"Interface" is a highly contested and contingent term that deserves detailed explication. Is it the hardware? The software? The visual language of a system? Two of those? None? Something completely different? There is no shortage of literature on what different thinkers believe the interface encompasses, and, as one would expect, interpretations of the term vary greatly based on the context of its use and the mission of the project within which it is deployed. In order to grapple with the contingency of the term and the tempest of competing voices eager to define its use, we will get to where we are going through those thinkers and the different ways they have come to define and discuss the term "interface." In doing so, we can glean what we might think of as encompassing an interface and also find where there may be holes or discrepancies in the understanding of the term that we might want to fix or fill.

What Is an Interface?

In this chapter, I will work toward a definition of "interface" that will provide a better framework for understanding the experience of personal computing devices by emphasizing how the design and materiality of those devices are instrumental in shaping the ephemeral phenomenon of user experience. To begin, let's consider the origin of the term outside of computer history. James Thomson, in his nineteenth-century writings on fluid dynamics, used "interface" to describe the shared boundary where two different types of fluids or a fluid and a solid meet.[7] In Thomson's work, the interface region is a space where potential actions and behavior can occur, actions that could change the nature of the fluids and their reactions to one another.[8] Another more familiar but equally useful variant of the term is to describe material sewn or fused to the unseen side of fabric to make it more rigid. Interfacing, as it is called, lacks the design and aesthetic qualities to be a fabric that one would use alone to make a garment.[9] But when the interfacing is brought into contact with another piece of fabric and attached to it through heat or sewing, the two pieces benefit from the aesthetic qualities of the outward-facing fabric and the structural characteristics of the interfacing.

These examples imply a point, space, or surface of contact across which there is potential for interaction, and the dictionary definition of "interface" bears this out: "A point where two systems, subjects, organizations, etc., meet and interact: '*the interface between accountancy and the law.*'"[10] That still leaves the definition quite broad and open to many interpretations. There is nothing wrong with that, but in order to come to a more concrete understanding of how the term relates to the experience of personal computing, we must put the term

7 James Thomson, "Continuity of States in Matter," in *Collected Papers in Physics and Engineering*, ed. Joseph Larmor and James C. Thomson (Cambridge: Cambridge University Press, 1912), 276–333; http://archive.org/details/collectedpapersi00thomrich, 327.

8 For more on fluid dynamics and the origination of the term "interface," see Branden Hookway, *Interface* (Cambridge, MA: MIT Press, 2014), 59.

9 "Interfacing," *Wikipedia, the Free Encyclopedia*, July 5, 2014; http://en.wikipedia.org/w/index.php?title=Interfacing&oldid=541144576.

10 "Interface," *Oxford Dictionaries* (Oxford: Oxford University Press); http://www.oxforddictionaries.com/us/definition/american_english/interface.

