempts

at realizing Sutherland's vision for a kinesthetic information display—served on the committee for Margaret Minsky¹⁸ in her trailblazing MIT dissertation “Computational Haptics: The *Sandpaper* System for Synthesizing Texture for a Force Feedback Display.” MIT's Touch Lab, where the discipline of computer haptics gained its most formal articulation, provided a launching pad for the next generation of haptics researchers during what would later be dubbed the “epoch of haptic interface”—an era marked by increasingly close partnerships among those trained in psychophysical methods, practiced robotics engineers, and computer programmers.¹⁹ Over the centuries, the science of touch gained expression in institutions, too, including the host of psychophysics and experimental psychology labs set up at the close of the nineteenth century, Robert Gault's Vibro-tactile Research Lab (active from 1925–1940; affiliated with Bell Labs), Geldard's Cutaneous Communication Lab (run at Princeton University from 1962 to 2004), Susumo Tachi's lab (established at the University of Tokyo in the 1980s to investigate what Tachi termed tele-existence), Srinivasan's Laboratory for Human-Machine Haptics (began in 1990 at MIT), Hong Tan's Haptic Interface Research Laboratory at Purdue, and Vincent Hayward's Haptics Laboratory at McGill University. All this suggests that touch's technogenesis should not be considered a quasinaturalistic unfolding but instead a project passed down through successive generations of institutionally grounded actors, many of whom were trained in similar sets of established experimental and design techniques (or protocols) for studying, knowing, and synthesizing touch.

The touch that emerges out of these successive phases of interfacing has undergone a radical reformatting and upheaval as a result of its repeated contacts with scientific, technical, and economic practices. These changes are far from finished: the rearticulation of touch through technoscience remains an ongoing project, attracting new intellectual and financial resources, spreading outward through its embedding in new communication infrastructures, and taking on a transmogrified shape in the marketing literature for technologies of digitized touch. Contemporary technical

systems, as Bernard Stiegler suggests, are in “an age of perpetual transformations and structural instability.”²⁰ With their market-driven need to rapidly render the present obsolete, this is particularly true for digital media. Regardless of the future forms technologized touch may take, its basic inertia has been firmly established, and its fluctuations will remain bounded by the positivist framework gradually erected around it during these five phases of interfacing.

A Tactile Modernity

The account of touch I provide is organized in its early stages around the idea of a tactile modernity—a way of thinking about touch as an alternative means of registering the impact of rational experimentation and positivist science on the organization of perception. The experimental methods, techniques, instruments, and protocols of what later became known as “scientific psychology” brought with them a new type of machinic tactile experience in the form of artificially induced, precisely targeted stimuli that experimental subjects were asked to carefully attend to and vocalize. In the confines of the lab, tactility became a site for expressing the researcher’s fantasy of capturing, controlling, and managing touch. The reorganization of touch through this materially realized fantasy had immediate consequences in pedagogy and medicine (discussed in Interface 2). But more significant for the overarching argument I craft in *Archaeologies of Touch*, the new experimentally derived model of touch laid the groundwork for the eventual engineering and design of haptic human–computer interfaces. By representing touch as something that could be revealed through lab experiment, this model provided an enduring epistemic frame for future investigations into the microprocesses of tactual perception that became increasingly useful to the subsequent generations of researchers who attempted to engineer touch communication systems.

My formulation of a tactile modernity is intended to both complement and expand conventional accounts of technological

transformations to the sensorium during the nineteenth century. These narratives depict the senses of seeing and hearing as the primary objects of modern psychosensory science. The quantification and dissection of vision and audition by lab science staged the incorporation of these new models of seeing and hearing in emerging representational technologies. Modern science, modern media, and modern models of perception were each coconspirators in what we might think of as a sensorial modernity characterized by the disruptive application of increasingly structured and formalized laboratory methods to the senses. Through the use of specialized psychophysical apparatuses, the senses were cleaved into discrete, isolatable, and quantifiable objects. In Jonathan Crary's telling of this story, the new image-making technologies developed as a result of vision's subjection to this process worked "to recode the activity of the eye, to regiment it, to heighten its productivity and to prevent its distraction."²¹ In conjunction with the veneration of seeing in Enlightenment philosophy and science, this recoded eye aided in vision's ascent to the "master sense" in modernity. A similar set of changes also occurred to hearing as part of what Jonathan Sterne terms the "ensoniment," defined as "a series of conjunctures among ideas, institutions, and practices" that "rendered the world audible in new ways and valorized new constructs of hearing and listening."²² Touch, however, has generally been treated as external to these developments, framed as a sense left behind by modernity, or reduced to a mere operation of new imaging technologies.²³ In Crary's formulation, for example, the stereoscope indicates the nineteenth century's "remapping and subsumption of the tactile within the optical,"²⁴ with touching reduced, via an ocular prosthesis, to a function of vision. In arguing for a distinctly tactile modernity, I locate a touch unsubsumed by the optical—irreducible to a mere operation of vision—as the object of the same scientific discourses and practices that were set upon seeing and hearing during the nineteenth century. This alternative account of sensorial modernity provides a parallel formulation of touch as something acted on by and shaped through the new lab science of the nineteenth century. Following medical historian Robert Jütte's observation that "the transformation of the

sense of touch in the industrial age is still uncharted territory,”²⁵ tactile modernity writes touch into a historiography of media that has rendered it absent.

Owing to the prompting of accounts like those provided by Crary and Sterne, the development of contemporary technical media has been linked increasingly back to the psychophysics and experimental psychology programs of the mid-to-late nineteenth century. Primarily, such studies examine the relationship between the quantification of the senses—the expression of the senses through laboratory equipment and experimentation—and their subsequent embedding in media technologies. Friedrich Kittler, writing on media of image and sound reproduction, noted that “media technology must first isolate and incorporate the individual sensory channels” before they can be connected together to form multimedia systems.²⁶ By “giving a mathematical expression to the data stream of sensual perception,”²⁷ psychophysics, according to Kittler, yielded a model of the senses as isolated, quantified, and individuated that would prove fundamental to the later development of technical media. Specific knowledge of the threshold between the perceptible and imperceptible—the ability of a sense organ to notice or not notice the difference between a unit of stimulation—allowed for the eventual efficient and rationalized coding of machine-generated sensations by technical media, what Sterne terms a “perceptual technics” used to economize the transmission of sensory data.²⁸ This tight link between psychophysics and information transmission technology that developed throughout the twentieth century embodies concerted efforts by American experimental psychologists to give their budding science a utilitarian function in industrial society, a multistage project of transforming psychology from a field underpinned by the method of contemplative reflection to one dominated by the mode of laboratory experiment that had proven crucial to modernizing advances in engineering, chemistry, electricity, and physics.

