The Language Of Images: A Visual Rhetorical Theory of Human-Computer Interface Design

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ABSTRACT

Human–Computer interface(HCI) has long been considered a stumbling block to information system usage. Researchers suggest that some of the reasons among many are: Users are often required to interpret, understand, and manipulate an Information System (IS) through an often complex and occasionally mystifying visual boundary; Basic design heuristics suffer from a common flaw in that they are often relevant to a specific context; Finally, inaccuracies due to incomplete, ambiguous, or meaningless representations of real-world objects can significantly decrease the quality of the communication. It is our belief that a generalized theory of HCI design that treats the user interface as a communication medium between the designer and the users will lead to more effective visual interfaces. In this paper, we introduce one such visual language model based on the premise that the HCI design can be thought of as a communication of purpose and intent between an HCI designer and the end-user through a visual symbolic language. A case is made for the use of Speech Act Theory (SAT) as the conceptual foundation for HCI design.

KEYWORDS
Human-Computer Interaction, HCI, Theory Development, Visual Design, Visual Rhetoric, Speech Act Theory

INTRODUCTION

By now, all people who have used a computer have likely used it for more than one task, anything from accessing the Internet for email or information, to managing the operations of businesses, to simply composing a letter. Without too much effort, each case could be generalized to an intentful user interacting with computer technology through the medium of a user interface, such as the visual user interfaces of Microsoft Internet Explorer, SAP, or Microsoft WORD. Human-Computer Interface (HCI) designers use their experience and design tools to create representations that allow users to interact with computer technology in order to accomplish some task. Users manipulate these interfaces as a means of interacting with the capabilities offered by a particular technology. The challenge of designing the user interface for an information system (IS) could therefore be thought of as attempting to create a rich, highly functional visual interface that the intended audience understands in order to use it in accomplishing some task. In this respect, HCI design could be regarded as a communication process where the designer attempts to communicate the capabilities of the IS, such as the ability to read email, to the user through the user interface (UI).

The human-computer interface has been considered a stumbling block to information system (IS) use, typically because individuals are required to interpret, understand, and manipulate the IS through an often complex and occasionally mystifying visual boundary (Barber, 1998; Raskin, 1997; Ahuja, 2000). HCI designers are aided in their work through the use of visual design rules and

guidelines, also referred to as design heuristics, which are often created and applied to develop a UI that users are likely to understand and use (Neilsen & Del Galdo 1996; Ahuja, 2000; Tognazzine 1998). However, most design heuristics suffer from a common flaw in that they are often relevant to a specific context, such as web design for a North American audience. Being contextually-based, the ability to understand and modify heuristics across contexts could be seen as difficult and time consuming for the designer, leading to communication difficulties between the designer and user. All things being equal, developing a generalized theory of HCI design that transcends design heuristics and treats the UI as a communication medium between designers and users should lead to more effective visual interfaces.

The purpose of this paper is to introduce a visual language model for HCI design that builds on the premise that HCI design can be thought of as communication of purpose and intent between an HCI designer and the end-user through a visual symbolic language. As a visual language it should also have rules of grammar and structure, no different from a verbal language. Speech Act Theory (SAT) will be used as the foundation to structure the visual language. SAT has normally been considered to be a theory of verbal language, but as it will be explained later, there is no substantive reason why this must be so. Applying SAT in a non-verbal or symbolic domain leads to the development of a visual rhetorical model of HCI communication, where visual rhetoric is defined as the use of visual or symbolic language in communication and persuasion.

The paper proceeds as follows. First, the use of SAT in IS design is reviewed to illustrate how software engineering has previously benefited from the application of communication theory. Second, visual rhetorical communication is defined and developed to demonstrate its relationship to current HCI design principles. Third, these concepts are then used to modify SAT to represent a visual rhetorical language theory applicable to HCI design. The paper concludes with a specific research agenda for refining and validating a visual rhetorical communication theory for HCI design.