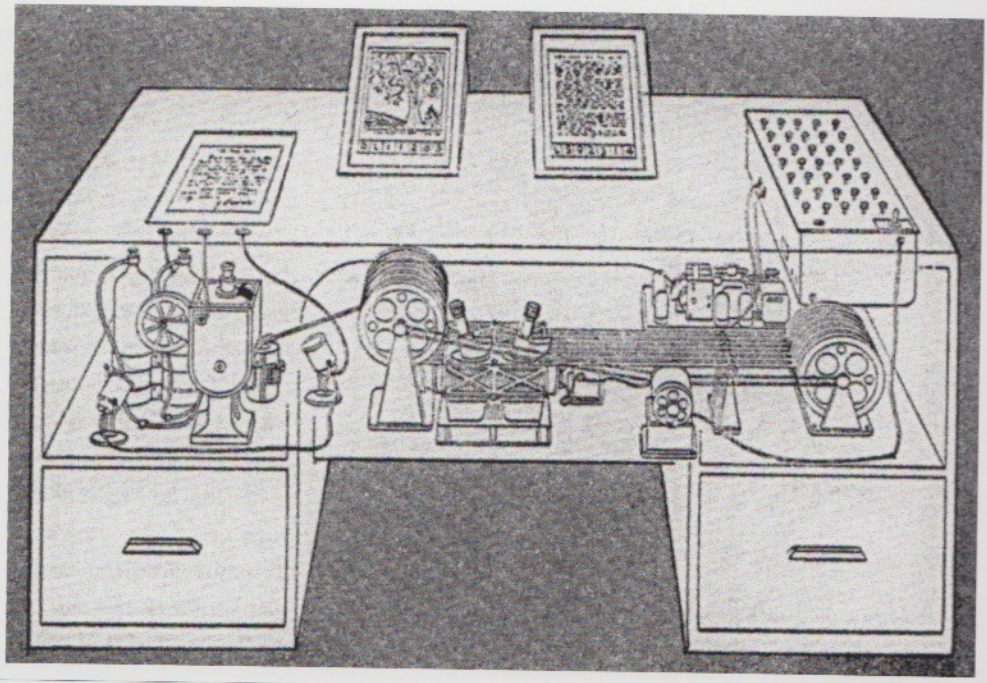

Fig. 2. Alfred D. Crimi and James Lewicki. Hypothetical memex from illustrated reprint of Vannevar Bush's "As We May Think," *Life*, September 1, 1945.

in the context of early computer systems to show how designers and theorists perceived the point where computers and users came together.

The earliest ideas of what computer interfaces might look like and how they should behave can be seen in the work of three scientists working during the 1940s, '50s, and '60s: Vannevar Bush, Norbert Wiener, and J. C. R. Licklider. The work of these men provides insight into the thinking about computers and their use and displays the wide range of disciplines that have addressed the challenge of computer design. Bush was an engineer and inventor, Wiener a mathematician and philosopher, and Licklider a psychologist and one of the first computer scientists.

Bush's seminal 1945 essay "As We May Think" is concerned with the enhancement of the user's experience in accessing information through improved designs of data storage and retrieval systems. In his essay Bush proposed designs for the "memex," a machine with numerous inputs and outputs for more efficiently accessing and manipulating what were then analog records on microfilm (fig. 2).[11] The memex was a complicated desk that stored information and allow-

11 Vannevar Bush, "As We May Think," *Atlantic Monthly* (July 1945): 101–8.

ed for input and access through a variety of key, pen, and lever controls, as well as a document scanner. Because Bush was working in an analog world, these designs have a physical approachability that is harder to find in contemporary computers, whose components have been maximized for size and efficiency by decades of miniaturization. While one could imagine pressing the memex's keys and levers or looking at the tiny images on the microfilm, a silicon microprocessor's functionality is largely invisible. As a result, there is a more direct connection between the physical design of the memex's interface (a term that Bush does not explicitly use) and the perceived improvements in information access experienced by the user.[12]

Whereas Bush was describing the components of a specific interface, Norbert Wiener's development of the science of cybernetics considered the importance of the evolving relationship between humans and machines. Wiener was concerned about the increased presence of technology in daily life. In his 1954 essay "Men, Machines, and the World About," Wiener recalled "a great engineer who never thinks further than the construction of the gadget and never thinks of the question of the integration between the gadget and human beings in society."[13] To address these concerns, Wiener set about to better understand parallels between human and machine participants in computer communications. He noted that the computer and user are both equipped with sensory apparatuses that allow them to notice changes in the information of the world around them. Both machine and human are able to internalize those conditions and perform a response that produces new information.[14] In much of Wiener's work, human and machine are connected by the ways in which they act analogously in systems that provide feedback. The experience of computing when Wiener was writing was far slower and involved noticeable time delays between the input and output of information, and in a certain sense humans and computers were operating on a similar scale of time. In contemporary computer experience, however, machines respond instantaneously, and the sensory responses of human and machine are integrated in the moment rather than in sequence over longer periods of time. This makes Wiener's writing even more resonant today, as his work both explicates and warns about the complex physical and experiential connections shared by computers and their users.