Because of E. H. Weber’s influence on his mentee Gustav Theodor Fechner, touch occupies a distinct place—one rarely acknowledged by media scholars, though often rehearsed by psychologists—in this history of psychophysics. Weber’s insights,

derived from his sustained program of meticulous experiments on the tactual senses, were so influential on Fechner's systematic development of his new science that he suggested, in the opening of *Elements of Psychophysics*, Weber ought to "be called the father of psychophysics."²⁹ However, outside of touch's primacy in the sequence of developments that resulted in the establishment of psychophysics, the story that emerges around it maps rather neatly onto other historiographies of sensory quantification, such as Alexandra Hui's recent study on the relationship between acoustics, aesthetics, and the emerging psychophysics of hearing,³⁰ and Jimena Canales's analysis of the tenth of a second as a concept that drove experimental research into the temporal capacities of the human perceptual system.³¹ This is not to suggest that touch's history is reducible to these other narratives, but rather to point out that touch did not lie beyond the reach of the scientific programs that media historians have taken to be essential to the development of technical media. Touch, as I show throughout this book, brought its own particularly complex set of research questions, practical challenges, specialized apparatuses, and laboratory protocols, derived in part from the difficulty of confining touch to a singular organ localizable to a specific site on the body. In spite of these peculiarities, touch proved equally capable of being made into an object of structured, positivistic stimulation and observation.

As a space of knowledge production vital to social advancement, the research lab has long played a defining role in accounts of technological, political, and scientific modernity. In Bruno Latour's formulation, the hermetic space of the laboratory established and perpetuated the foundational myth of modernity, providing a site where science could be cleaved off from politics. In the lab, science purportedly became an autonomous form of human activity, free from the contaminating influence of political and religious authority. Building on Stephen Shapin and Simon Schaffer's argument in *Leviathan and the Air-Pump*,³² Latour claims that the lab's simulated conditions provided a site where nature could be isolated, confined, and witnessed in a space that purported to be value-free through the implementation of experimental protocols. Through the laboratory experiment, nature spoke, and the exper-

imeter merely functioned to record its words. Suspicious of this conceit, Latour suggests instead that the separation of science from politics—the basis, he argues, of our modern ontology—never occurred in the way we imagine it. Science remains shot through with political considerations and instrumental calculations, as scientific knowledge remains firmly under the sway of human interests. Touch's enclosure in the lab, then, entailed a fundamental shift in its character and status; touch could be observed and laid bare without the purported contaminations of politics or culture. During the nineteenth century, touch was made modern through its enframing within the processes, procedures, and protocols of laboratory science. This enframing served as a necessary precondition for twentieth-century attempts to incorporate touch into electronic communication networks: without the establishment of a modern model of touch, the designers of cutaneous communication systems and haptic human–computer interfaces would not have had a stable, manageable, and quantified rendering of tactile processes to embed in their touch machines. In this aspiration to value neutrality—in the quest to arrive at a purely scientific account of touch—it emulated features endemic to modern laboratory science more generally.³³

Finally, a brief note on my choice to identify this as a *tactile* modernity, rather than a *haptic* one. “Haptics” was adopted to designate the science of touch only in the final decade of the nineteenth century, only once the new scientific techniques and apparatuses of experimentation had been set upon touch for several decades. As such, I use “tactile” to describe this variant of modernity, because it grounds these practices for knowing the touch senses firmly in the vocabulary originally used in the nineteenth-century medical and scientific literature, cementing the position of tactile modernity alongside the parallel experimental processes for specifying, quantifying, and isolating vision and hearing. Subsequent formulations of the distinction between haptic and tactile offered by neuroscientists and physiologists assert that the former involves an active mode of touching (including the kinesthetic and vestibular senses), while the latter refers to those touch senses housed in the skin (specifically, pressure, temperature, and vibration). But

while the line between the haptic and tactile senses may appear to be drawn thickly in the pages of psychology textbooks, in practice, even specialists have frequently used the terms interchangeably.³⁴ As I show by unpacking their relationship in the subsequent chapters, the fuzziness of the two terms often proved generative, with shifts in terminology indexing new connections between previously disparate fields and institutions.

The Haptic Subject

I propose the figure of the *haptic subject*³⁵ to specify a particular relationship between touch and processes of scientific-technical knowledge production that initially took shape in the nineteenth century. The haptic subject functions as both a driver and an outcome of research on the tactual senses; it is not only a subject who actively touches (consistent with Foucault's questioning, listening, seeing, and observing subjects) but also a subject who was passively touched, poked, prodded, shocked, and caressed by scientific instruments, with the goal of revealing the nature of a touch that transcended the confines and peculiarities of an individual body. In this way, the tactile subject recalls the figure of Crary's nineteenth-century observer: concerning vision, "the idiosyncrasies of the 'normal' eye" became the object of a physiological optics aimed at "determining quantifiable norms and parameters"³⁶ of human vision. While the methods of investigating touch assumed a similar form, the data given up by the haptic subject were not immediately pressed into service by popular culture machines—there were no zoetropes or stereoscopes for touch during the nineteenth century. Using his aesthesiometric compasses—crude instruments that initiated the emergence of a formalized scientific haptics—Weber aimed at isolating the varying capacities for distinguishing between applied tactual stimuli, probing the subject's capacity for noticing and not noticing the differences between applied stimuli. The perceptual parameters he uncovered gained their most widespread utility in reflexively providing proof of the psychophysical method's concept: the trials, owing to their simplicity, could be replicated with ease by any who wished to learn the rudiments of the

new practice. Neophyte psychophysicists undergoing formalized rituals of disciplinary indoctrination were asked to repeat Weber's compass-point experiments, experiencing the various tactile illusions induced by applying the device to different sites on their bodies. The establishment of haptics as a distinct set of techniques for knowing and revealing touch required a distributed network of subjects who would assent to and verify its key suppositions about the quantifiability and isolability of tactile experience.

