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Computing Attachments: Engelbart's Controversial Writing Technology

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Abstract

Douglas Engelbart's innovative computer system afforded controversial writing and computing practices that continue to sharply contrast with standard ways of writing with computers today. Using actor-network theory (ANT), this article traces the history of the computer system developed by Engelbart in the late 1960s, highlighting the previously contentious state of computer hardware and software used for writing that we now take largely for granted. Pushed aside in favor of computer systems more oriented toward print practices, Engelbart's project illustrates the difficulties such disruptive technologies face in terms of widespread adoption. Although all technologies require robust infrastructures for their continued existence, innovative projects are especially likely to be dismissed if they lack supportive networks. This article argues that increased attention to nonhuman actors such as computer hardware and software, and the support they need, can lead to more detailed understandings of their role in literate activities.

Keywords: Engelbart; NLS; Latour; Actor-network theory; Computer user; Innovation

1. Introduction

Controversies about computer technology arise and are settled at a remarkably rapid pace. Twenty years ago many would have disputed the suggestion that a desktop computer with a graphical interface and mouse was a tool for scholarship or business writing. Thirty years ago people would have argued about supplying an individual with an expensive CPU and hard drive to be used by that person alone, rather than time-sharing these components. The very term "computer" masks the complex and contentious pasts of the multiple technologies and practices that have been assembled under that label. In 2007, such settled controversies are now largely taken for granted; we tend not to recognize that what we call "a computer" represents a different grouping of technologies than would have been labeled as such 15, 20, 30, or even 50 years ago. As scholars such as Bertram C. Bruce and Andee Rubin (1993) and

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Fig. 1. *The NLS*. Source: Engelbart (1988, p. 199).

Christina Haas (1996) have noted, there is no singular "computer," only situated instantiations of various hardware and software put to different ends by a variety of people. Yet, for the most part, these assorted configurations are taken as one, obscuring the differences that shape the diverse range of literate activity (Prior, 1998) they support. An assemblage of complex mechanical and discursive parts, the computer functions as a given, a black box in Bruno Latour's (1987) use of the term.

The current setup of mouse, keyboard, and graphical interface was created largely without the input of writing researchers and teachers, yet these tools radically influence how we write. Disconnects between the development of these tools and the field of composition can make it difficult to imagine the possibilities of alternative configurations. Other devices seem wrong when compared with the normalized practices associated with computer mice and keyboards. However, these alternatives appear more interesting and plausible within histories that show the work of specific actors to support and reject various computer projects. In this article, I use the case of the On-Line System (NLS) to trace the technologies and practices that led to the established ways the monitor, mouse, and keyboard are used today. The NLS was developed in the 1960s and 1970s by a team led by Douglas Engelbart, a key figure in the creation of hypertext (Joyce, 2000; Landow, 1997; Rice, 2007). Engelbart's association with hypertext and the mouse typically overshadows accounts of other aspects of the NLS, including its collaborative writing software and other innovative hardware components. Besides the mouse and hypertext, the NLS introduced networked writing environments, a five-key chording keyset to be used opposite the mouse (see Figures 1 and 2), and video conferencing. Despite being touted as influential by computer designers both past and present (Cringely, 2004; van Dam, 1988), few units were ever built and the project disappeared after losing its funding from various defense and government agencies. This apparent contradiction between the influential aspects of the NLS and its disappearance serves as a productive breakdown, highlighting conservative attitudes toward computing and writing that led to the familiar components used today.

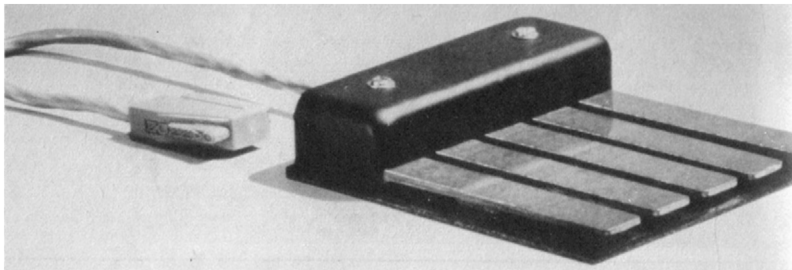

Fig. 2. *The five-key chord keyset*. Source: Engelbart (1988, p. 200).

Through this account of the NLS—exploring the varied and contested aspects of technologies we typically group together as a singular device—I also hope to extend the efforts scholars have made within computers and composition to address the often-overlooked links between technology and literacy. Cynthia Selfe's (1999) *Technology and Literacy in the Twenty-First Century* examines the ways government, schools, businesses, and parents work together to maintain and promote a limited definition of technological literacy. Selfe called on writing teachers to become more critically aware of the interlocking relationships between "technology, literacy, education, power, economic conditions, and political goals" (p. *xxii*) in order to change prevailing attitudes about technological literacy from merely "competence with computers" (p. *xx*). Similarly, Stuart Selber (2004) has called on teachers to be more attentive to their role in promoting "inequitable and counterproductive technological practices" (p. 8) and proposed that writing teachers need to participate "in the development and reconfiguration of literacy technologies" (p. 10). The history of the NLS is especially well suited to strengthen this work because the controversies it provoked were predominantly settled in favor of reductive visions of technological literacy. These settlements were not the result of any one person or event, but a network of people, government agencies, technology, and corporations.

Using actor-network theory as described by Bruno Latour (1987, 1996, 1999, 2005), I take up both Selfe and Selber's calls to intervene in the complex relationships that form technological literacy and to reconfigure technologies and the literate activity they support. These interventions require a way of mapping the large number of sponsors involved in these projects and their effects in order to see where alternate connections may be made, and I believe actor-network theory (ANT) offers just such an approach. Rather than providing specific explanations of why some technologies succeed or fail, ANT seeks to describe how actors translate the interests of others and to map how these acts of translation lead to stronger or weaker associations. Including artifacts and other nonhumans as actors in these accounts, ANT directs researchers to see the interactions between people and material objects as social action. In other words, objects are neither passively dominated by people's will, nor all-powerful in their ability to control humans. Instead, objects and people shape each other through their interactions. Using ANT to create maps of these interactions and their effects can help researchers and teachers reconsider the histories of writing technologies and the possibilities for change.