In 1960 J. C. R. Licklider developed a theory of symbiosis between humans and computers. He believed that computers could do more than just formulate

12 Vannevar Bush, "As We May Think," illustrated reprint. *Life* (September 1945): 123.

13 Norbert Wiener, "Men, Machines, and the World About," in *The New Media Reader*, ed. Noah Wardrip-Fruin and Nick Montfort (Cambridge, MA: MIT Press, 2003), 71.

14 Norbert Wiener, *The Human Use of Human Beings: Cybernetics and Society*, Da Capo Series in Science (New York: Da Capo Press, 1988), 26–27.

solutions to numerical problems, and he wanted computers to be involved in the thought process required to solve more complex problems. He believed that this would be achievable by improving the interactive platforms by which humans and computers communicated and cooperated. Along with proposing the reorganization of memory and language structures in computer systems in order to better suit the two sides of the symbiotic relationship, Licklider made specific suggestions as to what types of interface equipment would be required. He wanted users to be able to interact with computers through three input technologies: desk surfaces that could be drawn and written on in a manner legible to the computer; networked wall and desk displays that would allow for a team of users to present materials to one another and to the computer; and automated speech recognition technology that would enable the user to communicate in real time with the computer without having to learn new languages or speed typing.[15]

15 J. C. R. Licklider, "Man-Computer Symbiosis," in *The New Media Reader*, 74–82.

Although the physical scale of computers at the time seems incongruous with our experience of computers today—computers in 1960 still took up entire rooms—Licklider's desire to integrate multiple physical inputs is still useful when one considers the scope that an interface can encompass. In human-computer symbiosis, the humans and the machines are equal partners in a relationship that is made possible by communication through physical devices. This system also represents the type of cybernetic relationship that Wiener outlines, as the communicative system relies on inputs and feedback responses from both human and machine. During the period in which Bush, Wiener, and Licklider were working, the materiality of the computer was more visible than it is now because of the relative scale of the computing experience. As the microprocessor and transistor had yet to exert an influence on computing technologies, this was an era of room-sized mainframes, punch cards, and vacuum tubes. But as computers became smaller, cheaper, and more accessible, greater possibilities were afforded the individual user. It was during this transition that the term "interface" began to be used more frequently as a part of computer design discourse.

The works of Bush, Wiener, and Licklider were mainly conceptual or analytical, but Douglas Engelbart's research in the 1960s was aimed at developing usable systems that would improve human intellect. Engelbart hoped to augment human intellect in four ways: through artifacts, language, methodology, and training. The artifacts represented the physical features of Engelbart's

project and were "objects designed to provide for human comfort, for the manipulation of things or materials, and for the manipulation of symbols."[16] Engelbart's understanding of the "man-machine interface" was that it was a boundary or coupling across which energy flowed when human actions and artifact actions were exchanged. He believed the interface to be a border condition that occurred when the human interacted with the machine, not something that consisted of the user and/or material artifacts of the computer. In this sense, it was even less substantial than Thomson's fluid dynamic interface, which at the minimum consisted of the molecules at the intersecting points of the two liquids.

Noted design theorist and cognitive psychologist Donald Norman has frequently grappled with the materiality of the interface and the most effective way to design computer systems for human use. Norman sometimes interprets the term as a fleeting threshold, much as Engelbart did, while at other times he takes a position that focuses on the importance of the material conditions of the interface. In his essay "Cognitive Artifacts" (1991), Norman placed the interface between a person and what he called cognitive artifacts, artificial devices "designed to maintain, display, or operate upon information in order to serve a representational function."[17] The interface in this case provides an interpretable representation for the user of what the computer as cognitive artifact creates as it operates upon information. Furthermore, Norman provides a model of how "interface" operates within the relationship between a human and the computer as a type of artifact or thing, but the materiality or immateriality of the interface remains ambiguous. The distinct separation of user, interface, and artifact belies the simultaneity of three elements while one uses a computer. Norman notes that the interface has style and format, but he does not clarify whether he thinks those designed features are constituted within the representations and responses provided by software or are within the physical surface of the screen.[18]