The haptic subject, then, provides both the epistemological ground for knowing touch and the storehouse of technical knowledge required for touch's artificial stimulation. Its formation remains stable in a set of boundaries, but within those boundaries it constantly shifts, as the haptic subject is reaggregated on a continuing basis, its constitution changing in response to the idiosyncrasies of a given experimental system. Many of its particular features, then, are only ever temporary, as they are reevaluated in the frame of persistently intensifying modes of experimental investigation, and adjusted to meet the shifting demands of information-circulation economies. In short, the haptic subject gives structure and organization to a history of touch. As with Crary's figure of the "observer," the haptic subject exists only at the intersection of institutional, discursive, social, and technical relations.³⁷ The haptic subject signals the tacit embrace of empirically derived knowledge about touch, while also indicating touch's thorough working over by a set of assumptions about the proper way to generate and organize knowledge of the various tactile processes. It expresses a sequence of wish-images: first, the fantasy that touch can be revealed through empirical investigation, and later, the dream that this same science of touch can allow for tactility's extension into and through digital communication networks.

The production of this haptic subject mobilized a complex network of material processes, training procedures, scientific instruments, and institutionally grounded actors around the goal of revealing, laying bare, and imposing structure on the messy assemblage of human sensations designated by the term "touch." It was only when touch *became* haptics that it could begin to achieve its new, utilitarian function in a society increasingly dependent on the

machinic and computational circulation of information. Haptics describes a mode of productively enframing and revealing touch—a way of ordering touch as an exploitable resource in an economy that treated the human sensorium as a calculable network of discrete information-processing channels. Utilizing increasingly specialized and standardized apparatuses, the researchers who executed these lab experiments succeeded in disaggregating and subdividing touch into a set of constitutive submodalities, each with its own unique physiological structures. In the lab, the sense of touch became the *senses* of touch; touch's component parts—heat, cold, pressure, pain, weight, movement, and vibration—became the target of specialized machines, protocols, and experimental programs, all intended to render a detailed and holistic map of touch's ability to notice and not notice the differences between things.³⁸ Initially, the precision with which the available instruments could stimulate the tactual senses limited the accuracy of this map. But a positivistic, utopian faith in the forward progress of technology—a belief in the power of machines to reveal the secrets of nature—suggested to early experimenters that, for all its fuzzy borders, their extant map of touch possessed an infinite perfectibility. Or, as Frank Geldard suggested in his 1940 treatise on the existence of a distinct vibratory sense, “recent developments in apparatus and method are important since our future facts are a function of them.”³⁹

Machines, then, were vital to the production of this haptic subject: it was through the various “pieces for haptical work”⁴⁰ and the other psychophysical apparatuses that touch began to give up its secrets. The term “apparatus” does productive work in this literature, recurring throughout historical discourse on the psychophysics of touch, to the extent that the production of psychophysical knowledge would not have been possible without the range of explicitly titled apparatuses invented to study whatever aspect of mental life the psychophysicist wished to isolate and quantify. In that context, “apparatus” (appropriated from the German word *Apparat* by experimental psychologists like Titchener, who trained in Germany's newly founded labs) was generally used synonymously with “instrument,” as Horst Gundlach explains in his genealogy of the

term “psychological instrument.”⁴¹ The intricate late nineteenth-century pneumatic machine William Krohn and Thaddeus Bolton dubbed the “apparatus for producing simultaneous touches” (detailed in Interface 2), for example, allowed the experimenters to stimulate multiple sites on the subject’s skin simultaneously for the purpose of testing their ability to correctly identify and localize multiple tactual contacts. In the framework of the apparatus, repeatedly stimulating subjects helped experimenters map the skin’s capacity to perceive touch stimuli both accurately and inaccurately. Crucially, these psychophysical apparatuses acted on and through subjects: to generate useful knowledge about human psychosensory processes, they configured and constrained their subjects’ responses to applied sensory stimuli. When experimental subjects spoke, they spoke through the language of the apparatus. Kittler described this acquisition of machine languages as fundamental to the psychophysical project, noting that it was precisely the artifice of these languages—their differentiation from the test subject’s natural tongue—that made it “possible to isolate the subconscious mechanisms responsible for the construction of psychophysical reality from the cultural—that is, language-dependent—functions responsible for concept formation.”⁴² These apparatuses, however, did not assume total control over their subjects; though they required the subject to assimilate to the apparatus’s language, they did not reduce the subject to a mere function of the apparatus. If they did, the subject would be superfluous to the experiment. Instead, these apparatuses aggregated subjectivity, abstracted it, and made it statistical, disregarding and downplaying the differences among subjects while still depending on those differences to produce heterogeneous data about the specialized sensory operations.

Although the subjects of psychological apparatuses were in theory interchangeable—swappable cogs in a machinery of knowledge production that intentionally imitated the structure of the nineteenth-century factory—the actual subjects of these experiments (often the experimenters themselves or graduate students being acclimated to experimental psychology’s rigorous methods) had to be trained to carefully attend to the stimuli applied to

their senses.⁴³ They had to be what Weber called “good observers,” capable of maintaining a practiced attention in spite of quite uncomfortable testing conditions (Weber’s good observers, for example, had the misfortune of being repeatedly administered enemas of freezing cold water, in an effort to test the temperature sensitivity of the nerve trunks in the bowels). Each apparatus, in other words, depended on the production of a subjectivity—the agreement of the subject to undergo the active disciplining required to fuse with the apparatus in such a way that their articulated experience could yield useful and reliable knowledge about the sense modality or submodality under investigation.