2. Reconsidering Actor-Network Theory

Several scholars within rhetoric and composition have written about actor-network theory's value for writing researchers, arguing that it increases the number of relevant actors and issues when studying rhetorical activity and offers ways of seeing texts themselves as legitimate actors in society (Bazerman, 1999; Myers, 1996; Spinuzzi, 2005). As Paul Prior et al. (2007) propose, Latour's (1987) *Science in Action* could be seen as a "foundational text" for rhetoric because it offers new insight for expanding rhetoric to cover a wider range of the activities involved in composing than typically studied with the classical canons.

Most relevant to my research on the NLS, though, is *Aramis* (Latour, 1996), which traces a project with a similar outcome as Engelbart's NLS—an innovative public transit system that received government support through its conceptual and prototype phases but eventually lost that support and disappeared. Although the Aramis train never reached widespread use, Latour's analysis of its history showed that until its government and industry sponsors withdrew their support, Aramis looked no different than a successful research project. Certainly unexpected setbacks arose as engineers struggled with the technologies that allowed the train cars to connect and separate, but every technological project undergoes shifts resulting from the differences between the affordances of material objects and the goals of engineers. Aramis received different levels of political and industrial support over its time span, but many successful technologies have had periods of tenuous support that they subsequently overcame.

However, many of the people involved in the Aramis project reported afterward that they knew from the beginning that it was not feasible, that it would ultimately fail, either because the technology was too difficult to manage or the political and corporate support too fickle. Latour (1996) argues against these retrospective interpretations of inevitability, stating that all innovative projects, whether they turn out to be successes or failures, exist in states of uncertainty:

> A project is called innovative if the number of actors that have to be taken into account is not a given from the outset... the crowds that were thought to be behind the project disappear without a word; or, conversely, unexpected allies turn up and demand to be taken into account. (p. 72)

In other words, there are no guarantees of success and neither are there guarantees of failure. Innovators cannot know in advance what will be necessary to turn their prototypes into standard black boxes users can take for granted. Winning the government contract, interesting a niche group of beta testers, garnering praise from magazine reviews—none of these come with a guarantee.

Because the outcome of a project is uncertain, questions of feasibility point researchers in the wrong direction. Judging the technical components alone and determining that a project is, for instance, "ahead of its time," assigns too much responsibility to these nonhuman actors. Projects consist of more than mechanical parts; people are also involved. Furthermore, these technologies often rely on complex infrastructures consisting of relationships among people, artifacts, corporations, and bureaucracies. Judging them apart from these networks leads to an artificial result. As Latour (1987) describes,

> By themselves, a statement, a piece of machinery, a process are lost. By looking only at them and at their internal properties, you cannot decide if they are true or false, efficient or wasteful, costly or cheap, strong or frail. These characteristics are only gained through *incorporation* into other statements, processes and pieces of machinery. These incorporations are decided by each of us, constantly. (p. 29)

Tracing the processes through which technologies are incorporated into networks that make them available for everyday use results in maps that can disrupt traditional narratives of technological progress. Rather than assigning values (like inefficient or difficult) to technologies, an actor-network account describes the associations through which people come to label technologies as useful or not. Such accounts can aid researchers in resisting counterproductive or limited technological practices that have been black-boxed and assumed to be universally "best."

To follow these actors and their effects, Latour (2005) identifies two ways of acting—as an intermediary or a mediator: "An *intermediary*, in my vocabulary, is what transports meaning or force without transformation: defining its inputs is enough to define its outputs," while on the other hand, "[m]ediators transform, translate, distort, and modify the meaning or the elements they are supposed to carry" (p. 39). This distinction helps explain Latour's problem with traditional sociology; too many of the actors in such accounts are treated as intermediaries, passively transmitting the will and meanings of others. Even local, less connected actors rarely move in exactly the ways global, more connected actors might want them to move. An actor-network account tries to see more actors as mediators, to find all the actors that make a difference, that produce an effect. Under ANT, the sheer number of associations tying actors together often places them in contradictory positions. Clearly this conception of agency and power is at odds with more commonsense notions, where people can only be free individuals when they reduce the number of social forces directing their actions. From this perspective, people are like puppets, pulled this way and that unless they can cut those strings, or as many as possible. Using the puppet analogy, Latour reverses it: "the puppeteer still holds many strings in her hands, but each of her fingers is itching to move in a way *the marionette* indicates. The more strings the marionettes are allowed to have, the more articulated they become" (2005, p. 217). If the social is made up of associations, then "[t]he more *attachments* [an actor] has, the more it exists. And the more mediators there are the better" (p. 217). Contradicting more typical narratives of technological development suggesting that mediators interfere with the work of innovation, transforming and disrupting the ideas of a lone inventor, Latour argues the opposite—these mediators are in fact necessary for innovative projects to exist.

By re-conceptualizing context as the connections between actors that enable them to act, an actor-network account of technological innovation in the case of personal computers can depict the specific ways technology and literacy become entwined through the creation of hardware and software and the subsequent standardization of practices. Furthermore, by widening the category of actor to include nonhumans, ANT acknowledges the ways that actors, such as the personal computer, exert their pull on writers and how writers also shape these nonhuman actors to their agendas. The networks of literacy and technology are not as stable as we often suppose; as Anne Wysocki (2004) notes, writing takes place in networks of "social, cultural, political, educational, religious, economic, familial, ecological, political, artistic, affective, and technological webs" and altering even one of these elements sends changes "shimmering" across these networks (p. 2). In the case of the NLS, new technologies, writing practices, and identities formed concurrently, and these changes were met with resistance and support from connected actors.

3. Translation

In following all the actors that have an effect on a project, actor-network accounts quickly become too long for the space constraints of an article. Furthermore, ANT argues against accounts that attempt to produce a singular, definitive analysis of a project. Therefore, in this article, I trace a somewhat abbreviated actor-network account of the NLS in order to defamiliarize modern computers rather than to provide the ultimate history of this project. In a packed auditorium at the 1968 Fall Joint Computer Conference, Douglas Engelbart prepared to demonstrate the computer system his team had developed at the Augmentation Research Center (ARC). Sitting in front of a monitor and keyboard connected to the computer processor miles away at ARC in Palo Alto, Engelbart began the demonstration, speaking into a headset microphone as his image was projected onto a large screen for the audience. Additionally, the video projection often showed a split screen, with the monitor's image in the top half and video of Engelbart in the lower half. At several points during the demonstration, the video showed Engelbart's colleagues who were at ARC as they exhibited other aspects of the NLS.[1] Video conferencing in the modern age of the Internet remains technically tricky, and in 1968 this setup was sure to impress an audience of computer experts, many of whom still worked with computers that had no screen and were operated by punch cards or modified typewriters that punched holes in paper tape.

