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Abstract

Purpose – Information scholars frequently make use of "conceptual imports" – epistemological and methodological models developed in other disciplines – when conducting their own research. The purpose of this paper is to make the case that social semiotics is a worthy candidate to add to the information sciences toolkit.

Design/methodology/approach – Both traditional and social semiotics are described in detail, with key texts cited. To demonstrate the benefits social semiotic methods may bring to the information sciences, the digital display screen is then employed as a test case.

Findings – By treating the display as a semiotic resource, the author is able to demonstrate that, rather than being a transparent window by which the author may access all of the data, the screen actually distorts and conceals a significant amount of information, and severely restricts the control users have over software packages such as online public access catalogues. A programming paradigm known as language-oriented programming (LOP), however, can help to remedy these issues.

Originality/value – The test case is meant to provide a framework by which other information sciences issues may be explores via social semiotic methods. Social semiotics, moreover, is still evolving as a subject matter, so IS scholars could also potentially contribute to its continued development with their work.

Keywords Technology, Discourse, Semiotics, Display, Screen, Social semiotics

Paper type Conceptual paper

The fields of LIS and IS are awash in "conceptual imports," to borrow the term used by Frohmann (1994, p. 123) when discussing his own advocacy work for discourse analysis . Such imports necessarily bring their own discursive practices and biases into the information disciplines, as Frohmann explains it, and the changes they impose, or fail to impose, on existing power relationships within these disciplines are worth considering just as much as any methodological or epistemological benefits that they might have on offer. It is with these issues in mind that I carefully make a case in this paper for the incorporation of social semiotics paradigms and practices into information research. Social semiotics, to put it broadly, blends "traditional" semiotics – the study of signs as delineated by Ferdinand de Saussure and Charles Peirce, who were long considered to be the "co-founders" of the discipline even though they never actually coordinated their research – with critical theory. In particular, the work of linguistics scholar M.A.K. Halliday, who coined the term "social semiotics," is cited as a major influence. Early advocates of social semiotics – particularly Robert Hodge and Gunther Kress, who co-wrote one of its foundational texts – heavily criticized the work of Saussure and his followers, who they accused of disregarding the socially constructed aspects of meaning with respect to signs and symbols. Whether or not this criticism was justified, social semiotics scholars have built an impressive foundation of research in which they apply their critical methodologies to a wide variety of cultural artefacts. More recent research has also paid particular attention to the idea of "multimodality" – that is, the use of a variety of representational structures, such as language, images, and sound, within the same text.

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Social semiotics, I will argue, may prove valuable to LIS and IS by providing, among other benefits, a platform upon which seeming disparate areas of research could be brought together. For the purposes of this paper, I provide a detailed case study that focusses on a medium that has become increasingly pervasive (and perhaps invasive) in modern information research and practice – the electronic display screen, or computer "monitor" to employ an older term. These screens, which are now embedded across multiple digital devices, have become ubiquitous in a way that the earliest computer engineers and theorists did not, and perhaps could not, envision. By treating the display screen as a semiotic "resource," to the use the proper terminology, we may situate modern screens within a historical context that will allow us to better understand the socially constructed affordances and limitations expressed by such technology. As we will see, the ubiquity of the display has served to define and legitimize a model of human-computer interaction (HCI) in which the user is placed in an extremely limiting role, allowed only to define and modify simple data elements, and then to send this data to programs that largely keep their code hidden from view. While such an approach hews closely to the data structures and algorithms dichotomy well-known to computer science scholars and programmers, it also prevents the user from fully engaging with the fundamental elements of information-based applications such as online library catalogues and search engines.

Interestingly, social semiotics, as defined by some its strongest advocates, also advocates for the proposal of new ideas and structures that may better address the issues found in the analysis of one of more resources. In my case study, then, I will introduce the concept of language-oriented programming (LOP), an emerging field in computer science in which simple programming languages are developed to perform complex tasks. The development of LOP-based languages for applications like online library catalogues could allow for levels of user engagement and interaction that go well beyond what exists now, and could even enlist the user as a co-creator in the development of such online applications.

I will begin this paper with a brief discussion of traditional semiotics, and then elucidate the limited ways in which semiotic theory has been applied to current LIS and IS research. Following this, I will describe the emergence of social semiotics from a historical perspective, and then go on to explain its primary tenets, at least according to some of its leading scholars. Finally, I will introduce the case study, discuss the history of the electronic display and analyze this history using an approach grounded in the principles of social semiotics. As indicated, I will finish this case study with a brief discussion of strategies that could be employed to address the issues uncovered during the analysis phase.

Semiotics research in LIS and IS

Social semiotics emerged out of semiotics proper, and while it has done much to distance itself from the work of "classical" semiotics scholars, I feel that it is necessary to survey this field and to explore the ways in which semiotics has been applied to information research. As we will see, semiotics has featured in important LIS and IS research, though mostly in the field of knowledge organization, and mostly based off of the work of Peirce. This by no means is meant as a criticism of either field; rather, this situation presents an opportunity to bring a new epistemological perspective to areas of research that have so often successfully absorbed new forms of scholarship in the past.

Blair stands out as perhaps the first contemporary information scholar to discuss semiotics as a research tool in IS; he also might be one of the field's strongest critics.