To push on the theoretical implications of this relationship between apparatuses and subjects, I turn to Giorgio Agamben’s formulation of the apparatus not as a thing but as a process. Building on and extending Foucault’s expansive understanding of apparatuses as mechanisms of control, for Agamben, apparatus—or *dispositif*—designates a set of strategies for controlling and managing the behavior of bodies. Agamben locates apparatuses as definitional components of the “extreme phase of capitalist development in which we live,” a phase characterized by the “massive accumulation and proliferation of apparatuses.”⁴⁴ The lives of individuals seem to be totally subsumed by these formations; with daily existence constantly “modeled, contaminated, or controlled by some apparatus.”⁴⁵ The power of apparatuses lies in their ability to produce subjectivities, to remake individuals as subjects of disciplinary machines “from tip to toe.” But crucially, apparatuses are not imposed from without: at their roots, and thus at the base of all the subjectivities they produce, “lies an all-too-human desire for happiness.” Apparatuses clear away the old subject, replacing it with a newly reshaped one, constituted by new desires, which are above all the desire for apparatuses.⁴⁶ The double operation of this term—as designating both individual scientific machines and a larger, overarching social machinery that produces, manifests, and manages desires—will lurk in the backdrop of the argument I advance throughout *Archaeologies of Touch*. In early experimental psychology labs, for example, the haptic subject was one who

desired a transhistorical account of tactility, one divorced from their own individual idiosyncrasies, which could be revealed through the submission to the lab's sadistic machineries and protocols. The haptic subject conjured by today's designers and marketers is also a desiring one: a subject who understands interfacing with computers through touch as ameliorative and restorative, where a technologized touch can alleviate the suffering inflicted by the subject's continued subjugation to the apparatus of the audiovisual (non-haptic) interface. Contemporary haptic interfaces promise to *desubjectify*: in claiming to facilitate a mode of interacting with machines that is instinctual rather than unnatural, they tell users that they will be able to communicate with machines in a language of touch that does not have to be learned and submitted to. In other words, these interfaces promise to wipe away the old subject of information machines—the one whose bodily and perceptual habits had to acclimate to the interface's taxing artificiality—and replace it with a new haptic subject, fully embodied through the interface. Haptic interfaces expose what Immersion Corporation frames in its promotional materials as “the exhausted the limits of Information Age technology”;⁴⁷ in response, these devices offer to revitalize and restore “exhausted consumers” through the layering of touch feedback onto extant computing machines.

Apparatuses, crucially, are enacted through the adherence to *protocols*—through the agreed-on practices of usage that gradually sediment to provide the background consensus informing conventions and ritualized habits of action. Lisa Gitelman identifies a productive kinship between the protocols that structure the habitual use of scientific apparatuses and those that shape the accepted use of media technologies. Both protocols that inform the use of scientific instruments and media protocols require like-minded groups of actors to accept a set of usages associated with a given apparatus.⁴⁸ Although communities of actors frequently contest, debate, and refine protocols when they are new, once these protocols have settled—once the new transitions to the old—protocols become “a vast clutter of normative rules and default conditions” gathered around a “technological nucleus.”⁴⁹ The relationship

between protocol, cultural memory, and control is therefore vital: protocols, which Gitelman defines so broadly as to include all supporting structures that underpin the operation of a given medium, exercise their power when they slide into the backdrop of acceptable usage—once they become sedimented in institutions and materially realized in infrastructures. Gitelman’s instructive example is the telephone, which is undergirded by habitual uses (such as answering by saying “hello”), a set of business practices (the monthly billing cycle), and physical infrastructures (the wires and cables that connect phones to one another). This process of settling protocols around a medium is frequently messy and protracted, unfolding in a range of spaces and involving conflicts between heterogeneously situated actors vying for power. Where haptic interfacing is concerned, we are presently in a curious moment, as haptics technology is still in the process of being made intelligible, primarily through marketing and popular press discourses about technologized touch (see Interface 5). But part of the argument that I advance throughout *Archaeologies of Touch* concerns touch’s prior expression through scientific protocols, which has a long history reaching back into the eighteenth century (Interfaces 1 and 2). As the protocols around haptic interfaces settle—as the meanings and uses of haptics technology are made evident through the discursive construction of the technology—they do so according to a configuration of boundary conditions set forth gradually in the research labs where the haptic subject was first isolated, confined, and subdivided.

Although protocols are structures for enacting control, they also provide the parameters for contesting and interrupting the operation of control. The embedding of protocols in computing machines alters the parameters of protocol formation, control, and contestation. In Alexander Galloway’s formulation, protocols—as automated, machinic processes that distribute management and control—configure the exercise of power, while also making possible new forms of resistance and disruption within that configuration. Though protocols are not unique to computing, computing changes the parameters within which protocols are exe-

cuted and enacted. Accordingly, Galloway draws on Foucault and Deleuze to conceive of bodies as the fundamental objects of protocological control, as they specify the operation of material bodies in particular contexts and spaces.⁵⁰ Galloway offers a methodological orientation to protocol that allows it to be analyzed and confronted as a dynamic imbrication of sociopolitical and material processes, rather than a static set of decontextualized and disembodied rules. Protocol enables the “making-statistical” of life forms on a mass scale, functioning “as a management style for distributed masses of autonomous agents.”⁵¹ Merging these approaches, protocols can be seen as simultaneously cultural, technical, and institutional, serving as normative mechanisms that regulate, govern, and make productive the behavior of human bodies.

Through this intertwining of subject, apparatus, and protocol, I am suggesting here that the haptic subject be positioned at the intersection of changing techniques of management, control, negotiation, and subject formation. Paraphrasing Krohn and Bolton, the various touch machines described in these pages can be understood collectively as apparatuses for producing haptic subjects—outcomes of individual subjects’ tactual experiences in the lab, of material practices enacted by protocological control, and of subjectivities that animate individuals’ desire for the desubjectifying power of touch machines.

Recapitulating Touch

Touch’s current technohistorical situation makes the intervention *Archaeologies of Touch* provides especially pressing, as questions about tactile relationships with media achieve a new urgency, prompted in part by the touchscreen’s homogenization of previously diverse sites of physical interfacing. As we begin to interact with books, banks, music, spreadsheets, films, software, games, stores, and people only through the flat, dedifferentiated surface of the touchscreen, buttons, knobs, keys, shelves, desks, and bodies become nostalgic objects, only appreciated after their erasure. Specific to haptics, vibrational feedback (rendered with increased precision by

new algorithms, motors, and actuators) becomes the means of recapturing and recalling the lost materiality of those media and objects subsumed in the touchscreen. The rhetoric mobilized around touchscreens also invests the category of touch itself with a new set of meanings. Media studies, I suggest, finds itself quite unprepared for this situation: while we have excellent, comprehensive genealogies of seeing and hearing that show the senses to be sites where power is expressed and negotiated, to paraphrase Denis Diderot in his call for a tactile language, we have nothing for touch, although this sense has its own distinct history as a technical object. At stake in the present moment is the way that theories and genealogies of media historicize and ideate touch in general and haptics in particular. Considering the long history of technoscientific haptics implicates touch in a broader set of discourses about the relationship between technology, the body, and the senses. It showcases the power of media to order, subdivide, fragment, reconstruct, and reformat the senses, highlighting the new training regimes that the perceptual system underwent to be able to receive, decode, and manipulate machine-generated sensations. *Archaeologies of Touch* aims to get at the microphysical interactions among the material, discursive, and institutional constructions of haptics. It presents a positive empirical response to the present technohistorical situation by actively intervening in the production and reconstitution of what counts as the archive of media history. In this macrohistorical frame, “haptics” becomes as much a political term as it is a physiological and technical one, expressing a biopolitical fantasy where scientific power/knowledge achieves complete dominion over the range of human tactual senses.