In another essay, Norman wrote that "the real problem with the interface is that it is an interface. Interfaces get in the way. I don't want to focus my energies on an interface. I want to focus on the job. When I use my computer, it is in order to get a job done: I don't want to think of myself as using a computer, I want to think of myself as doing my job."[19] Something that is not there cannot get in the way, at least in the sense that Norman implies here. The interface has to be more than a transitional phenomenon; it has to be

16 Douglas C. Engelbart, "Augmenting Human Intellect: A Conceptual Framework," *Doug Engelbart Institute* (October 1962); http://www.dougengelbart.org/pubs/augment-3906.html.

17 Donald A. Norman, "Cognitive Artifacts," in *Designing Interaction: Psychology at the Human-Computer Interface*, ed. John Millar Carroll, Cambridge Series on Human-Computer Interaction (Cambridge: Cambridge University Press, 1991), 4: 17.

18 Ibid., 26.

19 Donald A. Norman, "Why Interfaces Don't Work," in *The Art of Human-Computer Interface Design*, ed. Brenda Laurel and S. Joy Mountford (Reading, MA: Addison-Wesley, 1990), 210.

something that has substance and can provide resistance. If Norman experienced the graphical user interface as a barrier, it would follow that the microprocessor limitations, monitor technology, and design of the mouse through which the GUI functions also hinder the user's experience. In this case, the obstruction Norman describes must be something that is experienced as a result of the way he has intended the computer, in a phenomenological sense, and not as a temporarily incarnated threshold.

If Engelbart's and Norman's concepts of the interface are placed at a distance from a physical, tangible experience of computing, we can see in the writing of Jef Raskin—who initiated the Macintosh project at Apple—a conception of the interface as a physically substantiated part of the computer experience. By the late 1970s and early 1980s, when Raskin started designing computers at Apple, the conditions and parameters within which interface design was happening had begun to change. Bush, Wiener, Licklider, and even Engelbart were working from a tradition of engineering that focused on pragmatic approaches to efficient information processing.[20] Furthermore, they were working in military, government, or academic settings, where the focus was more on pure research than on product development. As a result, their work addressed a computer user as part of an almost mechanistic practice. But once the Altair 8800 made its debut in 1975, a bona fide personal computer marketplace emerged, and the industry began to think not only about the development of large-scale computer mainframes accessible to only the wealthiest companies, but also about the office and home computer user, who would require a very different kind of interface experience. For this reason, designers had to start thinking about the salability of a device in ways that government and academic researchers had not. Their designs would have to take into consideration consumers making market decisions based not only on pragmatics such as specifications and capabilities, but also on emotional and personal responses to a device.

Raskin believed that the computing platforms produced prior to the Macintosh in both mainframes and personal computers did not provide nearly the level of usability that they should, and he began looking for solutions. For Raskin, "the way you accomplish tasks with a product, what you do and how it responds—that's the interface."[21] This definition recognizes that there is more to designing personal computer interfaces than particular technical and functional specifications, and that in order to create a compelling interface

20 Johanna Drucker, "Performative Materiality and Theoretical Approaches to Interface," *Digital Humanities Quarterly* 7, no. 1 (2013); http://www.digitalhumanities.org/dhq/vol/7/1/000143/000143.html.

21 Jef Raskin, *The Humane Interface: New Directions for Designing Interactive Systems* (Reading, MA: Addison-Wesley, 2000), 2.

experience, the manner in which the computer's design enables use of that system is of the greatest importance.