During this "mother of all demos," as it has often been called (Levy, 1994), Engelbart introduced the mouse, which was invented at ARC, and a device to the left of the keyboard called the five-key chord keyset that could be used to type or enter commands according to a binary pattern that produced each letter of the alphabet. To demonstrate the use of these devices, Engelbart did some quick typing and editing within the writing application, which organized all sentences into hierarchical outlines and contained hypertext links. In the demo, he selected links by typing the "jump" command with the keyset, clicked on text with the mouse, and used the keyset to rapidly edit that text. In addition to the text-manipulation and real-time interaction, Engelbart and his team went through significant portions of code, also written in the hierarchical outline form. This demonstration was intended to interest a wider number of people and institutions to associate themselves with the NLS and its technologies as well as to stabilize the existing connections it had with its funders—NASA and the Pentagon's Advanced Research Projects Agency (ARPA). Unfortunately, as Engelbart noted in a 1987 interview, after the demonstration

[1] Video clips of this presentation may be found, at the time of this writing, at http://sloan.stanford.edu/mousesite/1968Demo.html or http://invisiblerevolution.net/68-demo.html.

> some people came rushing up onto the stage, one in particular, Butler Lampson, who is a superbly intelligent guy... was just so excited and that was something pretty great. So I knew that there was a lot of enthusiastic reception about it right there. But basically I really was hoping that it would get other people seriously started in things like this too, but it just didn't. (Lowood & Adams, 1997)

Although many computer professionals claim to have been influenced by this demonstration, none went on to mimic the NLS's more innovative features.

Ten years later the NLS lost its funding from ARPA and was sold to Tymshare Inc., who employed Engelbart and a few ARC researchers who hadn't already moved on to nearby Xerox PARC. It was then sold to McDonnell Douglas in 1984, and Engelbart's laboratory subsequently closed in 1989. Some elements of the NLS have since become standard computer features, such as the mouse, hypertext, on-line collaboration, and easily searchable document repositories. Others, of course, remain as strange and off-putting as novice users in the 1960s found them, especially the chord keyset and the writing application that forced all text into hierarchical outlines. However, rather than pointing out the remnants of the NLS as they appear in modern computers, I want to trace the translations, the specific movements and transformations that incorporated or dismissed bits and pieces of the NLS and the writing practices of its users in order to create new versions of computers. More traditional accounts might see the NLS solely as an intermediary (to use Latour's term), a passive piece of technology that functioned as a conduit for the will of its creators and users. However, the NLS (like any computer) also transformed the meanings others attempted to transmit through it, facilitating some types of writing and computing while resisting others. As a mediator, the NLS functioned as an "actor-network." Latour (2005) uses this term to signal that any focus on a mediating actor also entails attention to its many attachments. An "actor-network," then, is defined as "what is made to act by a large star-shaped web of mediators flowing in and out of it. It is made to exist by its many ties: attachments are first, actors are second" (p. 217). The NLS did not act alone, but it was not fully determined by its attachments either, and the more attachments it gained the more it was able to act through them.

One significant group of nonhuman actors associated with the creation of the NLS was the components that made up the display system. Computer displays clearly have an effect on writing activity; for instance, early displays showed much fewer lines of text than current monitors, making it difficult to see entire paragraphs at once. But the NLS shows how a display can alter the affordances of the entire system and lead writers to different activities. During the time span that the components of the NLS were coming together, there were several options available for computer displays. The cheapest solution at the time was the common teletype terminal, which consisted of a screen that displayed a user's typed commands and the computer's response. In his history of Engelbart and the NLS, Thierry Bardini (2000) notes that this option was not feasible for the moment-to-moment interactivity the ARC team envisioned because the teletype functioned on a "statement-based" model, where a user typed in a command and the computer then executed it (similar to using the command line interface with a modern computer). This model was based on batch processing and did not afford real-time interaction (like word processing) made possible by the NLS's other components. The other two options capable of displaying real-time interaction between the user and computer were vector displays and raster-scan displays. As Bardini (2000) describes, both choices were too costly for ARC to purchase, but for different reasons. The vector displays used complicated, built-to-order internal electronics that resulted in high prices. The raster-scan CRT displays themselves were cheaper, but these displays required much more computer memory to create and refresh the image on the screen and computer memory during the 1960s was exorbitantly expensive. The researchers at ARC ultimately selected the raster-scan option but managed the memory problem in an innovative way to reduce the cost and, in the process, introduced a new set of affordances to the NLS.

Instead of using computer technology and costly memory to implement full-size raster-scan CRTs, ARC used small monitors connected to a video system. Relatively cheap 5-inch CRT screens sat in front of video cameras that piped the signals to the corresponding video terminals (essentially TVs). This option reduced the amount of memory needed to drive the raster-scan display system (and thus reduced the cost) and introduced new abilities, such as splitting the video feed to the monitor to include more than just the computer image as demonstrated during the 1968 demonstration. They were able to show the audience several combinations of images that depicted the computer screen alone, the computer screen in the top half and the keyboard, mouse, and keyset activity in the bottom half, and the computer screen with video of users' faces superimposed in the corners. As Douglas C. Engelbart and William K. English (1968) described in their article from the conference proceedings:

> [T]he video image of a user's computer-generated display could be mixed with the image from a camera focused on a collaborator at another terminal; the two users could communicate through both the computer and a voice intercom. Each user would then see the other's face superimposed on the display of data under discussion. Superimposed views from cameras focused on film images or drawings, or on the computer hardware, might also be useful. (p. 409)

Besides these possibilities, the video option allowed multiple terminals to receive the same video feed, effectively time-sharing the monitor as well as the computer (Bardini, 2000) and allowing for flexible mixing of graphics and text. The affordances of the video camera/raster-scan display setup enabled the 1968 demonstration by letting ARC mix video feeds projected for the audience, showing video of the mouse and keyset operation along with the software interface. Other technological actors would have shaped this event differently and the NLS itself in much different ways; even the same components utilized in less innovative ways would have led to drastically different computer systems. With the funding needed to buy more conventional monitors, ARC would have built a different computer and certainly produced a different event.