Naturalization narratives, like the ones mobilized around haptics, are inherently political: by positioning a given object as an operation of nature rather than of culture, these stories function to obfuscate the operation of power. The repeated claims, taken up in Interface 5, that interfacing through touch represents a more natural and intuitive mode of interacting with information distracts us from all the technical and scientific filters that touch had to pass through before it could enter the computer-mediated sensorium.

It orients us away from the vast institutional, financial, political, and philosophical investments made in this project over its long history. And by doing so, this naturalization narrative forecloses more possibilities than it opens. The strength of the media archaeological approach that *Archaeologies of Touch* takes toward haptic interfaces lies in its establishment of new and productive connections between the past and present, and in its ability to show the scientific and technical imagination mobilized around touch. Ontological arguments about touch—definitive pronouncements about its inherent, unshakable, and enduring qualities—seem not only quite uninteresting when contrasted with touch’s rich and textured empirical history, but more problematically, also serve to draw attention away from touch’s signature dynamism and flexibility.

Finally, although it is an enterprise that carries the risk of fetishizing what should be its critical objects, there is a demonstrated value to understanding the technical and material features of hegemonic media technologies on their own terms. This approach to media disrupts the power of media technologies by undoing what science and technology studies refer to as the “black boxing” of technology. It allows us to see the processes of negotiation and enunciation that occur at the early stages of a given technology’s development. In this way, *Archaeologies of Touch* is not intended as an endpoint but rather as a beginning: a way of orienting media studies to the range of interwoven issues—technical, legal, commercial, historical, aesthetic, epistemic, and political—at stake in the development of haptic interfaces. *Archaeologies of Touch* seeks to make haptic interfaces analogs to visual and aural media not by way of technical analogy, but rather by suggesting that media scholars approach them as analogous critical and historical objects. Understanding the present as an outcome of technogenesis explicitly recognizes the historical contingency of the current situation, and in doing so, opens up new ways of thinking about the future trajectory of media technology. It reveals the ways the body and its senses are specified through the microprocesses of scientific invention, technological deployment, and strategic marketing.

Toward a Haptocentric Media Archaeology

The five phases of interfacing I use to organize the historiographical narrative in *Archaeologies of Touch* provide a means of assembling and shaping a path through the archive of haptic interfacing. Imposing this structure on a diffuse body of materials scattered across four centuries is intended to help contribute to a history of the present. However, this type of linear narrative is anathema to many in the loosely defined field of media archaeology, which is often positioned as staunchly against what Timothy Druckrey calls the “anemic and evolutionary model” that has come “to dominate many studies in so-called media.”⁵² Media archaeology, as a methodological strategy, is offered as a means of combating teleological accounts of media change, emerging as a response to the deterministic narratives mobilized to explain the evolution of visual media and their affiliated representational techniques. Kittler articulates a similar critique of linearity in his *Optical Media* lectures: “in spite of all beliefs in progress, there is no linear or continuous development in the history of media.”⁵³ The pioneering media archaeologist Erkki Huhtamo also suggests that this approach “runs counter to the customary way of thinking about technoculture in terms of constant progress, proceeding from one technological breakthrough to another, and making earlier machines and applications obsolete along the way.”⁵⁴ As a theoretical apparatus intended to actively reshape media history, media archaeology positions itself as standing militantly against linear narratives and the ideological association between technical and social progress they imply.⁵⁵

But where touch (and other nonaudiovisual⁵⁶) media are concerned, no linear and teleological narrative exists for media archaeologists to problematize and overturn. Instead, the history of nonvisual modalities and their affiliated media comes into view only by considering their role in fostering vision’s seemingly inevitable rise to dominance. The rendering of media-historical time as the history of visual media results in an almost unspoken assumption that these nonvisual modalities have no concrete, independent, or empirically observable historical trajectory. Or if they do, such histories, trajectories do little to complicate the visualist narrative

of media history embraced, even if reluctantly, by media archaeologists. Calls to eclipse linear or evolutionary accounts of media history have proceeded against the backdrop of substantial research programs dedicated to constructing an extensive and increasingly sophisticated history of vision and visual media. The linear and evolutionary visualist account of media history therefore serves as the often unacknowledged historical *a priori* of media archaeology; by attempting to overcome its limits, media archaeologists remain indebted to it, even if only as a point that can be departed from and pushed back against. This is to suggest that, however much linear and evolutionary accounts of (visualist) media ought to be deconstructed and resisted, it is precisely these accounts that provide media archaeology with its cohesive identity. The militant stance media archaeology takes against linear narrative thus originates from a position of disciplinary privilege.

In contrast, those of us interested in the history of touch media do not have the luxury of a linear, dogmatic, hegemonic, progressivist, evolutionary account to push back against.⁵⁷ We have no agreed-on canon—the story of touch’s imbrication with technical media is one that exists only in fragments, distributed in arcane scientific and technical documents, scattered across centuries and various specialist fields. *Archaeologies of Touch* imposes a necessary ordering on the chaos of this archive, while also recognizing the problems inherent in such impositions. It takes seriously the charge that “media archaeology should be seen as primarily a critique of progress”⁵⁸ by portraying haptics not as a value-neutral window to the operations of the human tactual senses but rather as the product of a politically charged positivist research program that repeatedly disavowed and denied its foundational politics. Simply by continuing to historicize and theorize touch only through the visual, media studies has been complicit in circulating this image of touch; to paraphrase Fiona Candlin, the field has continually risked turning touch into a subset and mere operation of vision.⁵⁹ It may simply be the case that up until now, we have had no cause to occasion such a systematic engagement with touch’s history as an object of technical and scientific research, driving home the point that media change not only remediates old media but also

prompts a reevaluation of what counts as media history. Wolfgang Ernst identified laying bare “the technoepistemological momentum in culture itself” as one of the animating aims of media archaeology; the haptocentric media archaeology I present in *Archaeologies of Touch* exposes not only the technoepistemological momentum embodied in haptic interfaces, but by doing so, reflexively calls attention to the epistemological momentum operating in the loosely defined field of media studies itself.⁶⁰