Some of his arguments against it, in fact – he expresses deep reservations, for example, with respect to any notion of essentialist connections between signifiers and signified – resemble those that the first social semiotics scholars were making at roughly the same time (Blair, 1990). He goes on to claim that the "central difficulty" with the field is that "without a clear definition of contents/signifieds most Semiotics reduces to a topography of imaginary landscapes" (Blair, 1990, p. 135). Despite such reservations, however, Blair notes that semiotics has "useful aspects" to it. He first highlights Peirce's concept of "unlimited semiosis," which draws attention to the fact that most signifieds go on to become signifiers, creating potentially indefinite links between symbols and meanings. Blair sees substantial benefits to abiding by this concept. With respect to the "representation of texts," he notes that "there can be no necessary and sufficient [. . .] representation of a text." As a consequence, "the standard to be used to judge the usefulness of a particular textual description is not that of "correctness," but one of "appropriateness" (Blair, 1990, pp. 137-138). These are ideas that would be picked up shortly by other scholars.

As indicated above, semiotics is particularly well-represented in contemporary research in the fields of knowledge organization and classification. There are many names worth highlighting here, though the work of Mai is perhaps the most recognized. In a 2001 article Mai (2001) explored the potential utility of semiotics in the "subject indexing process" (p. 591). He is interested in particular in the role semiotics plays in the "indexing process," which he delineates using the "three-step approach" of previous scholars:

(1) determine the subject matter of the document;

(2) reformulate the subject matter in a natural language statement; and

(3) translate the subject matter into the indexing language (all from Mai, 2001, p. 592).

As with Blair, Mai (2001) draws on the notion of "unlimited semiosis," which he defines as "the process of one sign producing another sign," to serve as the foundation of his model (p. 598). He argues that the process of subject indexing (as described in the three-step approach) involves the passing on of signs at each point along the way. It is worth citing Mai (2001) in full here:

> The process begins with an initial sign, the document. The indexer initially makes an act of interpretation (the first step) in order initially to determine what the first sign, the document, is about. The product of this act is a new (or second) sign, the subject. A new act of interpretation (the second step) is then made in order to convert what the indexer has come up with as a subject to something more manageable and concise for indexing. The product of this act is still another new (a third) sign, the subject description. Finally, still another act of interpretation (the third step) is made in order to fit the subject description into a given subject indexing system's vocabulary. This act in turn develops still another new (the fourth) sign, the subject entry (p. 603).

This paradigm offers a much richer picture with respect to indexing as compared to earlier scholarship that, according to Mai, focussed largely on the last step in the process.

Other information scholars have proposed and applied methods similar to Mai's, but with differences in emphasis and accent. Thellefsen, for example, adopts a more grounded position, starting at the point where a particular knowledge domain requires a formalized framework upon which to classify and organize relevant information (Thellefsen, 2002). This process begins with the development of "concept" names that reflect one or more important elements of a given knowledge base; Thellefsen notes that the extraction of unwritten "tacit" knowledge is particularly important at this stage. These concepts therefore act as signs, in that they "represent a potential knowledge content which becomes actualized whenever the concepts are interpreted" (Thellefsen, 2002, p. 74). This process is continued, so that "[t]he fundamental signs and their radial structures form a semiotic skeleton that consists of a certain amount of fundamental signs and their related concepts" (Thellefsen, 2002, pp. 74-75). Friedman and Thellefsen (2011) also make note of the role of subject headings as pointers to meanings in a given knowledge domain, but they caution that "[o]ne may argue […] that what semiotics has in theoretical depth it lacks in application" (p. 667). Brier goes over the same materials from a more library-centric perspective, paying particular attention to the "language games" librarians and library workers have to navigate. He warns his readers that this is no easy task, noting that "[t]he skill of the librarian to mediate between different language games in document mediation is a complicated one that becomes increasingly complex every year" (Brier, 2006, p. 22). Semiotics, then, allows us to elucidate – and, hopefully, improve upon – the tasks and procedures undertaken by indexers, librarians, and related professionals.

LIS and IS, then, have a very decent track record with respect to semiotics-based research. Much of the work that is out there is reflective and critical, yet also instructive with respect to the potential benefits of semiotics. That is not to say that things are perfect; I can identify two issues that need to be addressed. The first is that this scholarship is almost exclusively focussed on the work of Peirce. While his work is defined and critiqued very well, the larger context of semiotics research is somewhat obscured. While Saussure's work is quite different, for example, it could be worth mentioning the reasons why his version of semiotics may or may not apply. The second issue is the fact that very nearly all of this research is focussed on knowledge organization and related fields. It is, I believe, worth exploring other areas in LIS and IS where semiotics could prove to be useful. In the sections that follow, then, I will address both of these concerns by advocating for a role for social semiotics in information scholarship.

Social semiotics – an introduction

Social semiotics emerged as a somewhat antagonistic response to traditional semiotics, with Hodge and Kress serving as its chief polemicists. In their work *Social Semiotics*, they indicate that they do not intend to "break with the past," but they then state the following about Saussure's work:

> On the one hand he projected a discipline with the widest possible scope, while on the other he laid down a set of strictures which split his heritage in two, deforming linguistics, and preventing the coming of semiotics for decades (Hodge and Kress, 1988, pp. 13-15).