What makes Raskin's work compelling, both in written form and in the Macintosh as a product, is that his approach to interface synthesizes the design of hardware, software, and user experience. This is particularly notable in a series of texts Raskin composed in 1979 that would be the first outline of the parameters for the Macintosh. In laying out general hardware specifications, Raskin defined the shape of the computer, the type of monitor and keyboard, and the suggested price. He also listed design parameters focused on more esoteric experiential principles for the device: it should not become a "tangle of wires"; there should be "no computer jargon on the key-tops"; and the machine should be learnable and easily serviceable. Raskin did likewise when discussing software criteria. Alongside the technical specifications of what programming languages should be used, Raskin emphasized that software should be consistent and intuitive.[22] Raskin was conceiving of the interface of the Macintosh even at this early stage as a totality, developing a product where the hardware and software were connected fundamentally to the goal of generating a certain kind of experience for the user. This was a philosophy that aimed at creating a computer that would, in Raskin's own words, "be truly pleasant to use, that will require the user to do nothing that will threaten his or her perverse delight in being able to say: 'I don't know the first thing about computers.'"[23]

Despite Raskin's best attempts to assert the interface as a comprehensively designed platform for experience, the development of the Macintosh has actually caused the fields of computer design, human-computer interaction, and new media studies to narrow the view of what should be considered when discussing interface. Because of the success of the Macintosh and subsequently of Microsoft Windows, the GUI, with its windows, icons, and desktop metaphor, have come to represent the idea of interface for most people. This is in part because the success of these platforms resulted in very little change in the design of computers until the recent explosion of mobile computing devices such as the PalmPilot and the iPad. The typical setup of keyboard, mouse, computer, and monitor was designed for use with these types of operating systems, and this standardization has pushed awareness of the importance of hardware in the interface experience to the background. This is visible in one of the core texts of new media studies, Lev Manovich's *The Language of New Media*.

22 Jef Raskin, "General Criteria," in *The Macintosh Project: Selected Papers from Jef Raskin (First Macintosh Designer)*, circa 1979; http://www.sul.stanford.edu/mac/primary/docs/bom/gencrit.html.

23 Jef Raskin, "Design Considerations for an Anthropophilic Computer," *Making the Macintosh: Technology and Culture in Silicon Valley*, May 29, 1979; http://www-sul.stanford.edu/mac/primary/docs/bom/anthrophilic.html.

As a wide-ranging text that aims to catalogue and organize the various aesthetic components of new media, Manovich's book places the interface alongside operations, illusions, and forms. Whereas the other sections focus on software, appearance, and commonly used conventions within new media, the interface chapter is about the human-computer interaction (HCI) and operating system.[24] It becomes clear that for Manovich the relationship between human and computer is narrowly delineated and restrictive. In 2002, when the book was published, the experience of the Internet through the browser was challenging the dominant paradigm of the desktop-metaphor GUI. For this reason, Manovich's consideration of the interface focuses completely on the metaphorical, aesthetic, and semiotic conditions of the desktop. There is only one sentence that expands the idea of the interface beyond these considerations into the material conditions of computers as new media machines: "HCI includes physical input and output devices, such as a monitor, keyboard, and mouse."[25] Manovich's narrow view of the interface and his interest in the formalistic study of the iconography, cultural expression, and data-intensiveness of new media works lie in his connection to cinema. Manovich is making a critical move that aligns the screen experience of using a computer with the screen experience of cinema. He even describes the conditions of restrictions these different screens impose on the user/viewer: "Dynamic, real-time, and interactive, a screen is still a screen. Interactivity, simulation, and telepresence: As was the case centuries ago. We are still looking at a flat, rectangular surface, existing in the space of our body and acting as a window into another space. We still have not left the era of the screen."[26]

This construction of a media experience linked to more passive modes, such as film and television, is not limited to Manovich, as many new media critics and theorists understand the interface as consisting solely of the screen and the software viewed within that space. Approaching computers in this way focuses on a very limited portion of the history of interface design. Devices such as the PalmPilot, iPad, and Kinect have popularized different shapes for devices and expanded the variety of forms of input, moving past Manovich's accepted paradigm of monitor, keyboard, and mouse. As a result, the digital industry must now design software and web experiences to respond to a wide range of interface experiences. These developments affirm that the material design of an interface remains important in shaping both the experience of computing as well as the cultural forms Manovich highlights.