Perpetually Immanent: The Teleology of Haptic Interface Design

While media studies offers no comprehensive account of touch’s history as a technoscientific object, popular press and technical chroniclings of haptics have advanced a somewhat cohesive narrative to help familiarize and historicize this exotic new mode of interacting with computers. The circulation of this narrative is vital to the propagation of haptic interfacing, illustrating the extent to which the project is as much social as it is technical and scientific: the uptake and adoption of haptics technology depends on establishing haptics as a necessary and inevitable response to the limits of audiovisual media, the outcome of a naturalistic and teleological evolution of the mediated sensorium. The narrative consists of three strands that work together to present an origin story around haptic interfaces—a framework in which any new developments can be slotted without complicating the metanarrative. These narrative strands are *myths*, in Roland Barthes’s sense of the term, that serve to make sense of an unfamiliar and alien set of technologies—but crucially, as Barthes explains, myth is not a designation that denotes untruth. Rather, these myths work to conceal operations of power and ideology by imparting a deterministic and naturalistic inevitability to touch’s technogenesis.

The first narrative strand mobilizes what I term a *logic of analog medialization*—a discursive framing of changes in the technologized sensorium that suggests touch can become like the technologically augmented senses of seeing and hearing through the acquisition of its own mediatic apparatuses. This narrative framing has its roots

in the beginning of technical media; Thomas Edison, writing in 1888, employed a similar logic when he described the kinetoscope as “intended to do for the eye what the phonograph does for the ear.”⁶¹ As if borrowing from Edison, one popular press treatment describes vibration-enabled touchscreens as part of “a new breed of ‘haptic’ technologies that do for the sense of touch what lifelike colour displays and hi-fi sound do for eyes and ears.”⁶² As with those prior media technologies, haptic interfaces are situated not only as a way to capture, store, and transmit sensations but also as a way to transform the senses themselves through technical enhancement. As I show in Interface 4, this logic of analog medialization, mobilized by computer scientists in the early years of haptic interface design, was not merely descriptive—it also informed design practice and structured subsequent efforts by marketers to articulate the value of haptics technology.⁶³ The logic of analog medialization voiced the designer’s desire to employ technology as a means of transmogrifying touch: by recuperating a neglected experiential modality, they hoped to regain something lost with the rise of the visualist interfacing paradigm.⁶⁴ Designers, in narrating the products of their labor, often foregrounded complex descriptions of electro-mechanical techniques for generating haptic sensations by referencing philosophical arguments about touch’s centrality to human experience.⁶⁵ The fundamental inadequacies of visual interfacing, according to this argument, could be remedied by adding mechanisms for convincingly synthesizing haptic sensations onto existing media apparatuses. Designers assure an anxious public that the dematerialization accomplished by computational media can be undone by folding haptics technology into the interfacing schematic. A technologized tactility promises to be therapeutic, ameliorating the immense stresses image and sound media have placed on the sensorium. Further, the logic of analog medialization makes a naked and not uncontroversial declaration that touch can be virtualized, countering the common claims that touch, as John Durham Peters puts it, “defies inscription” and “remains stubbornly wed to the proximate.”⁶⁶

A second strand locates haptics in a state of perpetual immanence, poised for rapid progress forward and ubiquitous adoption

in a wide range of technocultural practices. Since haptic interfaces took center stage in Howard Rheingold's bestselling 1990 book *Virtual Reality*, the technologies have been a source of continued fascination and wonder, simultaneously exoticized by the designation "haptics" and made familiar by the promised intimacy of touch.⁶⁷ But as the promised tomorrow continues to never arrive, haptic interfaces are suspended in this state of perpetual immanence, always just on the horizon, always only five short years away, always invested with technoutopian hopes, and always inevitable.⁶⁸ Together with the logic of analog medialization, the trope of perpetual immanence works to suggest a natural and deterministic progression to the technologization of the human senses.

Layered on the narratives of analog medialization and perpetual immanence, the third strand foretells the coming of a *master device* that will finally result in the rapid uptake of a standardized, high-fidelity haptic interface. With the arrival of the master device, all preceding efforts will seem like steps toward this single inevitable outcome, rendering them obsolete and irrelevant. Building on the logic of analog medialization, the master device will accomplish for haptics what the adoption of standard recording and playback formats accomplished for image and sound media, giving haptics a unified, stable, and intelligible identity coterminous with the technological extension of touch. The idea of the master device tacitly recognizes what Abrash made explicit in his 2015 address: the challenge posed by haptic interfaces is one of both hardware and software design; the successful proliferation of any eventual master haptic device will require the development and adoption of a shared language for coding computer-generated tactual sensations. And as with image and sound media, the competition to lay claim to a master device and its attendant standards involves a fierce battle between corporate intellectual property holders (described in *Interface 5*) with each entity vying for control over what Jacques Derrida, in a short passage on haptic interfaces, termed the "algorithms of 'immediate contact.'"⁶⁹

By locating haptic interfaces in the broader political project of productively disciplining the senses, *Archaeologies of Touch* provides an alternative narrative, in which the recent attempts at transform-

ing touch through technology are not unique to the age of computing but instead exist in continuity with the exertions of previous generations of scientists and engineers. This story is not necessarily an unfamiliar one to hapticians—Martin Grunwald’s sprawling 2008 edited volume *Human Haptic Perception*, for example, juxtaposes chapters by historians of psychology and medicine detailing touch’s scientific and cultural history with essays by researchers actively pursuing the design of new haptic human–computer interfaces.⁷⁰ However complex, well-researched, and detailed these histories are, they are situated in a progressivist epistemological framework that treats scientific knowledge as the gradual accumulation of increasingly refined truths (precisely the sort that media archaeology so vehemently calls on its adherents to disassemble). Further, though this origin story may be fairly well circulated among haptics specialists, it is fairly obscure outside of that cohort, remaining nearly unknown to media historians.