Hodge and Kress criticize de Saussure (1983) for many reasons, but they dwell in particular on the "sharp dichotomies" described in his *Course in General Linguistics* (1983). Saussure used these dichotomies to distinguish which aspects of language and linguistics could be studied using his conception of semiotics. According to Hodge and Kress, this strategy was unnecessarily limiting. Moreover, they accuse Saussure of picking the wrong side, so to speak, within each pair. Working from this, they list several new areas of study that they believe should be incorporated into an "alternative semiotics," including "other semiotic systems alongside verbal language," "diachrony, time, history, process and change," and "the material nature of signs" (Hodge and Kress, 1988, p. 18). By exploring such areas, they claim, semiotics would be able to understand the apparent "chaos" that lies outside of its traditional boundaries.

Social semiotics was informed and inspired in part by research that Hodge and Kress had conducted several years earlier in the field of linguistics. In their work *Language and Ideology*, they emphasize the role that language plays in supporting ideology, which they define as "a systematic body of ideas, organized from a particular point of view" (Hodge and Kress, 1979, p. 6). From this perspective, according to the authors, we may better understand how language operates as an "instrument of control as well as communication," and, more specifically, how language "involves systematic distortion in the service of class interest" (Hodge and Kress, 1979, p. 6). These concerns carried over into their later work, but with social semiotics they moved away from the position of treating language as the primary source of cultural meaning making. As they later state, "meaning resides so strongly and pervasively in other systems of meaning, in a multiplicity of visual, aural, behavioural and other codes, that a concentration on words alone is not enough" (Hodge and Kress, 1988, p. vii). A critical approach to cultural artefacts, they believed, could and should apply to any and all relevant "texts," regardless of what systems they use to express meaning.

While they dwell for the most part of the work of Saussure, Hodge and Kress do touch on Peirce's version of semiotics and the issues they have with it. Given the prominence of Peirce's work in contemporary LIS and IS scholarship, it is worthwhile to dwell on this aspect of their work. The concept of the "interpretant" is particularly popular in information literature, though definitions of it can extend beyond what Peirce had intended. Consider, for example, Mai's (2001) explanation of the term interpretant:

> The interpretant is […] the sign that is produced from the representamen. In other words, when the representamen is perceived as a sign, a new and more developed sign is created on the basis of the representamen. The person who interprets the sign makes a connection between what he or she sees (which is the representamen) and his or her background knowledge (which is the object) and thereby creates an understanding or meaning of the sign (which is the interpretant) (p. 597).

This passage makes it appear as if the interpretant is a highly subjective construction. Peirce, however, was a staunch realist. As explained by Garrison (1994), Peirce "believed in the reality of universals," and in objective, scientific truth, so that rational research could uncover the "fixed and final structures of external reality" (p. 6). It is precisely this position that Hodge and Kress take issue with; for Peirce, "[t]he relation between 'sign' and 'interpretant' is still controlled by the relations with the object, with material existence" (Hodge and Kress, 1988, p. 20). The sign itself, moreover, also connects with this objective reality, with the interpretant serving as a medium that imparts meaning to the observer. Interestingly, there is actually a social element to this process with respect to the interpretant, for in order to be understood, interpretants must be situated within contexts familiar to listeners and readers; such a context is known as a com-interpretant, which draws from a larger contextual commens understood by all (Liszka, 1996). Despite this, interpretants still possess an objective "realness," and Hodge and Kress were looking to devise an epistemology that did away with all notions of objectivity, privileging instead the subjective interpretations of the observer.

In the years after Hodge and Kress's work was published, a core group of researchers emerged as champions of social semiotics. Daniel Chandler (2007) refers to this group as the "Sydney school" because of the influence of Michael Halliday, who finished his academic career at the University of Sydney (p. 220). Theo Van Leeuwen, now one of the leading researchers in social semiotics and related fields, also works out of Sydney, and several other members of the group earned graduate degrees there. In 1991, members of the group established the academic journal *Social Semiotics*. In the first issue, the editors explained the goals of their project: "to put the social back into semiotic, and to see semiotics as a transdisciplinary site – a way of understanding the practices of meaning-making across a range of texts and institutions" (Cranny Francis *et al.*, 1991, p. 1). Taking texts of all forms as the focus of their work, they were concerned with "the politics of textuality, with exploring the politics of textual semiosis and of the institutional siting of text, and with the politics of the theories and methodologies which undertake that siting" (p. 1).

Social semiotic research has moved in a variety of directions since these early years, though, as noted, there seems to be a tendency to move away from research that focusses purely on language. The notion of "multimodality" has emerged as a means to reference and analyze more complex cultural artefacts. According to Kress, multimodality considers "all the means we have for making meanings – the modes of representation – and considers their specific way of configuring the world" (Kress, 2004, p. 110; see also Kress, 2010). It is important to note that Kress is not conflating mode with media – rather, media are used to express specific modes, so that "modes and media exist in culturally and historically shaped 'constellations'" (Kress, 2004, p. 113). These constellations are growing increasingly complex, according to Kress, with the advent of globalization and the "vast web of intertwined social, economic, cultural and technological changes" that come with it (Kress, 2010, p. 5).

Despite all these innovations, or perhaps because of them, Van Leeuwen has attempted to synthesize the basic tenets of social semiotics, at least from his perspective, in a recent work titled *Introducing Social Semiotics*. Van Leeuwen's (2005) approach focusses on the concept of the semiotic resource, which is meant to replace the sign as the key element of analysis:

> In social semiotics resources are signifiers, observable actions and objects that have been drawn into the domain of social communication and that have a *theoretical* semiotic potential constituted by all their past uses and all their potential uses and an *actual* semiotic potential constituted by those past uses that are known to and considered relevant by the users of the resource (p. 4; emphasis in original).