Latour uses the term "translation" to denote the way actors produce such effects. Translation, in actor-network theory, "takes on a somewhat specialized meaning: a relation that does not transport causality but induces two mediators into coexisting. . . . There is no society, no social realm, and no social ties, *but there exist translations between mediators that may generate traceable associations*" (2005, p. 108, emphasis in original). Continuing with the marionette analogy, Latour does not see effects as caused by one actor forcing another simply by "pulling" on the string connecting them. Instead, effects are the result of an actor's full range of often-contradictory connections responding in sometimes-unforeseen ways to a "pull" from another actor. In other words, actors that function as mediators don't have just one puppeteer, and the puppeteer's actions don't solely affect the puppet but also many of the other puppeteers to which it is connected.

In the above example, the addition of the video cameras exerted a "pull" on the NLS and its creators, resulting in unexpected actions and possibilities as new actors were added (the video splitter), new practices were introduced (video conferencing and conference demos), and new media were brought into the computer (film and still images). The video hardware did not simply cause these changes, nor did the ARC researchers cause them—they were the result of the affordances of the actors involved and the translations resulting from their relationships.

4. The Chord Keyset

In order to become an actor recognized as capable of participating in people's everyday work, the NLS went through several trials. As Latour (1999) describes, actors are defined through their actions, illuminated by "asking what other actors are modified, transformed, perturbed, or created by the character that is the focus of attention" (p. 122). Several of these trials involved the five-key chording keyset, a device Engelbart began experimenting with early in his research, prior to even obtaining a computer. In the late 1950s and early 1960s ARC did not yet exist and Engelbart was the sole investigator in a research project aimed at augmenting human activity and intelligence with computer technology. He had received a small grant from the Air Force Office of Scientific Research (AFOSR) to pursue issues related to information processing. Engelbart's first report to AFOSR in 1962 (published as a book chapter in 1963) proposed that interactive computer technology, as opposed to the batch-processing model then predominant, could greatly enhance an individual's work effectiveness. He claimed that "digital computers [have the] promise of great flexibility in the composing and rearranging of text and diagrams before the individual's eyes" (1963, p. 9) in addition to enhancing other kinds of work processes. However, it would be a few years before Engelbart, and later ARC, were able to acquire enough funds to purchase computers and monitors that would facilitate writing "before the individual's eyes." Engelbart instead started with somesthetic experiments related to what he called "man-to-machine information transfer" (1961), or attempts to improve communication between computers and humans. The most successful of these experiments involved the five-key chord keyset. In this section, I follow an early trial faced by the chord keyset and show how it highlights the way innovative literacy technologies are often translated to reproduce familiar social and ideological formations (for a detailed discussion of how this process works in the case of hypertext, see Johnson-Eilola & Selber, 1996).

The director of the information sciences division at AFOSR, Harold Wooster, took an interest in the keyset after reading Engelbart's initial reports. The correspondence between the two men that Wooster initiated in 1962 represented an important challenge to what would become an integral aspect of the NLS. The letters are stored in the Douglas Engelbart Collection at Stanford University and contain marginal notes written by Engelbart. In Wooster's first letter to address the five-key chord keyset, he suggested that Engelbart was wasting government funds on an obsolete technology. (Engelbart's underlining is noted, and his marginal notes are in parentheses and bolded.)

> Dear Doug, The price of ignoring history is repeating it. Before you go any further with your five-keyset, I suggest that you get and read a good European history of telegraphy. (Chapter 22 of Volume IV of the Oxford History of Technology [sic] will do for a start, along with the section on Telegraphy in the 11th edition of the Britannica.) What you have apparently done with your five-finger set is to re-invent, not the wheel, but the sledge runner. (“**earlier form**”) (Letter dated October 18, 1962; Box 6, Folder 12)

To supplement Engelbart’s library research, Wooster proceeded to write a complete page on the history of five-key telegraph devices, closing with the following dismissal:

> The principal advantage of your five-finger system to me has always been its *novelty* (“**relative to what?**”). I now find that it is not new at all, but somewhat over 100 years old; that it is not something being tried for the first time, but rather an old and abandoned state of the telegraphic art. I have no objections to antiquarianism as a hobby—restoring and learning to ride a high-wheel bicycle could be fun—but re-inventing the high-wheel bicycle with government funds is something else again. (Letter dated October 18, 1962; Box 6, Folder 12)

Wooster here showed his belief in narratives of technological progress where older technologies are abandoned due to their inferiority in comparison with newer technologies. In the summarized history he provided in the letter, Wooster argued that if five-key devices were valuable then they would still be in use by telegraph operators. In his reply, Engelbart refuted Wooster’s arguments by reviewing the keyset’s history and arguing that technologies exist within specific historical contexts and are not often judged on their technical merits alone:

> The conclusion would seem to be that the five-key keyset vanished because of economic, technological, and system factors which do not exist in our contemplated type of applications. There seems also to be the factor in its disappearance that is all too common in our technological history—i.e., that innovations whose use is associated intimately with operational systems of some size very often survive or perish according to the over-all success of the total system rather than of their independent abilities to meet functional needs. (Letter dated November 15, 1962; Box 6, Folder 12)

Engelbart re-interpreted the history referenced by Wooster to claim that each instance of five-key telegraph devices disappeared for historically and technically situated reasons and that using the keyset to operate a computer would not re-create those conditions.

Rather than allow Wooster to associate the keyset with a linear history of telegraphy that would result in the keyset’s technical failure for all time, Engelbart made an argument similar to Latour’s. The keyset, as a device, was removed from the telegraphic system because of its inabilities to meet the specific demands of telegraph operators. Incorporated within a new computer system, the keyset, Engelbart believed, would be able to meet the demands of computer users, which were different than those of telegraphers. For instance, in his other annotations of Wooster’s original letter Engelbart noted that the “attractive feature” of the keyset was its one-handed operation, which differentiates it from traditional keyboards. Wooster had suggested that a single-key Morse code device might suffice for one-handed operation, but Engelbart contested the idea that it could be as fast or efficient as a chording keyboard.