As I show throughout *Archaeologies of Touch*, the narrative strands woven around haptic interfaces are not new stories for touch—the teleological suggestion of a finality to research on touch technology, the framing of touch as analog to seeing and hearing, and the notion that one technologized device for tactual communication would emerge victorious over the rest each recur at different points in the history of touch chronicled here. The formulation of haptics as the doctrine of touch, for example, was intended to make the science of touch analogous to the sciences of optics and acoustics. Diderot’s suggestion (taken up in Interface 3) that touch could have its own fixed set of signs—a “clear and precise language of touch”⁷¹—was similarly aimed at making touch like seeing and hearing, and staged Geldard’s later attempts from the 1950s on to divine a “tongue of the skin” through the engineering of psychophysically grounded machine languages. In each instance, making touch like seeing and hearing was also understood as a vital, socially transformative project that would bring touch—once it passed through a technological, scientific, or linguistic filter—into a modern ordering of perception that had previously barred its entry. Like the master device, the tongue of the skin was taken to be a singular entity that engineering psychology would eventually

reveal. And as with the narrative of perceptual immanence, for several decades, the desired end seemed just on the horizon. Establishing these productive connections between past and present undermines the fetishistic claims of novelty mobilized around haptic interfaces. It resists succumbing to what K. Ludwig Pfeiffer describes as the “vertigo of alleged media revolutions” that media studies and popular culture more generally often relishes, through an exposition of the technoscientific forces that have acted on touch over the past three hundred years.⁷² *Archaeologies of Touch*, then, does not attempt to put to lie the narratives of analog medialization, perpetual immanence, and the master device, but seeks instead to connect these stories to longstanding cultural anxieties voiced in debates around the senses and technology.

Genealogies of the Haptic

The term “haptic” has had a curious life in media theory, quite apart from the one it lives in the psychology, engineering, and computer science discourses that I treat throughout *Archaeologies of Touch*. Scholars working with these divergent genealogies have thus far generally been content to allow the tensions between the traditions to persist without resolution. However, given the term’s centrality in this book, and the book’s positioning at the intersection between media theory and computer science, this brief explanation of how the two genealogies map onto each other helps provide some mutual legibility to the divergent fields. This will not, of course, resolve the tensions between the two genealogies, but it will show them as fundamentally linked at a crucial historical juncture. For media theorists, the term originates in work of Austrian art historian Alois Riegl (1858–1905). Throughout his 1901 *Spätromische Kunstindustrie* (Late Roman Art Industry), Riegl developed a theory of haptic vision, where the eye, in caressing the visible surface of an artwork, assumed a tactile function—as if it were a fingertip moving across a textured material space.⁷³ The argument Riegl crafts around this haptic vision is a complex one, invoking a web of relations between the phenomenology of perception, the expression of cultural hierarchies of sensation through

works of art, and epochal shifts in reception habits.⁷⁴ But crucially, the term “haptic” did not appear anywhere in the book. A year after the publication of *Late Roman Art Industry*, in a short follow-up essay, Riegl suggested that “haptic” be retroactively substituted for “tactile,” not only in that solitary essay but also throughout the whole of the original argument. He justified the strategic repositioning, in the essay’s lone footnote, by claiming that the new term “haptic,” unlike “tactile,” did not situate vision and touch in opposition to one another.⁷⁵ It implicated touch in a harmonious rather than antagonistic relationship with the visual; haptic vision, in comparison to tactile vision, indicates a synergistic coupling of the touch and vision, a vision capable of becoming like touch.

Riegl’s definition of “haptic” as a nonoppositional mode of touch has been echoed frequently in film and media theory. Gilles Deleuze and Félix Guattari, for example, rehearse Riegl’s definition almost verbatim in their claim that “‘haptic’ is a better word than ‘tactile’ since it does not establish an opposition between two sense organs but rather invites the assumption that the eye itself may fulfill this nonoptical function.”⁷⁶ “Haptic” functions consistently as a strategy of sensory dedifferentiation, providing a means of breaking down the barriers between the senses and endeavoring to show how touch can be active as an agent in the process of seeing. As it did in Riegl’s formulation, “haptic” serves a strategic and ideological function in these works. Laura Marks makes this explicit in her writings on haptic visuality, defining the haptic as “a feminist visual strategy”⁷⁷ that allows her to identify a counter-visual mode of seeing that operates in particular types of cinematic images. In these strands of thinking, the haptic conjures a counter-hegemonic perceptual subjectivity activated through vision.

By his own admission, however, Riegl had not invented the term whole cloth. Rather, according to his footnote, he appropriated it from physiology,⁷⁸ where it had been taken up in the 1890s as a way of designating the vast research being carried out on the psychophysiology of tactual perception. In borrowing the term, Riegl had substantially modified its meaning—he steered away from its scientific, doctrinal, and experimental connotations, hinting only vaguely at the new research paradigm it designated. In

contrast, in the genealogy rehearsed in psychology, engineering, and computer science, the term's roots are entrenched firmly in the field Riegl poached it from. In this tradition, described above, "haptic" relies on a radically corporeal and embodied touch: it refers to both a body of knowledge about touch and a set of instruments, protocols, and processes used to further specify the components and subcomponents of tactual perception. It is, in short, an epistemic framework for knowing touch. As a consequence of these two traditions, we are left with a bifurcated genealogical account of the term; media theorists,⁷⁹ unaware of the scientific tradition associated with the haptic, use it to designate a flexible and not necessarily tactile phenomenology of touching, while haptic interface designers embrace and deepen the haptic's roots in the technician and materialist practice of experimental psychology. The two traditions imply radically different notions of touch. For media theorists, "haptic" is a model of touch that can operate without touching, where the senses are capable of becoming synesthetically active in one another. For psychologists and engineers, the material act of touching is fundamental to the formation of haptics as an accumulated body of knowledge; they do not seek to differentiate the senses, but instead to radically and intensely differentiate touch itself through the application of experimental techniques and apparatuses.