Note the nuance here with respect to how "signifier" is defined. It is the same term that classical semiotics uses to denote the representation of a specific, "signified" meaning. Van Leeuwen expands the scope of this definition so that signifiers become dynamic objects that may convey a range of meanings. It is therefore important for the social semiotics researcher to determine this range of possible meanings, which Van Leeuwen (2005) describes as the process of "inventorizing the different material articulations and permutations a given semiotic resource allows, and describing its semiotic potential, describing the kinds of meanings it affords" (p. 4).

This type of research can become rather complicated, particularly when we are dealing with resources that have built up a vast array of cultural and economic meanings. For such a case the researcher should trace the history of the resource, particularly with respect to how its semiotic potential evolves over time. The wider contextual environments within which the resource was embedded must also be considered. This history ideally would capture evidence describing how the resource was used, as well as the opinions and perspectives of those who engaged with it (or did not engage as it were). Van Leeuwen compiles these tasks and others in his three-point description of the work performed by a social semiotician:

(1) collect, document, and systematically catalogue semiotic resources – including their history;

(2) investigate how these resources are used in specific historical, cultural, and institutional contexts, and how people talk about them in these contexts – plan them, teach them, justify them, critique them, etc.; and

(3) contribute to the discovery and development of new semiotic resources and new uses of existing semiotic resources. (all from Van Leeuwen, 2005, p. 3).

This work is all meant to contribute to a better understanding of semiotic resources in action. As Van Leeuwen (2005) indicates, "social semiotics is by and large about the how of communication. How do we use material resources to produce meaning?" (p. 93). As such, he highlights four dimensions of analysis that he feels are central to a social semiotics approach to research:

- discourse, which Van Leeuwen calls "the key to studying how semiotic resources are used to construct representations of what is going on in the world";
- genre, defined as "the key to studying how semiotic resources are used to enact communicative interactions";
- style, "the key to studying how people use semiotic resources to 'perform' genres, and to express their identities and values in doing so"; and
- mode, "the key to studying how people use semiotic resources to create the truth or reality values of their representations" (all citations from Van Leeuwen, 2005, p. 91).

It probably goes without saying that these ideas and rules are not set in stone. I do find, however, that Van Leeuwen's approach is quite elegant in its simplicity and flexibility. Its third "step," moreover, is extremely compelling in that it advocates for the researcher to apply knowledge gained in the analysis of a specific semiotic resource. Such applications may not be suitable in every instance, but I do make an attempt to follow this advice in the case study below, and generally aimed to hew closely to his overall ethos.

Case study: electronic displays

Social semiotics is a powerful tool precisely because it allows researchers to consider a variety of phenomena under the same rubric. For the purposes of LIS and IS, it enables us to expand on existing research by looking into artefacts and texts that were previously considered to be marginally relevant, if they were considered at all. We can then study more familiar information artefacts and practices from new perspectives, gaining insights to how they function as semiotic resources, and how antecedent resources contributed to the ways in which their semiotic potential has been realized. For the purposes of this case study I will focus on a seemingly essential component of any information technology system: the electronic display, which may also be called the computer display or "monitor," and is often referred to simply as the "screen." The actual screen is, of course, only one component of a display, but it is by far the most relevant for the majority of computer users, in that it serves as the site for activities ranging from word processing to graphic design to gaming. As Lev Manovich (2001) puts it, "coupled with the computer, the screen is rapidly becoming the main means of accessing any kind of information, be it still images, moving images, or text" (p. 94). To this list we may add LIS and IS tools such as online public access catalogues (OPACs), article databases, and search engines. Even when we seek out physical media, we generally spend at least some time interacting with screens, and we are increasingly trending towards the use of digital media as researchers, as library patrons, and as consumers.

Since interactivity is a key issue here, it might seem more appropriate for us to adopt ideas and methods from the field of HCI. It just so happens, moreover, that there is a sub-field within HCI for what is called "computer semiotics" (a good overview may be found in Andersen, 1991; also Andersen, 1997). There are some interesting correlations between this model and social semiotics; note, for example, Andersen's (1991) arguments with respect to the overall purpose of computer semiotics:

> Semiotics must necessarily view computer systems as sign-vehicles whose main function is to be perceived and interpreted by some group of users. It has nothing to say about data in itself, only in its capacity of being interpreted and used as a source of knowledge or guide for action (p. 6).

The user interface is, according to Andersen (1991), "one obvious example of a computer based sign," but the typical computer system is composed of several layers of meaning making, so that if we navigate "the different layers of the system, passing through the operating system and the assembly code, down to the actual machine code, we will encounter signs most of the way" (p. 6).

The primary drawback of computer semiotics, however, is that it is built off of ideas originating from classical semiotics. This means that the critical methods encouraged in social semiotics are largely – though perhaps not entirely – absent here. Computers are depicted as "sign-making" machines that use various forms of representation to translate machine code up to end-user software. Computer semiotic systems are ultimately depicted as elaborate, multi-layered exercises in synecdoche so that, for example, "the interface of a flight reservation system stands for flights" for those working at the airport counter, while to a developer the same system is presented in code (Andersen, 1991, p. 6). While these are surely useful principles from an HCI point of view, this is not sufficient evidence for a critical semiotic paradigm such as social semiotics. We are missing out on the subjective perspectives of users, developers, marketers, and related individuals and institutions. We lack important information with respect to the historical contexts within which a given artefact was used, and we have recast the user as a largely passive recipient of symbolic information. For these reasons, I believe that social semiotics has more to offer in the present analysis.