24 Lev Manovich, *The Language of New Media* (Cambridge, MA: MIT Press, 2002), 11.

25 Ibid., 69.

26 Ibid., 115.

Even the critics who challenge Manovich's aesthetic and formalistic understanding of the GUI as interface seek to place increasing distance between "interface" and the materiality of the personal computer experience. Alexander Galloway, in *The Interface Effect* (2012), directly responds to Manovich's text, asserting that its formalist methodology wrongly approaches computers and the realm of new media as "essencing" machines that idealize platforms for virtually infinite possibility. Galloway is concerned that thinking of these machines in this way extracts them from the realm of critical cultural discourse by denying that they are in fact contingent, historical objects that play a significant role in determining and shaping the course of cultural development.[27] Galloway's book in many ways shares the goals of this exhibition project by placing the concept of interface in a historical context to better situate the impact it has on our culture. But Galloway's "interface effect" is about computing experience only insofar as it maintains that software as a whole is inherently unworkable and reflects the obstructions that inevitably arise in digitally mediated communication. Galloway critiques the political conditions of our digital culture, and as such his work is more invested in unpacking the social implications of software structures than the lived experience of the devices on which that software runs. In fact, Galloway explicitly strips the objectness from the computer in his discussion, stating that "the computer is not an object, or a creator of objects, it is a process or active threshold mediating between two states."[28] Galloway uses "interface" as a broad term to highlight practices and effects that extend not only throughout cultural production, but also across society, and he looks to use the analog of the effect of interface to enable political and ethical interpretation of a whole field of possible texts and conditions. His is the broadest expansion of the term away from a sense of objectness and materiality, and as such shows not only the complexity of the term, but also the ease with which the direct and impactful experience of physically interacting with technology can be dismissed and abstracted.

27 Alexander R. Galloway, *The Interface Effect* (Cambridge and Boston: Polity, 2012), 19–20.

28 Ibid., 22.

Anchoring the Interface in Experience

The variety of usages of "interface" employed in the texts above is informative in that it demonstrates the level to which the term can be interpreted and abstracted. It is notable that the point in history at which each of these texts was written colors its usage, reaffirming the contingent nature not only of the experience of interface, but also of theorization about and critique of that experience. Branden Hookway in *Interface* (2014) has argued that the point where the interface happens is "neither fully human nor fully machine; rather, it separates

human and machine while defining the terms of their encounter."[29] In this definition, the interface is explicitly not a thing, but a relationship that manifests itself only when human and machine interact. This approach provides a platform from which to question positivist approaches to technological development and its implications for humanity. But by claiming that the interface exists solely as an intangible relationship between computer and user, Hookway deemphasizes the very tangible lived experience of personal computing. In abstracting the interface in this way, Hookway has taken the teeth out of his own argument for the importance of the interface. Like many of the texts discussed above, the assertion that the human and machine exist apart is meant to enable a questioning of how technology augments the human. This separation reduces the interface to an intellectual construct.

We know, however, that the give-and-take between user and computer happens not just as a practice of discourse. Brenda Laurel provides a corrective to this decoupling when she writes that "an interface is a contact surface. It reflects the physical properties of the interactors, the functions to be performed, and the balance of power and control."[30] Laurel's definition reminds us that the interface is a tangible foundation of the computer experience. If the interface is a contact surface, then it can be argued that it is the place where the physical interaction between the user and the computer is materially constituted. The user's experience of this place is not just in how one engages with or intends the surface, but in the whole of the machine as the user expresses himself through the keyboard, mouse, stylus, finger, or sensor, cognizant that the computer will recognize the input and respond with feedback. The interface as materially constituted is therefore the result of the physical conjoining of both human and machine, consisting in toto and simultaneously of the brain as thought producer, the body as action executor, the input device as interaction receiver, the processor as input translator, the software as feedback generator, and the screen as feedback provider. Understanding the interface as this connection of parts situates the computer experience in a tangible reality, rather than at the level of pure discursive analytics. Theorizing the objectness out of the interface, as Hookway and others have done, ultimately denies the importance of the material in understanding the symbiotic, cybernetic, and augmentative characteristics of the computing devices that play such a central role in our cultural life.