Wooster was satisfied with Engelbart’s letter, tersely replying with this short note:

> Dear Doug, I guess, under the circumstances outlined in your letter of 15 November, I will not object to your going ahead with the five key-set experimentation. Please keep me read in on your transmission rate experience. At least, as a result of [the research you sent], we will be spared the mutual embarrassment of treating it as if it were new (Letter dated December 6, 1962; Box 6, Folder 12).[2]

Wooster and Engelbart, in this exchange, illustrate the two opposing perspectives of science defined by Latour (1987) as ready-made science and science-in-the-making. Wooster represents the position of ready-made science, arguing that the five-key keyset is a fully researched, finished technology made obsolete by keyboards. Engelbart represents the position of science-in-the-making, claiming that the keyset's properties and affordances are uncertain in the context of computing and worth further investigation. From the perspective of ready-made science, technologies stand on their own, independent of context, and can be judged accordingly. On the other hand, the science-in-the-making perspective starts with uncertainty and continues negotiations and translation until people begin to use the technology as a black box. Maintaining this sense of uncertainty is a crucial requirement for innovative projects introducing disruptive practices.

Taken together, Wooster's reply and his original letter present a powerful conservative discourse that attempted to contain the new possibilities afforded by the keyset. In his original letter, Wooster identified one of the keyset's advantages as "novelty," but several times in both letters he privileged traditional ways of working, suggesting that Morse code may work best because of people's familiarity with it, or traditional keyboards for the same reason. Finally, in his reply, he asked to be kept informed about Engelbart's transmission speed, again privileging a way of working that reproduces existing conditions—typing alphabetic text quickly. However, the keyset afforded more than text entry on the NLS; it allowed for rapid navigation of documents and was used to enter interface commands. Although Engelbart also privileged speed and efficiency in computer use, he and the others at ARC were oriented toward computers supporting new efficient practices rather than speeding up older ones. The keyset represents the site of conflict between these two positions—with Engelbart advocating its novel use but also subject to the more conservative views of funding agencies, as evidenced by his continued submission of reports documenting the typing speeds achieved by ARC researchers using the keyset.

5. Writing with the NLS

Just as the introduction of video cameras to the NLS created a new set of connections through which new practices and ideas about computing were able to travel, the keyset came to afford a user experience akin to Mihaly Csikszentmihalyi's (1990) concept of "flow."[3] Of

[2] For an alternate analysis of the Wooster-Engelbart correspondence on the keyset that more fully explores the keyset's role as a challenge to the traditional QWERTY keyboard, as well as a history and analysis of multiple-key telegraph devices, see Bardini (2000), chapter 2.

[3] Csikszentmihalyi (1990) defined flow as "the state in which people are so involved in an activity that nothing else seems to matter" (p. 4).

course, when viewed alone the keyset seems to only afford frustration or dismissal. When novice users of the NLS judged the keyset on its independent abilities, most saw it as difficult and time-consuming to learn. With its five unmarked keys, the keyset demanded touch-typing and thus hours of practice. The ARC researchers, though, imagined users who would put in those hours of training to integrate the keyset and NLS into their working habits. Bardini (2000) identifies Engelbart's motivation behind developing the keyset as a desire to use technology "to change the way people work" rather than "accomodat[ing] his technology to the way people work" (p. 80). With the invention of the mouse at ARC, the keyset achieved new value in Engelbart's eyes when the two were paired. In a 1992 interview with Bardini, Engelbart compared the mouse and keyset to "'wings' allowing the user to 'fly' through the maze of the system" (Bardini, 2000, p. 118). Convincing others that "flying" through the system was a valuable activity worthy of learning the NLS was another matter. To use Madeleine Akrich's (1992) dramatic terms, finding users willing to fulfill the roles scripted into the NLS by the ARC researchers proved a serious obstacle.

The keyset can be easily dismissed as an unnecessarily difficult replication of keyboard functions if viewed solely as a one-handed means of writing alphabetic text; however, its features included more than typing in alphabetic characters and digits. By pressing different buttons on the mouse, the keyset could be set to one of five modes, or "cases." The first four cases consisted of lower-case letters, upper-case letters, digits, and special characters. The fifth case was called "control case," and in it users "could delete... recent input, specify underlining for subsequent input, transfer to another case, visit another case for one character or one word, etc." (Engelbart, 1969, p. 17). Control case may seem complicated now to writers used to working with interactive computers and GUI word processors, but in the late 1960s editing text in this manner was a new experience. Previously, editing text involved procedures such as typing in commands along with the text on paper tape to be processed later by the computer—not pointing the mouse at the desired position, executing the command with the keyset, and seeing the result immediately on the screen.

Furthermore, the mouse and keyset pairing exploited the unique writing environment of the NLS. In this environment, all text existed within a "structuring convention" that "would make explicit (for both the user and the computer) the various types of network relationships among concepts" (Engelbart & English, 1968, p. 398). Under this convention, all text was organized into a hierarchical structure, essentially an outline. In this structure, text was broken up into "statements" that consisted of a small number of sentences or even a single sentence, preceded by a marker (e.g. 1B2C, indicating its location as under the first heading, within the second subheading, etc.). Each statement could be linked to because it existed as a separate unit identified with a unique marker. A reader following a link to a statement within a new document would thus be able to see where that statement existed within the structure of the new document (whether it was a heading, or just a nested statement under a larger point). Furthermore, the hierarchy of statements in a document could be collapsed or expanded according to any level, allowing readers to view only "top" level statements to get a quick overview of the text, or to only expand one particular section to full detail, or any other combination.[4] View specifications

[4] Anders Fagerjord's (2005) online article provides an example of this technique, which he calls "stretchtext." Each section of the article can be collapsed or expanded by readers.

could also be determined by keyword filter, where only statements containing the search criteria would be shown.

With the NLS, users operated the mouse and keyset in tandem, navigating texts according to all the possibilities just mentioned. The interface was not fully graphic, so these operations were not as simple as "point and click"; navigating the links, hierarchies, and keyword filters was primarily accomplished through keyset commands with the mouse used to position the cursor. Clearly, no novice user in the 1960s was going to "intuit" any of these commands or possibilities from either the hardware or software interface cues. The NLS required training for even basic use and extended practice to take full advantage of the features just mentioned. But with these features and the training provided by ARC team members, the NLS afforded an innovative user experience.