To approach this from a social semiotic perspective, then, I have employed the three practices delineated by Van Leeuwen in the following manner: I first traced the history of the electronic display back to the mainframe computer era of the late 1940s and early 1950s. In keeping with Van Leeuwen, I took a "systematic" approach in my research, but I will focus here on those resources that had were the most influential in terms of perpetuating and normalizing the use of the display with digital computers. Second, I analyzed each resource based on the four elements listed by Van Leeuwen: discourse, genre, style, and mode. I will present here what I consider to be the most important results of this analysis. Finally, I sought out ideas and methodologies that could potentially improve upon existing resources, and perhaps even enable the creation of new resources. For this final step, I adopted the perspective of the user, as opposed to, for example, the manufacturers or vendors of this sort of equipment. With respect to the structure of this analysis, my findings from the first and second steps will be blended within a single narrative path. My work on the third step will then follow.

Electronic displays, then, have improved significantly over the years and decades in which they have been used. While the cathode ray tube (CRT) was the primary display technology for much of this time, liquid crystal display monitors are much more compact, and offer better image quality, and therefore have supplanted CRT as the technology of choice. Despite all this, conceptually the display has changed very little since it was first introduced. The user guide for the IBM 2250 Display Unit, one of IBM's earliest electronic displays, illustrates this point quite well. The guide describes the display screen as a "virtual square grid," then notes the following: "This grid covers the 12-inch by 12-inch display area on the face of the CRT [screen], and comprises 1,024 equally spaced X positions and 1,024 equally spaced Y positions," adding "the X and Y coordinates of each display element [...] are specified by data in the display program" (IBM Systems Reference Library, 1971).

The points along this virtual grid are what we now call pixels, and the dimensions of this grid are now usually referred to as a display's resolution. So the resolution of the IBM 2250 is 1,024×1,024, denoting the X and Y dimensions, respectively. Laptop computers built in recent years tend to use 1,366×768 displays, but for slightly older machines 1,024×768 was more common (Melanson, 2012). When we discuss electronic displays used with computers, then, what we are really talking about are these "pixel grids" that form the basic building blocks of all the text and graphics we see and interact with on a screen. The pixel grid display, then, is a semiotic resource that is employed virtually every time we interact with digital information, and will be the focus of this case study[1]. Note that the level at which we are working with respect to meaning making is higher than it would be if we were to apply classical semiotics. This approach offers significant advantages in that we get a better understanding of how meaning is constructed and communicated, as well as how meanings change over time.

To jump right into the narrative, then, we can go all the way back to the postwar period, when the first mainframe computer were being designed and built, with the USA and the UK leading the charge. Given the importance of the electronic display today, it might seem surprising that almost all of these early machines did not come with any sort of display whatsoever. This was not a technology problem, as the CRT had been in existence for many years. So why was the CRT display so unpopular? While there are probably many factors in play here, a simple explanation might be that there was simply no recognizable need for them. The first computers were designed largely to process data a piece at a time (or perhaps a few pieces at a time), with punched card and magnetic tape serving as the primary media by which such data was input and output. Functionality was limited, but so were expectations, a point worth emphasizing given Van Leeuwen's concerns over context. The ENIAC, the first general-purpose computer to be built in the USA, was designed "to assist the US Army in calculating firing tables required for the various new weapons and ammunition then being developed for the conduct of World War II" (Polachek, 1997, p. 25). Computers were math machines – very good math machines that could store data in memory and perform complex repetitive tasks at an alarming rate (at least for the time) – but were still just number crunchers serving as instruments of war.

It was only through tentative experimentation that the CRT display was introduced into computer system architectures. It is generally accepted that the first applications of CRT displays to computing systems occurred within the context of the "Whirlwind" project at MIT. Whirlwind was one of the most unusual of the early university-based computer-building projects – the original Whirlwind was commissioned in 1945 by the US Navy, in partnership with the Servomechanics Laboratory as MIT, to be an all-purpose, mechanical flight simulator. The project evolved quickly to become both a mechanical simulator and a digital computer – eventually, the simulator aspect was dropped, so Whirlwind was, for a short time, an experimental digital computer with no specific purpose (Redmond and Smith, 1980).

It was within this chaotic context that the CRT display was introduced. Initially, in 1948, the only display device in use was a five-inch oscilloscope, and its purpose was simply to depict the values of certain memory registers onscreen. Norm Taylor, who worked on the Whirlwind project, noted the following in a presentation he made at the SIGGRPAH conference in 1989:

> Keep in mind we were not trying to build a display here; we were building a computer. All we used the display for was testing the various parts of the system so displays were ancillary completely to the main event (Hurst *et al.*, 1989, p. 22).

Taylor succinctly yet effectively conveys the general sentiment of the era with respect to electronic displays. They were useful with certain menial tasks, but they were just "ancillary" add-ons to devices that relied on print for their most important work. This marginalization, however, would soon become something of an advantage, as I will discuss in more detail below.