Reasserting the materiality of the interface in this way is not just an exercise in defining parameters for the use of the term. It is also meant to emphasize

29 Hookway, *Interface*, 44.

30 Brenda Laurel, "Introduction," in *The Art of Human-Computer Interface Design*, xii.

a direction from which we can approach computers and their history within a broader cultural context. The near ubiquity of computing devices in our lived experience raises serious questions about how these technologies influence everyday life in both visible and invisible ways. Baudrillard warned that, as we increasingly rely on computers to manage our lives without understanding how, the ubiquity of these devices can cause a subordination to the structure of the integrated circuit. To avoid this, we must perceive the interface experiences not just as an individual interaction with a computer, but also within the context of larger sociocultural and technological systems. This means that the computer objects featured in this book and exhibition are addressed from a perspective that includes their design, manufacturing, distribution, reception, perception, and use. This strategy helps us to better understand the artifact and system within society.[31] From keyboards to mice to styluses to touchscreens, the material design of computers has shaped how they respond to our actions and how we respond to their feedback. As such, the design of hardware becomes central to our understanding of the experience of interface, because of how it determines the real and perceived affordances[32] made available to the user, both with regard to the physical interaction with the device and the range of possible operations that can be enacted via software.

Having established the material conditions of the interface, it is important to emphasize that the experience of interface is continuous, variable, and ephemeral. Erkki Huhtamo has written that "an interactive system is characterized by a real-time relationship between the human and the system. . . . In an interactive system the role of the human agent is not restricted to control and occasional intervention. Rather, the system requires the actions of the user, repeatedly and rapidly. . . . Thus an interactive system is not based on waiting, but on constant (re)-acting."[33]

To understand the interface is therefore to understand our experience of computers, while maintaining an awareness of duration and ephemerality, and to comprehend how our actions and reactions and the corresponding actions and reactions of the computer change the nature of the interface. It is through this sense of time-based lived experience that we can situate the interface experience within a historical, cultural, and social context to better understand how computers shape our lives and the world around us. As Sherry Turkle has noted, "computational objects, poised between the world of the animate and inanimate, are experienced as both part of the self and of the external world."[34] In order

31 W. D. Kingery, "Technological Systems and Some Implications with Regard to Continuity and Change," in *History from Things: Essays on Material Culture*, ed. Steven D. Lubar and W. D. Kingery (Washington, DC: Smithsonian Institution Press, 1993), 217–18.

32 The term "affordances" was introduced to design by Donald Norman, who describes real affordances as all those things that can be done with an object. Perceived affordances are those that are made perceptible and meaningful to the user through the object's design. Norman's example is the computer screen. All screens afford the ability to be touched, but only some respond to touch. The use of graphic elements to denote where to touch makes those affordances perceivable. Donald A. Norman, "Affordances and Design," *jnd.org*; http://www.jnd.org/dn.mss/affordances_and.html.

33 Erkki Huhtamo, "From Cybernation to Interaction: A Contribution to an Archaeology of Interactivity," in *The Digital Dialectic: New Essays on New Media*, ed. Peter Lunenfeld, Leonardo Series (Cambridge, MA: MIT Press, 1999), 106–7.

34 Sherry Turkle, *The Second Self: Computers and the Human Spirit*, 20th anniversary ed. (Cambridge, MA: MIT Press, 2005), 5.

to understand an interface in an exhibition or as an object of study, we must therefore be able to ascertain what kind of personal relationship we can build with that device. We must consider how that relationship changes over time as we use it and determine from real and perceived affordances how our conception of that device influences our understanding of our larger relationship with computational culture.