THEORETICAL DEVELOPMENT

1. Language And Communication Models In IS Design:

IS designers and researchers regularly ground their work in highly structured modeling processes, such as entity relationship diagrams (ERD), dataflow diagrams (DFD) and object models (Lowgren, 1999; McMaster, 2001; Rosson, 1999). The benefit of following such an approach is typically described as an improved ability to accurately represent a problem domain, resulting in an IS design "that can be readily comprehended, quickly learned and reliably operated" by an individual (Lowgren, 1999, p14). Words such as 'representation', 'comprehension', and 'learning' exemplify how IS design could be considered a language process. As a linguistic process, one goal should therefore be the effective, or mutually understood, communication between designer and user (Slaughter, 1990).

A few researchers have gone even further and directly used linguistic theories in their work, most notably in data structures (Wand & Wang, 1996) and database design (Weber, 1996). Both Wand and Wang (1996) and Weber (1996) use rather innovative approaches in exploring the link between successful IS design and linguistic theory and deserve further examination.

Weber's paper asks whether the design grammars used in the creation of database schemas should differentiate between entities and attributes. He takes the position that "in regard to database design, entities and attributes are distinct real-world features because humans have learned or created mental models to understand the world where, for some reason, the distinction is important" (Weber, 1996, p139). Weber's paper focuses on the ability of popular database design tools, ERD and Object Oriented Modeling (OOM), to accurately represent the "real-world" features of a problem domain, *as it exists in the designer's mind*. In the process of creating a complete system, it becomes the designer or design team's responsibility to interpret and transform real-world features twice; first into a data structure or database design and then into a user interface design. In Weber's description, the IS designer can be seen as a 'translator' that works with her own understanding of the "real-world" as well as with mental models of a problem domain to translate and communicate those models to different audiences. Effective communication is dependent on the ability of both the design language and the grammar rules to represent the way designers and end users perceive the world.

Wand and Wang (1996) (referred to from this point on as 'W&W') go one step further and define a set of grammatical rules for a data structure design language. In doing so, they introduce the concept of representational quality and accuracy. W&W demonstrate how the application of language and grammar rules to data structure design assists in ensuring that an accurate message is conveyed. For example, inaccuracies due to incomplete, ambiguous, or meaningless representations of real-world objects can significantly decrease the quality of the communication act from the IS designer to the end user. W&W illustrate why grammatical rules are vital to enabling effective communication to occur between the designer and end user in the context of IS data structure design.

Taken together, the Weber and W&W papers point to the relationship of language and grammar principles to IS design. The communication rules embodied in these principles emphasize the view of IS design being a communication process between designers and intended audiences. As such, significant benefits in the way of increased robustness and generalizability is gained by developing and applying a theoretically sound linguistic theory approach. The purpose of the following section is to make a case for the use of SAT as the conceptual foundation for HCI design.

2. Speech Act Theory in IS Development

SAT is a descriptive linguistic theory, which states that words communicate meaning beyond their literal definitions and that meaning is imparted through the acts of using words, or speech acts. A speech act is defined as the use of language to make statements, give commands, ask questions, make promises, or other ways in which to communicate to an audience (Searle, 1969). SAT uses a hierarchical structure to explain the act of communicating. In a linguistic context, the lowest level of the hierarchy is words themselves, referred to as utterances. The next levels are propositional, illocutionary, and perlocutionary utterances, respectively. Table 1 defines the four levels.