In any event, Taylor went on to discuss a program he called "Waves of One," which displayed the binary values of a select group of memory registers as a series of dots – the value 1 would be represented as a dot, while a 0 would be represented as a blank space. The result was a 16×16 grid of dots and spaces (Taylor, 1989). While seemingly rather mundane, this was actually a crucial moment in the overall history of the pixel grid. While oscilloscopes were perhaps better-suited to plot waveforms, it would seem that Whirlwind's engineers hit upon the idea of using them also to plot fixed grids of simple points. As they continued to acquire better displays, moreover, Whirlwind's engineers and programmers quickly became more creative, and recognized that they could use the display for more interesting tasks. By 1949, the display was considered to be an important element of the overall machine, albeit one with a limited, specific role to play, as this internal report indicates:

> The display equipment now in use with WWI is intended primarily for demonstration purposes. It gives a qualitative picture of solutions to problems set up in test storage, and it illustrates a type of output device that can be used when data are desired in graphical rather than numerical form (Servomechanisms Laboratory, Massachusetts Institute of Technology, 1949, p. 29).

Following Van Leeuwen's framework, this passage is important as it reflects the evolving context within which the electronic display was embedded. It discloses the fact that Whirlwind's engineers were beginning to experiment more freely with such displays. It was still not considered to be an essential piece of equipment, so such experimentation carried few risks. This context allowed for innovations such as the "Bouncing Ball" program, arguably the first application that truly showed off the capabilities of the CRT-equipped computer. Bouncing Ball was simply a program that could solve a specific set of differential equations, but, working with the display, it used these solutions to present an animation of sorts. A "ball" – really just a single point on the display – would appear near the top-left corner of the screen. As it moved from left to right, it would "fall" – that is, move vertically down the screen – until it hit a horizontal line, at which point it would "bounce" and move vertically up the screen. The end result was "a series of parabolas of decreasing height" that traced the movement of the ball/pixel (Pias, 2006, p. 169).

The experimentation with Bouncing Ball did not end there, however. As Taylor explains it, the program became much more intriguing when an interactive component was incorporated:

> A little later [Bouncing Ball developers] Adams and Gilmore decided to make the first computer game, and this was also in '49. This is a more interesting display. You see that the bouncing ball finds a hole in the floor and the trick was to set the frequency such that you hit the hole in the floor. This kept a lot of people interested for quite a while and it was clear that man-machine interaction was here to stay. Anyone could turn the frequency-knobs (Norman, 1989, p. 21; see also figure 1).

While his claim that this was the "first computer game" is debatable (though not necessarily false), Bouncing Ball provided a means for players to interact with the program, with the display serving as a sort of medium. Yet the display only gave players a snapshot of the work that was being performed by the computer to determine the ball's trajectory; the plotting of the ball's trajectory was merely the end product of this work. Player agency was therefore limited in the sense that they were only presented with a portion of the information they needed to "win" the game.

Moving a little further ahead in time to 1963, MIT was the site of one of the most innovative applications of the CRT monitor – Sketchpad, an interactive drawing and design program developed by PhD student Ivan Sutherland. To use the opening line of his dissertation introduction, Sutherland claims that Sketchpad "makes it possible for a man and a computer to converse rapidly through the medium of line drawings" (Sutherland, 1963, p. 1). To put this more technically, Sketchpad enables its users to interact directly with a CRT display via a "light pen" to produce drawings and diagrams. Despite its name, the program did not let users draw freehand – rather, users would use the light pen to pinpoint the vertices of a particular shape, and the program would then construct the shape using line segments. Functionality to allow circles and curves was also included, and the program also allowed for easy replication of common elements (Sutherland, 1963).

The impact of Sketchpad on the history of computer software is difficult to overstate. It is generally recognized as the forerunner of virtually all computer-assisted drawing software in existence, and is often credited as the inspiration for the graphical user interface, as is credited with providing "fundamental work on iconic representations, object-oriented techniques, constraints, interaction techniques, and approaches to animation" (Grudin, 2006, p. 45). For our purposes, it is also worthwhile to know that Sketchpad was developed at MIT's Lincoln Laboratories, a computer technology lab that was built out of, and as a direct result of, the Whirlwind project. It should come as no surprise, then, that it was here that the electronic display was put to such innovative purposes.

In addition to such accolades, Sketchpad also played a critical role in shaping discourses around the electronic display and pixel grid that are still with us today. Sutherland presented his program as a means to "converse" with a computer, a term suggesting direct, and seemingly equitable, communication between users and computing systems. This notion persists in studies of Sketchpad and its influence: Manovich, for example, states that "with Sketchpad, a human operator could create graphics directly on a computer screen by touching the screen with a light pen" (Manovich, 2001, p. 102). Myers (1998) writes that "the now ubiquitous direct manipulation interface, where visible objects on the screen are directly manipulated with a pointing device, was first demonstrated by Ivan Sutherland in Sketchpad" (p. 45). Such praise is not exactly inaccurate, but it does obscure somewhat the complex nature of screen-based computer interactivity.

To understand what is really going on here, we have to examine the computer display within its full context. Manovich (2001) actually hints at the true heart of the matter when he states the following:

> Sketchpad exemplified a new paradigm of interacting with computers: By changing something on the screen, the operator changed something in the computer's memory. The real-time screen became interactive (p. 102).