Only through training and practice could users achieve the sense of "flying" with the keyset and mouse that Engelbart identifies. However, I would argue that, regardless of training, such an experience is much more difficult, if not impossible, to achieve with a keyboard and mouse combination. With modern word processors, for example, users must either navigate the text with arrow keys, which can be awkward, or take one hand off the keyboard to use the mouse. Using the keyset and mouse together, without the need to reposition the hands or bend them in awkward ways to reach key combinations with the CTRL or ALT keys, created a kind of smoothness of action well suited for the speed with which the ARC team envisioned users working. The hierarchical structuring convention represents the most obvious area where such speed could be used to great effect, with users able to quickly change views, jump on links, select and edit text, or copy text and navigate to new documents to paste it. Certainly the mouse alone can accomplish many of these tasks in modern graphical interfaces, but the alternation between hands on the NLS and the separation of tasks for each hand affords more speed and reliance on body memory.

These operations recall Jay David Bolter's (1991) discussion of using computer outlining programs to revise writing by focusing on structure rather than content. The smoothness in manipulating structure afforded by the keyset/mouse pairing enabled users to more fully embrace Bolter's suggestions. Furthermore, this sense of smoothly flying through data and text structures resonates with Johndan Johnson-Eilola's (2005) discussions of knowledge workers and their activity:

> Today, many of us thrive on information overload: Email, cell phone, satellite TV, instant messenger. We live in a cloud of data, the *datacloud*—a shifting and only slightly contingently structured information space. In that space, we work with information, rearranging, filtering, breaking down, and combining. We are not looking for simplicity, but interesting juxtapositions and commentaries. (p. 4)

Similarly, in her study of the ways information has become uncoupled from its material forms N. Katherine Hayles (1999) argues that these ways of working with information are enacted bodily with the input devices and displays of computer technology. Bardini (2000) describes the mouse and chord keyset as "prosthetic extensions of the body of the user"; as such, they incorporated the "commands and the architecture [of the interface] in the body of the user" (p. 118). With the keyset, Engelbart and the others at ARC were attempting to incorporate the kinds of activities Johnson-Eilola was describing into the bodies of NLS users. As Engelbart (1962) noted in his first report to AFOSR, he believed that people's tools and mental strategies for dealing with information were inadequate. By augmenting these tools, people's mental strategies would evolve simultaneously with their embodied use. The user experience the ARC researchers scripted onto the NLS in order to materialize the augmentation Engelbart envisioned seems a bit more palatable now because of the potential to "flow" within the datacloud. However, at the time it seemed to many a solution in search of a problem. Key sponsors of the NLS began to challenge it directly as it took physical shape, demanding that it facilitate the activities they saw as worthwhile. Interest in exploring the as-yet-undefined activities that *could* be supported by the NLS was minimal.

For the ARC researchers, training users on the NLS involved more than keyset practice; they wanted to teach users new ways of working with text and code in the structured hypertext writing environment. However, the ARC researchers were not able to determine how others received the NLS or experienced its assembled technologies. Early supporters of Engelbart and the NLS project eventually came to see the NLS as a tool that was too difficult to learn, whereas the ARC researchers saw themselves as creating tools that were easy to use (i.e. facilitating complex work by requiring no explicit attention for high-speed use) once one had been trained.

This conflict is exemplified in an exchange between Engelbart and J.C.R. Licklider in 1977, recounted by Engelbart in a 2005 interview (Cringely, 2005). Licklider was the first within ARPA to support Engelbart's research and proved to be valuable in securing technology and favorable working conditions for Engelbart and ARC. In the mid-1970s, ARC hired recent college graduates to support and train people to use the NLS where they worked, a project that Engelbart was very excited about. As Engelbart remembered, Licklider responded to a description of the program's early success by saying

> You just told me your system's no damn good.... If it was any damn good, the computer system itself would know what the people need to learn and teach them; you wouldn't need any of these damn kids out there teaching them. That just tells me your system's no damn good. (Engelbart qtd. in Cringely, 2005)

According to Engelbart, Licklider was firm in his belief in Artificial Intelligence (AI) and that computers should be smart enough to anticipate what users want to do, or at least learn from them. On the other hand, the ARC researchers were moving in almost the opposite direction, as described by Bardini (2000):

> The design of the interface combining the chord keyset and mouse was intended to produce a scaling effect, producing a qualitative transformation in people and their practices by means of the quantitative increases in speed that experienced users actually had achieved. It was this goal that drove the whole concept of the interface—and making the design serve the end of coevolutionary transformation was the complete opposite of the idea of making the system simple to learn and use. (p. 119)

The AI approach was aimed at fully supporting users' existing ways of working, requiring no change on their part. Its influence can still be seen in the continued development of so-called intuitive interfaces, those that anticipate a user's desired actions and either act directly or present a small list of options. Such interfaces, though, often end up frustrating users when the system has incorrectly anticipated a user's wishes or is seen as patronizing (Microsoft Word's "Clippy" agent being the most glaring example of the latter).

Licklider's critique came near the end of the project's government funding and showed the NLS's increasing difficulty in holding together its various sponsors. Without user support, the NLS could not claim to be a "finished" technology, easily incorporated into larger infrastructures as a black box. As Latour (1996) argues, "the object, the real thing, the thing that acts, exists only provided that it *holds humans and nonhumans together*, *continuously*" (p. 213, emphasis in original). Nonhuman actors, in order to exist as useful objects, must absorb people's many conflicting demands. Engelbart demanded that the NLS and its users co-evolve and develop new practices. Licklider demanded that users be able to do their work with the NLS. Many NLS testers demanded to use a computer without spending time training. These contradictions could no longer be absorbed by the NLS as it existed within the ARC lab. However, the NLS's inability to meet these demands does not make it solely responsible for its failure as a computer system. "On the one hand, [technologies] can be said to hold people together," Latour states, "but on the other hand, it is people who hold [technologies] together" (p. 213). By the late 1970s, the human actors were no longer willing to negotiate their demands to create a modified NLS, and thus ARC closed. At the end of a project, from the perspective of ready-made science, it can be tempting to argue that any technology, such as the NLS, succeeds or fails on its own merits. But from the perspective of science-in-the-making, the many layers of human and nonhuman support are more visible. Successful technologies may appear to stand on their own but they too draw on other actors' support. The competition between NLS technology and other computers at Xerox PARC in the 1970s provides an illustration of how supporting actors and infrastructures become discounted when a successful technology appears to stand on its own. By drawing on the knowledge of publishers and editors as well as existing print practices and technologies, the NLS's rival at PARC succeeded in persuading a significant group of users to accept the scripts created for them by the new computer system.