Category	Definition
Utterances	An utterance is a spoken word or string of spoken words. At the simplest level, to utter is simply to say a word with no particular forethought or intention to communicate. *An utterance by itself has no particular meaning (cat fork orange)*
Propositional Utterances	A propositional utterance makes reference to or describes a real or imaginary object. Propositional utterances contain utterances *To make an utterance that contains a reference to something else (an orange cat)*
Illocutionary Utterances	An illocutionary utterance is spoken with the intention of making contact with a listener. Illocutionary utterances usually contain propositional utterances, (they make reference to things in the world), but it is their intentional nature that is most important *To make an utterance with the intention of interacting with the receiver (Is that your orange cat?)*
Perlocution-ary Utterances	A perlocutionary utterance attempts to persuade or influence behaviour *To make an utterance with the intention of changing or influencing the behaviour of the receiver (Please feed my orange cat)*

Table 1. Categories of Speech Acts
(Adapted from (Searle, 1969))

Speech Act Theory is a familiar theoretical foundation for IS design research (Janson, 1995; Kimbrough, 1997; Ulijn, 2001). Three reasons for its popularity may be its hierarchical structure, its broad acceptance, as well as the shortage of suitable alternative theories. SAT structures language into a hierarchy, a particularly useful attribute in areas of IS development such as data structure, database, and HCI design where large, complex, ordered arrangements are built from a variety of single elements (e.g. entities and attributes), which are meaningless on their own. SAT is also widely established in linguistics, philosophy, and MIS research, a testament to its wide applicability (Kimbrough, 1997). In addition, SAT has virtually no comparable contenders in terms of applicability to IS research, due largely to its capacity to structure language (Kimbrough, 1997). These three reasons, and principally robustness and generality, make SAT widely applicable in the context of IS design theory.

3. HCI Design as a Visual Language

The previous literature supports the applicability and use of linguistic theory in IS design, but also remains firmly fixed in verbal linguistic theory. Modern user interface design, however, relies heavily on a 'visual metaphor' model (Raskin, 1997) and is often anything but verbal. If individuals learn and respond to visual language exactly as they do the verbal then this issue would be moot and the work of researchers such as W&W and Weber could be directly relied upon to develop a visual linguistic theory of HCI design. However, as past research into visual imagery and symbolic learning has shown, humans do in fact learn, interpret, and assign meaning in different ways between verbal and visual contexts (Scott, 1994), particularly when cultural norms and meanings are also considered (Barber, 1998).

4. Visual Language and Rhetoric

In the context of linguistic study, rhetoric is defined as the study of the effective use of language, particularly the specialized literary uses of language, such as figures of speech. As a theory of communication, Scott characterizes rhetoric as "an interpretive theory that frames a message as

an interested party's attempt to influence an audience" (Scott, 1994, p252). Scott builds on the previous work of the modern Rhetoricians Burke and Corbett to suggest that visual design could be considered a form of rhetorical communication if it had certain properties. These properties are the ability to represent "concepts, abstractions, actions, metaphors, and modifiers, such that they can be used in the invention of a complex argument" (Scott, 1994, p253). At this point it is interesting to note the similarities between Scott's definition of rhetorical communication and the arguments of Raskin ("metaphors") and W&W ("concepts" and "abstractions"). By demonstrating that visual elements can be regarded as a symbolic system of communication, Scott makes the connection between the verbal and visual structures of language.

Scott states that three necessary conditions for communication must exist for visual elements to be capable of communicating thoughts and ideas to an audience. Visual elements must be capable of: inventing a complex argument (capable of metaphor); sequentially guiding the argument through arrangement of the visual elements; and varying the argument by varying style or placement (capable of contextual meaning). These three conditions are echoed in a second paper on visual rhetoric where McQuarrie and Mick (1999) discuss a hierarchical visual rhetorical taxonomy with three levels. The first level consists of all figures or elements in a language where each element differs by degree of abstraction or metaphor. The second level differentiates rhetorical elements by type, either schemes (elements which form meaning through arrangement) or tropes (elements which form meaning through metaphor). At the highest level are rhetorical operations, which actually use the schemes and tropes in a setting. Both Scott's and McQuarrie and Mick's papers complement each other; both imply abstraction, arrangement, and delivery, concepts that are similar to the HCI design heuristics regarding artifact representation, artifact placement, and design consistency (Neilsen, & Del Galdo 1996; Tognazzine 1998). McQuarrie and Mick (1999) capture the lack of theoretical distinction between verbal and visual rhetoric when they state:

> *"The definition of rhetorical figures as templates independent of the specifics of individual expressions indicates that visual rhetorical figures ought to be possible. Nothing in the fundamental definition of a figure either requires a linguistic expression or precludes a visual expression" (McQuarrie and Mick 1999, p.39)*

Allowing that visual elements are capable of forming a complex and cohesive language, the next logical step would be to structure that language in a way that aids study.