Through this brief comparison of the two models, I am not seeking to abrogate or resolve their differences. Rather, by pointing to their common origin in the nineteenth-century research lab, I hope to map the opening up of the chasm between them and in doing so, plot possible sites where this chasm might be bridged. The fundamental question here involves touch's capacity to be mobilized—via the haptic—as an agent in a counterhegemonic politics. As I suggest throughout *Archaeologies of Touch*, understanding haptics as an epistemic framework for touch shows it to be the object of a hegemonic—rather than counterhegemonic—instrumental rationality operating in industrial and postindustrial capitalism. At the same time, in the scientific and engineering discourse around touch, the pursuit of technical knowledge about tactility was frequently seen as a means of undoing sedimented, hegemonic hierarchies of per-

ception. Those who took up arms under touch's banner did so with the explicitly stated intent of reversing or ameliorating the harmful effects of a societal overreliance on vision and its affiliated technologies. Although I do not want to suggest to direct a kinship between, for example, Marks's formulation of the haptic as a countervisual strategy and haptic interface designers who posited their practice as a means of reasserting touch's power in a visualist interfacing schematic, there is nevertheless a distinct resistive and disruptive impulse motivating the two mobilizations of the term. By taking some steps toward providing them with a mutual legibility, I hope that *Archaeologies of Touch* will help facilitate future exchanges between the fields.⁸⁰

Groping toward the Future

The promise of haptic interfacing is an enduringly seductive one: to be able to step into a virtual world, or to extend the body via a surrogate into a remote environment, and feel the whole range of wondrous haptic sensations—rain pounding against the skin, wind on the face, the embrace of a distant or lost loved one—that present themselves so effortlessly in everyday life. Achieving this end of a seamless and one-to-one link between the haptic system of the user and their virtual or remote avatar appeared readily at hand in science fiction novels and Hollywood films: tactile variants on cinema (as in Huxley's *Feelies* and Salvador Dali's *Le cinéma tactile*), the notion of jacking into a cyberspace that provided even more data for touch than it did for vision and audition (a common feature in cyberpunk fiction like William Gibson's *Neuromancer*, Neal Stephenson's *Snow Crash*, *The Matrix* trilogy, and *eXistenz*), accessing virtual reality through some more messy physical interface (as in *The Lawnmower Man* and Ernst Cline's novel *Ready Player One*), or the establishment of a stable connection between the self and a remote body (Robert Heinlein's *Starship Troopers* novel; the films *Avatar* and *Surrogates*). And although the ease of this feat on page and screen belies its near impossibility in the design lab, the promise of haptic interfacing retains its power. Particularly amid fears over technology's inability to bridge the psychic and emotional

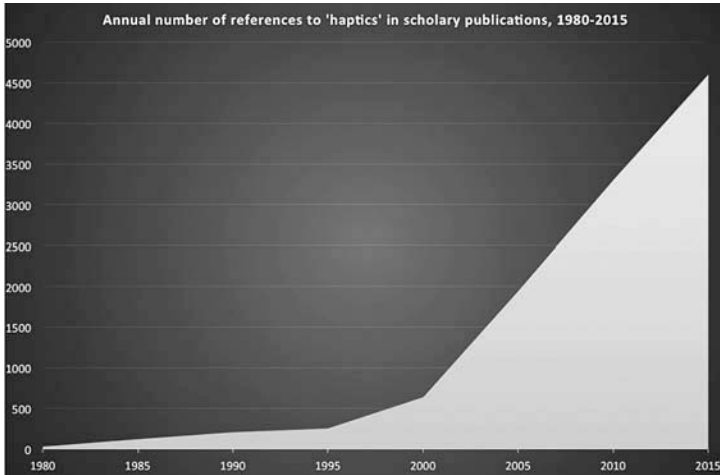


Figure I.1. The number of academic publications that reference haptics by year, from 1980 to 2015. Data based on a Google Scholar search.

gaps between communicative subjects, these touch technologies offer an appealing way of reconnecting through a sense valorized for its ability to provide an authentic and irreducible form of embodied experience.

Over the next decade, the continued proliferation of touch technologies in a range of computing applications will push toward some of these imagined outcomes, buoyed by the recent sharp spike in investments into haptics research. The increasing complexity of the actuators and corresponding control algorithms used to produce vibrational feedback in touchscreens will allow users to feel a greater variety of tactile textures on the screen's flat glass surface. If any of the virtual reality interfaces from Oculus, HTC, or Sony succeed in gaining widespread adoption, the ensuing platform standardization will fuel new investments in haptic interfaces for virtual environments, as developers push toward precisely the type of "breakthrough research" Abrash called for in his 2015 keynote address. Disney's substantial efforts at developing Surround Haptics⁸¹ may begin to bear fruit. Teledildonics devices, no longer

tethered to clunky desktop computers by cumbersome wires,⁸² are also poised to take some small steps forward after decades of stalled efforts. The dual motor configuration used to produce rumble feedback in videogame console controllers since 1997 may see some minor alterations; its stability across successive generations has allowed for the stabilization of best practices in rumble feedback.⁸³ The application of haptics in prosthetics research also holds great promise, as neuroscientists team with engineers in an effort to fuse artificial limbs directly to the human nervous system.⁸⁴ In his 2015 State of the Union address, U.S. president Barack Obama assured the nation that ongoing efforts by the Defense Advanced Research Projects Agency (DARPA) to create “revolutionary prosthetics” would allow “a veteran who gave his arms for his country [to] play catch with his kids again,” with a slide that accompanied his speech showing a robotic hand that could be “moved with thoughts alone, and feel the warmth of touch.”⁸⁵ Such innovations will continue to be underpinned not only by formalized networks of professionalized actors and ad hoc DIY user communities but also by legal frameworks given shape through ongoing battles over haptics patents.⁸⁶ In short, even the most conservative and sober projections of current trends in haptics technology suggest that the next decade will bring the concretization of new standards both in haptics hardware and software—likely not the triumphant rise of any master device but instead incremental continuations of decades-old trends. If haptic interfaces do move toward the widespread uptake of universal standards for hardware, software, and haptic effects design, the present moment will seem in retrospect very much like the early decades of cinema’s history, when the new medium gradually cohered around a stable identity with a fixed set of cultural practices, technical standards, and supporting industries. In those formative years, cinema acquired its constitutive protocols through complex processes of negotiation, which quickly became naturalized as definitional elements of the medium.⁸⁷ Almost without critical commentary from those in media studies, the past three decades have seen a chaotic swirl of new research on computerized touch, with the number of scholarly publications that reference

haptics increasing nearly tenfold, from an average of 443 per year in 1996–2000 to an average of 4,256 in 2011–2015 (see Figure I.1). Regardless of the future direction any individual haptic interface takes, the process of naturalizing and domesticating haptics—and settling the protocols of haptic media usage—promises to continue unabated. In response, *Archaeologies of Touch* calls on media scholars to attend to and engage with its microprocesses, not as an origin of technics but as the intensification of a macrohistorical project explicitly aimed at giving touch a vital new utility in the political economy of communication.