6. NLS Reassembled

During the mid 1970s, many ARC researchers were hired away by Xerox PARC's Robert Taylor, who had earlier supported the NLS in his positions at NASA and later as Licklider's successor at ARPA. Taylor hired these ARC researchers to create a version of the NLS for Xerox that came to be called POLOS (PARC On Line Office System). Michael Hiltzik (2000), in his history of Xerox PARC, gave a good description of one outsider's perspective on the NLS. Larry Tesler joined the POLOS team upon arrival at PARC, but found POLOS too complex because it required users to "learn a dizzying array of commands and key sequences involving the mouse, keyboard, and—especially frustrating—a bizarre device known as the 'keyset.'... Tesler could not imagine why anyone would want to use such an esoteric gadget" (Hiltzik, 2000, p. 201). Tesler reacted strongly against POLOS in part because of his belief in creating software that "render[ed] the computer intelligible to the layman. By the time he reached PARC he had already written several programs aimed at turning computers into handy tools for average users" (p. 203).

Because of his complaints about POLOS, Tesler was reassigned along with Tim Mott, another Xerox employee, to investigate ways that Xerox PARC hardware and software might be used to support Ginn & Co., a publisher and Xerox subsidiary (Hiltzik, 2000). Ginn's management had seen POLOS demonstrated and thought it might somehow automate or facilitate their work. But Tesler and Mott "shuddered at the thought of training a typical Ginn editor or secretary, or any ordinary user, to utilize POLOS's baroque routines" (p. 205). Even though Mott found the structured text used by POLOS to create hypertext and manipulate views a "fascinating model for analyzing computer programs or navigating through information space," it wasn't, in his words, "a particularly good model for editing manuscripts, let alone doing page layout of text and graphics" (qtd. in Hiltzik, 2000, p. 205). Mott and Tesler, responding to the pull of the mediator Ginn & Co., focused on writing software oriented toward traditional print practices.

Ultimately, Tesler and Mott turned to the first graphical word processor, which introduced icons and menus and was created for the Alto computer (a project within PARC that rivaled POLOS). They redesigned the program and called it Gypsy. Mott credits its success with his close collaboration with the Ginn & Co. employees. At one point, he took an Alto to Ginn and, without turning it on, asked the workers how they would use the device to do their jobs. In fact, Hiltzik (2000) notes that the ubiquitous interface terms "cut" and "paste" originated in this project because they were used by publishing employees to describe the work they did with scissors and paste pots. Even these workers, as integrated in the Gypsy design process as they were, were still initially reluctant to use the word processor. Mott described them as saying "'You're going to have to drag me kicking and screaming'.... But everyone who sat in front of the system and used it, to a person, was a convert within an hour" (qtd. in Hiltzik, 2000, p. 210). Like the NLS, Gypsy needed a demonstration to prove its worth, but unlike the NLS, users immediately began working with Gypsy and seeing it as a solution to their problems.

Tesler and Mott's efforts at usability resonate with Robert Johnson's (1998) arguments for the privileging of user knowledge. He proposed that more attention should be paid to users' knowledge to recover what it means for a user to be a "practitioner," one who has a "*cunning intelligence* involved with practice" (p. 45). Users should be involved in the design process, he argues, so that they can mobilize this intelligence with designers to negotiate the difficulties of use together, rather than introducing a system that overloads a novice's patience. Most new users of the NLS or POLOS reported significant frustration with the system and, as Engelbart wrote in ARC's final 1970 report to NASA,

> [The NLS] users are, however, intended to be "trained" as opposed to "naïve." Thus the system is not designed for extreme simplicity, nor for self-explanatory features, nor for compatibility with "formal" working procedures.
>
> Rather it is assumed that the user has spent considerable time in learning the operations of the system, that he uses it for a major portion of his work, and that he consequently is willing to adapt his working procedures to exploit the possibilities of full-time, interactive computer assistance. (qtd. in Bardini, 2000, p. 154)

Here users and designers are not depicted in negotiation—Engelbart's position may even be considered hostile to users. Adaptations are done on the user's end, not the designer's, since presumably the ARC researchers have spent their time learning and implementing the "best" ways to augment human intelligence.

Of course, the "best" ways are not only subjective but also contingent on a host of factors. In explaining the disappearance of the chord keyset from modern personal computers, another PARC researcher claimed that

> The reason the chord keyset was so popular was that the NLS user interface was so terrible that it was almost impossible to use it without the chord keyset. There was so much requirements [sic] to flip back and forth between what you did with the mouse and what you did on the keyboard that it was vitally important to have the chord keyset. But as soon as people made a user interface that was even a little bit better, the chord keyset was no longer cost-effective and people wouldn't use it. (qtd. in Bardini, 2000, p. 166)

From this perspective, the "power" gained by the keyset is only necessary within complex interfaces, and once simpler interfaces were constructed that power no longer added functionality. Further evidence that the NLS designers had no monopoly on the "best" ways the NLS could be used comes in the case of the mouse. The users Tesler and Mott interviewed suggested a new use for the mouse, one unimagined by ARC researchers:

> When it came to deleting text, they talked about wanting to strike through it, just like they would with a pencil. They wanted to use the mouse to draw through the text. Up until that point, the way that a span of text had been selected was to mark the beginning point, and mark the end point and say "select." No one had actually used a mouse to draw through text. (Mott qtd. in Moggridge, 2006, p. 50)

A key action now associated with the mouse was suggested by novices, not invented by its designers; as this example illustrates, not all uses of a device are obvious to everyone. By introducing the publishing employees—new mediators—into the project, Tesler and Mott made space for new transformations and translations of existing devices and practices.

Gypsy's success could seemingly be attributed solely to its features and their intuitive ease of use for the publishing employees and others. However, such an interpretation ignores the infrastructure that supports the software and makes its features appear intuitive. The publishing employees were extensively connected to a vast network of publishing technologies and engaged in practices designed around the affordances of these technologies. Gypsy supported these associations and was incorporated within this larger infrastructure. In other words, it was the link that Ginn employees saw between their tasks and the computer that made the computers easy to use, not necessarily the graphical interface based on typesetting metaphors. Even if these interfaces were successful for the writing work done by these employees, different interfaces would likely be similarly successful at supporting different kinds of writing activity. Instead of viewing Gypsy as facilitating a model of writing valuable for the situated activity of publishers, Xerox PARC management positioned Gypsy as applicable to most writing activities and ended the POLOS project. Granted, Gypsy's interface smoothed the transition for print writers to computers, but it also obscured possibilities for digital writing practices and products with no print analogs.