Recall that the basic building blocks of SAT are the utterances, the words that comprise a language. The 'words' in a visual language are the myriad of individual visual elements in a UI. Applying SAT to incorporate visual elements enables the analogy of words to visual elements to be made. Successfully making this analogy provides the bridge connecting SAT to the visual rhetorical theories of Scott and McQuarrie and Mick, illustrated in table 2.

Speech Act Theory	**Scott (1996)**	**McQuarrie & Mick (1999)**	**HCI Examples**
Utterances (words)	Artifacts (visual elements)	All figures (level 1)	Colours, Shapes, Textual Elements
Propositional Utterances (representation)	Invention (metaphor)	Schemes and Tropes (level 2)	Icons (e.g. mailbox), Workspace illustrations (e.g. Taskbar, program "windows")

Illocutionary Utterances (communication of intent)	Arrangement (argument construction)	Rhetorical Operations (level 3)	Spatial, temporal, and cultural rules for interpreting visual objects (e.g. reading left to right, top to bottom, cultural meanings of colour)
Perlocutionary Utterances (intention to interact)	Delivery (argument delivery)	*(rhetorical delivery is not expressly discussed, only construction)*	The combination of visual elements in such a way as to invite interaction (e.g. flashing a red stop sign icon to signal immediate danger)

Table 2. Comparison of Speech Act Theory to Visual Rhetoric and HCI Elements

Drawing on the similarities between SAT and visual language as illustrated in Table 2, the model of a proposed visual rhetorical language can be developed. Figure 1 demonstrates the model.

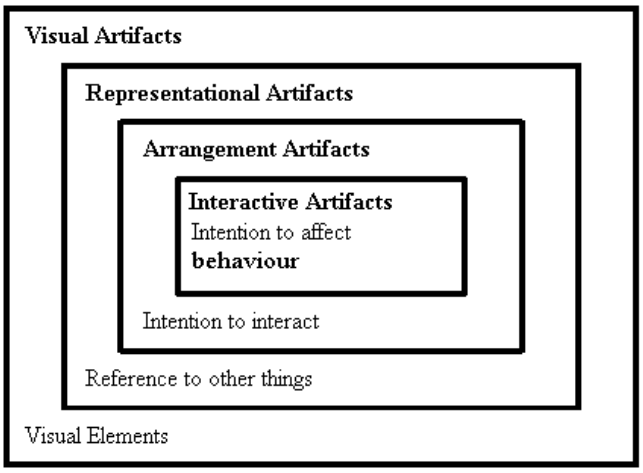

Figure 1. Rhetorical Model of Visual Language

5. Theory of Visual HCI Design

The rhetorical model of visual language (RMVL) has a hierarchical structure where each level above the first builds on those below it. Like SAT, RMVL begins with discrete elements, and then adds rules governing how to combine, place, and present these elements to create a communication channel to users. These levels, made up of the visual, representational, arrangement, and interface artifacts, embody both the UI designer's visual palette and the design heuristics that govern their use. Each of the four levels is described in the following sections.

The base level of the RMVL is the visual artifact. In the context of this discussion, these visual elements are the shapes, colours, texts elements, fonts, etc. that an HCI designer may use to construct icons or other more complex representations. Individually and without a context, visual elements are not capable of communicating to an audience. It is not until an arrangement of visual elements are made that a reference to some 'other thing' is made. For example, the first HCI designers of North American email programs combined grey, black, brown, and red shapes into the representation of a North American mailbox, a representation that became popular and appeared in many different interfaces. In this example the designers combined visual elements to create a representation, or reference, to an external object that obviously had no direct physical relationship to a computer. This is the essence of a metaphor, captured in the RMVL as representational artifacts.