While he continues to employ the concept of direct interaction (here expressed as "real-time" interaction), Manovich also makes the key observation that these interactions actually involve the manipulation of a computer's "memory." While users interact with Sketchpad via the light pen and screen, and the computer "responds" to these interactions via the same screen, there is also a great deal of work going on within the system that remains largely invisible to the user. The Sketchpad program is always running in the background, waiting for user input to arrive via the light pen. Sketchpad's code governs its functionality in very specific ways. Despite all appearances, users do not have total freedom to draw and sketch as they please. Rather, they must obey the rules set out by the program in order to get anything to appear on the screen. If these rules are not followed exactly, the result will not be what the user had intended.

This all may seem somewhat obvious for those of us living in an age in which all manner of information is produced in controlled digital environments (via word processor, graphics editor, and database, among other tools), but that is only because we implicitly accept the limited semiotic potential afforded to the technologies we use. We know generally what the electronic displays that we use are capable of rendering, but we do not often consider the wider context in which these capabilities are enabled, while others are suppressed. While working within more familiar software environments – for example, a modern graphics editor such as Adobe Photoshop, or any Microsoft Office application – we are generally allowed to manipulate specific sets of data, but little else.

It is worth bringing some technical language into this discussion. While object-oriented programming and related innovations have complicated matters, it is still reasonable enough to conceive of most computer programs as consisting of two basic elements: data structures, and algorithms. Borrowing from a classic textbook on the subject, a data structure can be defined as a means by which to "store and organize data in order to facilitate access and modifications," while an algorithm is "any well-defined computational procedure that takes some value, or set of values [i.e. structured data], as *input* and produces some value, or set of values, as *output*" (Cormen *et al.*, 2009, pp. 1, 9; emphasis in original). Manovich (2001) claims that, in computer programming, "the world is reduced to two kinds of software objects that are complementary to each other – data structures and algorithms" (p. 223). This is a rather bold statement – in truth, the data structures and algorithms model is but one of many possible theoretical configurations. But Manovich's statement makes clear that it is the model that has come to predominate in modern computing.

The data structures and algorithms paradigm is not value-neutral, nor is it a passive construct. Rather, it imposes a very particular conceptual model which helped to give rise to many important programming languages, such as Pascal, C, C++, and Java[2].

This paradigm, while generally quite useful, also provides a near-perfect mechanism by which to separate information intended for the user – that would be the data embedded within data structure – and information that will remain hidden – that would be the algorithms which process data and keep the program going. While most programs generally share only a portion of the available data, it is only in very rare cases that the algorithms are similarly exposed. The screen, as discussed earlier, mediates and normalizes these relationships, though in a way that balances agency in favor of the computer[3]. While the user naturally has some control over what goes on the screen, they may only act on this information via the affordances provided by whatever software is running on the machine.

This is not the end of the story, however. While the electronic display allows only for limited interaction with the computer, it is generally thought about and talked about as a resource that allows for "direct" communication with computer systems. This discourse has remained remarkably consistent over the years, and generally places an emphasis on data. The operating manual for the IBM 2250 Display Unit, for example, claims that the display gives the user "direct and rapid access to stored data which can be scanned visually, selected, processed, modified, and redisplayed in alphameric [sic] and graphic representation" (IBM Systems Reference Library, 1971, p. 5). In an online advertisement for the high-resolution "Retina display" available on the iPad (beginning with the third iteration), Apple states the following: "pick up the iPad with Retina display and suddenly, it's clear. You're actually touching your photos, reading a book, playing the piano. Nothing comes between you and what you love[4]." These statements discursively define data and users, and the interactions between them, as the foundational elements of computing. Yet the user here is relegated to the role of input "producer," feeding data into algorithms so it may be processed and output. The nature of this role is obscured by texts that serve to define, legitimize, and normalize the electronic display as a semiotic resource.

Analysis

It is worth pausing for a moment to inventory our findings. As indicated at the beginning of this case study, we have focussed almost exclusively on one type semiotic of resource: the electronic display, with the pixel grid serving as the primary mechanism by which digital computers produce output on the screen. We noted the ubiquity of the screen in modern digital devices, and inquired as to how this relationship was first established. As part of a larger research effort, I highlighted those displays that I felt were particularly important resources. Taking in the entire history of the display as a whole, we can connect the modern electronic screen with its functional and conceptual antecedents. One of the advantages of using a social semiotics approach here is that we have a significant degree of flexibility with respect to scale. Rather than getting lost in the details of a specific display or computer system, we can maintain a high-level analysis as resources emerge and evolve over the course of several decades.

As already discussed above, tracing the history of the electronic display from a purely technological perspective will not do us much good. We also need information about the contexts within which these early displays were embedded. Here is where Van Leeuwen's second practice comes into play. By studying the extant materials of the time, we were able to determine that the first displays were initially considered to be of little value beyond assisting in diagnostic exercises. The display was an "ancillary" device, and it seems likely that its marginalization allowed it to become a site for experimental programming. Its value as a platform for interactivity was arguably not fully understood until Sutherland developed Sketchpad. At this point, however, the conversations around the display shifted rapidly, so that it was suddenly recast as something of an honest broker, presenting users with pure, unvarnished data, and information. This role has more or less survived to the present day.

It is worth emphasizing once more how the social semiotic approach to this history allowed us to gain such important insights. The first advantage it offers is that it allows for any entity or object to act as a semiotic resource. It then provided the means to treat semiotic resources as platforms for symbolic meaning, but from a subjective, contextual perspective, so issues such as objectivity and essentialism were sidestepped. Finally, since many of its proponents were previously involved in critical linguistic work, the social semiotics model includes a sizeable toolbox of critical methodologies and techniques.