Computer interface researchers John Carroll and Mary Beth Rosson (1987) have written about the drawbacks of interfaces like Gypsy's that use metaphors for analog tasks and technologies. From their research on users, they concluded that most are initially oriented toward quickly producing things (like written documents) rather than learning the system more generally. Users also tend to apply their experiences from outside computer use to learn new computer operations. Both tendencies, however, tend to result in faulty reasoning that leads to unwanted behavior from the system and under use of potentially valuable features. Although they suggested several design changes that may help alleviate the negative aspects of these tendencies, Carroll and Rosson argued that these difficulties should be treated “not as design problems to be solved, but as true paradoxes that necessitate programmatic tradeoff solutions” (p. 80). Navigating these paradoxes requires more situated analysis of individual software programs and the activities they are meant to support. Simply attempting to make interfaces for complex activity universally intuitive or easier to learn cannot solve these paradoxes; they require critical reflection on the tradeoffs of each option.

Mapping the processes through which users and designers negotiate and compensate for these tradeoffs provides researchers and teachers with better pictures of the complex ecologies of writing activity. Cynthia L. Selfe and Richard J. Selfe (1994) model this kind of reflection in arguing that so-called intuitive interfaces never accommodate the diverse range of knowledge and experience that different users bring to a system; they more often privilege existing powerful discourses and ways of knowing and thus represent an unfair tradeoff. Also discussing the limits of intuitive interfaces, Bardini (2000) concludes that it “is time to reflect once again on the benefits of interfaces that are easy to use, whatever it may take to learn them” (p. 227). With the creation and success of the original Macintosh that drew on many of Xerox PARC’s innovations, the key aspects of the interface designed by Tesler and Mott were standardized. Easy to learn, intuitive interfaces closely associated with print-based writing and editing practices became identified as interfaces easy to use for any situation or activity. For almost 25 years these familiar, easy-to-learn interfaces have maintained their dominance as people continue to buy and use them largely without question.

The case of the NLS, then, suggests that judging writing technologies solely, or even predominantly, on the criteria of ease of learning tends to support existing infrastructures and practices. Writers interested in challenging these forms could benefit from instead judging technology by mapping the new associations writing tools make possible. Recognizing that these technologies will continue to function as mediators, transforming and translating writers’ goals, allows writers to be more conscious of the ways they recruit these tools for their projects. Even successful technologies need constant maintenance and connections with sponsors (e.g., the vast electrical grid powering our many electronic devices) even if that support has become transparent and naturalized. Making way for innovative technologies and the possibilities they offer requires more conscious and purposeful support, but maintaining the perspective of science-in-the-making allows writers to see that such explicit support is not a sign of a technology’s deficiencies.

7. Conclusion

Actor-network theory, by mapping the connections through which actions and meanings are translated and transformed by actors, provides alternate ways of imagining the activity of computing when hardware has become black-boxed along with specific models of use. In this account, I have attempted to show the historical controversies that resulted in modern GUI interfaces and the ways these interfaces were fully oriented toward print practices. The history of the NLS presents an alternate vision of computer use and users that lost out in the face of more traditional conceptions of people and work. Using ANT to highlight the multitude of actors that have played or continue to play a role in writers' uses of computer technology suggests that shaping digital writing practices involves much more than training on software. To support innovative new media and multimodal composition practices, we should continue to make more actors visible, acknowledging the mediating roles of more technologies, people, institutions, and ecologies.

Deborah Brandt (2001) has similarly shown in the realm of literacy that powerful sponsors are always propping up and benefiting from specific kinds of literacy. Gail E. Hawisher and Cynthia L. Selfe (2006) have extended her work into the technological realm, exploring the sponsors of individuals' technological literacy and drawing attention to the "complex social and cultural ecology, both local and global, within which literacy practices and values are situated" (p. 628). Their discussion of the literacy narratives of two students from China and Taiwan adds to Brandt's "literacy sponsor" the concept of *guanxi*, referring to "networks constituted by relatives, acquaintances, teachers, or organizations that can help people achieve something they might not be able to achieve alone" (p. 633). *Guanxi* resonates strongly with ANT by highlighting the contingent, informal ways that associations can be made between actors. Support of innovative technologies and practices need not take the form of permanent infrastructures; even loose alliances can sometimes provide significant momentum for a project.

Although other histories of the NLS and Engelbart's part in the shaping of computer technology might detail similar episodes as I have here, the specific value of ANT for my project continues to be its focus on the role of nonhuman actors and people's efforts to incorporate them within larger projects. This focus has turned my attention to the keyset as an intersection of embodied practice and writing activity. The mostly negative reactions to the keyset reveal what Hayles (1999) has called the "inertia" of embodied practices, which makes them "surprisingly resistant to conscious intentions to modify or change them" (p. 204). But at the same time these changes in the way we use our bodies for writing and other activity can have powerful effects. Remaining open to the possibilities for change afforded by new technologies means, in large part, attending to their concrete physical properties and how ecologies shape the ways people manipulate those properties.

In the account of the NLS I have traced here many of the military and corporate sponsors of computer projects privileged speed and efficiency in the physical use of hardware. Engelbart, though, sought to add computer support for writing activity that remained complex. When computer technology is developed to support speed and ease of learning as opposed to speeding up tasks that continue to be understood as difficult or complex, the technology most often ends up de-skilling workers. As Richard Ohmann (1985) and Shoshana Zuboff (1988) have argued, machines erase workers' embodied and situated knowledge about their jobs and reconfigure people's work as repetitive. To resist this erasure, it is necessary to re-script computer technology by exploring alternate configurations that support models of users and digital literacy that recognize the complexity of writing. Although no real people outside of ARC took up the user model of the NLS supported by ARC, it does represent one alternate script for computer use. Many writing researchers and teachers would rightly reject ARC's vision of users, but the NLS history presents another depiction of the frequency with which complex visions of literate activity are simplified discursively and technologically. Remaining critical of the relationships between literate activity and different interfaces and applications, especially when these interfaces are disruptive, will ensure that new ways of composing digitally are not dismissed out of hand or radically simplified.

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