Creating an icon is not enough for communication between the HCI designer and an audience to occur, there must also be the invitation, or intention, to interact. Expanding the email example, an icon of a mailbox may have meaning in that an audience may be able to recognize, or define, what it is (or may not), but by itself the picture of a mailbox does not communicate action until an audience learns or reasons the intentions of the designer, in this case that clicking on a mailbox icon accesses an email program. It is at this level in the RMVL that communication between the designer and audience could occur, and requires a belief on the designer's part that an audience will interpret a mailbox icon to mean access to email, and a belief on an audience's part that designers will indicate access to email through use of a mailbox metaphor. In SAT, this mutual understanding corresponds to illocutionary utterances, acts which must be mutually understood through reference to beliefs and intentions shared by the designer and the audience. Thus,

effective communication is based on mutual understanding of some problem domain, represented in RMVL's third level by interpretation artifacts. Interpretation artifacts are the shared meanings, interpretations, and beliefs of HCI designers and their audiences, for example that a mailbox icon is related to receiving email or that an image of a red stop sign with an exclamation point is related to some important warning. As such, interpretation artifacts are obtained through learning processes.

The highest levels of the RMVL are the interactive artifacts, which attempt to persuade or influence interactive behaviour. HCI designers have evolved ad-hoc standards for arranging the visual artifacts within an HCI in attempts to suggest, or influence, user behaviour (Pressman, 2001). These standards guide the placement, flow, and 'hiding rules' of the visual design, examples of which are the 'standard' placement of high-level menu items in a Microsoft Windows application ('File' .. 'Edit' .. 'View' .. etc.), the ordering of multiple screens (MS Excel worksheets being default numbered 'Sheet 1' .. 'Sheet 2' .. 'Sheet 3' from left to right), or the cascading of hidden option selections on a website interface (hiding the 'Local Weather' selection under the 'Weather' icon option along the (normally right-hand) side of a news website). The interpretations of the arrangements are learned, similar to interpretive artifacts. However, while the interpretive artifacts are generally learned through direct experience with either the representational artifact or the real-world object that it represents (such as a mailbox), interactive artifacts are learned through direct experience as well as indirect and unrelated communication experiences, for example that English is read from left to right or that local weather is a 'sub-set' of national weather. Interaction artifacts are the shared understandings and meanings of the rules that imply order and hierarchy, such as the script direction of reading, relationships between sets and sub-sets, or groupings of visual artifacts that logically belong together. Interaction artifacts influence behaviour by suggesting the order, hierarchy, grouping, or categorization of interaction. It is at this level that interactive communication can occur, where users are presented with interfaces that invite interaction that involves some type of organization.

6. An Example of Applying the RMVL

Building on the linguistic foundation of RMVL leads to an interesting proposition. If effective HCI design uses a language, then it follows from linguistic theory that the learning of that language should be culturally bound (Lumsden, 1989; Meltzoff, 1999; Shanker, 2001). In other words, the interpretation of meaning and effective use of a user interface is limited by culture and directly impacts user performance and usability. In terms of RMVL, this represents a potential breakdown between representational and interpretive levels, where the intentions of the designer are not transferred to the user, leading to less effective communication. This proposition has received early empirical support in the IS design literature (Barber, 1998) but has yet to be explained in theoretical terms.

The proposition that user interface usability is culturally bound has significant impacts for HCI design practice, particularly in a web-enabled world made more accessible through the development of the Internet. For example, an interesting question at the macro-cultural level would be whether a universally usable website interface exists?