LOP

Now that we have gained such valuable insights into how electronic displays act as semiotic resources, it is time to move to Van Leeuwen's third practice: the "discovery and development of new semiotic resources." Is it possible to develop new resources – either hardware of software – that help to overcome the limitations of the electronic display? To narrow our focus to something more manageable, let us focus here solely on search-based applications. This would include modern OPACs, article databases, web search engines, and similar tools. These applications allow users to enter search terms, send search "requests" to computer systems, and read the "results" of a search from an electronic display (and, when relevant, to connect to web sites and/or electronic documents). While the output data are visible, the actual algorithms used in these searches remain hidden. The display once again serves to legitimize and normalize the user's role as a simple data creator.

How may this system be improved upon? Perhaps the user should be given increased access to the algorithmic code by which search functions are executed; this is generally the approach taken by most open-source software (OSS). If the user could manipulate onscreen the code that directed how a search was conducted, then they could, possibly, customize this process to better serve their needs. Programmers have been using displays for such purposes for many years, of course. The problem here is that many end users – or perhaps most end users – are not programmers, while the typical search application is extremely complex. If users were provided with source code, then, they might simply be overwhelmed by the level of technical detail.

An alternative, then, might be something that allows for at least some of the customization offered in the OSS approach, but using a development system that may be learned and used more quickly. Interestingly, an emerging field within computer science knows as LOP addresses similar concerns. LOP is an approach to the development of programming languages that focusses on using short, simple constructions with which to complete complex tasks, and has arisen as existing programming languages and software have grown increasingly complex. As explained by Dmitriev (2004), one of LOP's major advocates, "programmers today have very restricted freedom. Sure, I can do anything on a computer, but some things take me years of effort when it should take much less time. Something is wrong here" (p. 1). LOP attempts to address these issues by focussing on very specific problems, and then developing simple, or "high-level" languages that can be used to execute complex actions specific to such problems. As Ward, another key proponent of LOP, explains it, "with a problem-specific very high level language, a few lines of code are sufficient to implement highly complex functions" (Ward, 1994, p. 6).

It is not overly difficult to imagine how such an approach might benefit users interacting with search applications. Searching is a very specific problem, particularly when you consider one specific application, such as a particular online catalogue or search engine. With the right LOP-influenced language, an application interface could be altered to allow users to build their own search algorithms, and then feed those into the search system. Such an approach, in fact, could alter the very conception of the passive "user," giving individuals the means to participate in and actively modify the very mechanisms that govern the operation of software applications. Such active users could come to see the electronic display as a much more valuable resource in terms of enabling interactions with computer systems, and they could therefore engage more meaningfully with the programs that they use on a regular basis.

Conclusions

This case study was a cursory attempt to cover the major aspects of a social semiotic analysis as defined by Van Leeuwen, and could be expanded upon on a number of fronts. For example, while interactivity was a major theme here, the means by which users are able input data into a given computer system was rarely mentioned. The light pen, which arrives on the scene at a surprisingly early date, is one such tool, but mouse (or touchpad) and keyboard are now more familiar devices. Direct interaction with the screen, however, has made a comeback, with popular consumer products such as smart phones and tablets leading the way. Such devices could easily be treated as semiotic resources, and might possibly exert significant influence with respect to how users perceive information displayed on their screens. In the iPad ad copy discussed earlier, the act of "touching" the screen was emphasized. The mouse, meanwhile, serves to emphasize the notion of the screen as a virtual "desktop," particularly if the user is sliding one across their actual desktop. More research would be necessary to expand upon these observations, but such a project could prove to be a valuable compliment to the work on the electronic display that I have showcased here.

In any event, social semiotics is still a relatively new field, with a small core of key adherents and advocates. The ideas and problems that it concerns itself with, however, are in line with those of other critical approaches that are more familiar. A key advantage of social semiotic research is the ease by which it integrates a multitude of expressive channels – text, images, sound, etc. – and considers them as parts of a whole, multimodal, meaning-making system. Kress and Van Leeuwen, in particular, have been moving in this direction, but hopefully many more scholars will follow suit, adding their own insights into the larger project. Much work remains to be done with respect to the theoretical side of social semiotics, which is perhaps one of the main reasons why it is advantageous for LIS and IS scholars to get involved now. Social semiotics as a field, in turn, would greatly benefit from the insights provided by such scholars.

Notes

1. In an effort to keep the jargon to a minimum, I will usually refer to the pixel grid display as simply a "display" or "screen" over the course of this analysis.
2. There are other languages, such as Lisp and Prolog, for which this dichotomization would be problematic. For the sake of space and clarity I will not discuss such languages in this paper, but they are worth mentioning because they stand in contrast to the languages I will focus on here.

3. Computer have used other output devices over the years; printers and teletypes served as the primary means of output for a wide variety of machines before the electronic display became widespread. These devices could also be framed and analyzed as semiotic resources, but this work is beyond the scope of the present discussion.
4. This ad copy has actually started to disappear, and can only be found now on the web sites of third-party vendors. A quick web search on the text should turn up some results, or else try www.macworld.com/product/1350151/apple-ipad-with-retina-display-wi-fi-16gb-black.html. I have kept it here because it is such an ideal exemplar.

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