In the web-enabled world, any assumption that designers and their intended audience share the same understanding of the meanings of visual, representational, arrangement, or interactive artifacts cannot be made. As previous researchers have shown, different cultures assign vastly different meanings to both visual artifacts such as colour, font, and shapes as well as representational artifacts such as the North American mailbox, a clock, or a flag. In this example miscommunication can occur at several levels, such as between visual and representational artifacts (a green clock may have different meaning in Egypt vs. France), as well as between representational and interpretation artifacts (the ordered arrangement of icons may be interpreted differently in Israel vs. Canada). At issue is the possibility that a sub-set of visual, representational, and interpretive artifacts exists that could create universal interactive artifacts. If such a set were to exist, RMVL could be used to structure a universal design language, for example to design non-country-specific Internet websites. The alternative is to accept that distinct cultures require distinct interfaces and that the communication potential of the Internet is limited by cultural boundaries, an assertion that could also be grounded in RMVL.

A visual rhetorical model of the language of user interface design offers the potential to provide a theoretical basis for HCI design. Basing such a model on well-established linguistic theory, in this case SAT, creates a strong preliminary argument for theoretical validity. A research program directed at refining and further validating RMVL is required as the next step in theory development.

FUTURE RESEARCH

A research agenda for confirming the validity of the theory described in this paper is required. In their work on visual rhetoric, McQuarie and Mick (1999) describe a multi-method approach to research that is adapted for use here. Theory validation should confirm four assumptions underlying RMVL: that a UI can be reliably decomposed into the four categories of visual artifacts; different artifacts reliably convey meaning as either metaphor or command; the arrangement of these artifacts impacts understanding

and usability; and that communication and understanding is carried from designer to user through the grammar and language of UI design. Four specific research methods are ideally suited for validating RMVL: archival, text-interpretive, experimental, and reader-response. Each method is briefly described below.

Archival research methods perform secondary analysis on previously existing records, documents, or other objects (Robson, 1999). An example of archival research would be to assemble samples of UIs and classify/verify the visual artifacts (common patterns of colour, shape, font, etc.), representational artifacts (common visual element metaphors), arrangement artifacts (repeated patterns of representational artifact alignment and grouping), as well as interactive artifacts (arrangement patterns that reliably invoke user action) (see (Barber, 1998) for example). This technique could be used to validate the hierarchical relationships in the model.

Text-interpretive methods are known by names such as semiotics, hermeneutics, and content analysis. These methods attempt to understand the integrative meaning of an object or 'whole' by deconstructing and examining the parts and relating them back to the larger whole, sometimes in an iterative fashion, until holistic meaning is achieved. Text-interpretive methodologies are particularly appropriate for studying the ability of users to understand the intended relationships between the four artifact types, as well as the designer's ability to use them in constructing a meaningful UI.

Experimental methods involve the strict measurement of the effect of one variable on a second through the assignment of research participants to different conditions under the control of the researcher (Robson, 1999). In user interface design research, this method could involve varying either presence or absence of RMVL-based visual and grammatical language rules in the development process of an HCI and then measuring functionality and usability metrics as reported by the research participants. This methodology could be used to validate all four levels within RMVL but would be ideally suited to testing interpretation artifacts, for example, testing the associations between representational artifacts and the actions they are intended to produce.

Reader-response refers to the method of showing a user interface to a research participant, or letting him use it for a period of time, then interactively discussing the experience with them. This methodological style is particularly suited to examining the interaction of functionality and complexity as well as culture on visual interface literacy. One such example would involve having research participants view website interfaces from a selection of sub-cultural sites (sports, hobbies) and cultural sites (national governments), use these sites for directed and undirected tasks, and then take part in after-contact interviews to discuss impressions such as understanding and usability.

CONCLUSION

Language and grammar structures evolve over time. RMVL provides the framework around which the language and grammar of HCI design can be structured. The ability to represent visual user interface design practices and design heuristics at the conceptual level can be accomplished by grounding HCI design in strong theory. The result could lead to better interface designs as well as the ability to achieve new design innovations at a faster rate as opposed to learning from and refining contextually limited design heuristics. Further validating and applying the rhetorical model of visual language as it applies to user interface design offers this potential.

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