User-System Interface Design

An Organisational Semiotic Perspective

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Abstract: Many design principles relating to the interface between computer-based systems and their human users derive from human factors (HF) considerations. In the first part of this paper, it is shown how some of the most important HF-based principles may be fitted into the Organisational Semiotic framework proposed by Ronald Stamper. In the second part of the paper, the benefit of this integration is demonstrated, by showing how a semiotic perspective can lead to a more analytical understanding of the implications of the design principles concerned.

Key words: Design, User interface, Computer, Organisational semiotics

1. INTRODUCTION

The design of the interaction between computer-based systems and their human users has been discussed in many places; see, for example, Dix et al. (1998), Lansdale and Ormerod (1994), Newman and Lamming (1995), Preece et al. (1994), Shneiderman (1998) and Sutcliffe (1995). Generally, the design of the user-system interface (or human-computer interface) has been approached from a Human Factors (HF) point of view. This approach has led to great improvements in the usability of systems, and has become an integral and valuable part of the process of user-system interface design (USID).

However, other perspectives on USID are also possible. More specifically, a semiotic approach is feasible, as shown notably by Andersen (1997), to whose work we shall return below. See also Jorna and van Heusden (1996) and Nadin (1988).

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The present paper, likewise, adopts a semiotic perspective. Its purpose is to consider how some important principles of USID relate to the framework of Organisational Semiotics (OS). In particular, it will focus on the six-level model proposed by Stamper (1991), and discussed further in Connolly (2000). Its central concern will be with the following two questions. Firstly, how do existing USID principles fit into the OS framework? (The benefit of answering this question will be that designers working within the OS-based approach should then find it more straightforward to incorporate accepted USID guidelines into the systems that they produce.) Secondly, what insights are offered by OS that may help to deepen our theoretical and practical appreciation of established USID principles? (The benefit of finding answers to this question will be to make possible a degree of refinement to our understanding of the process of USID.)

In OS theory a nested hierarchy of information systems is recognised, known metaphorically as the 'organisational onion'; see Stamper (1996: 365-367) and Liu (2000: 109-111). The outermost information system is the informal one, based on natural language (manifested, for instance, through informative conversations) and not involving explicit analysis-methods. Embedded within this is the formal information system, in which, for certain purposes, standardised documents (such as forms) are employed that are not necessarily comprehended fully by everyone who uses them. Nested within the bureaucratic formal information system is the technical information system, or in other words the IT system, which automates at least part of the formal information system and is available to support part of the informal information system as well. The principles of USID generally pertain directly to the design of the IT system. However, insofar as they stem from HF considerations, they are also connected to the psychological and social characteristics of the human users who are the agents at the higher levels of the nested hierarchy. In this way they are implicated in the connection among the three organisational levels. Consequently, they are of inherent interest from the point of view of the OS enterprise.

2. SOME PRINCIPLES OF USID

The literature on USID is far too extensive to survey within a short paper like this. What we shall do instead is to take one well-known example of the writings on USID, namely Shneiderman (1998), and use this as a source of guidance on USID principles. While we shall not be able to encompass the whole spectrum of USID guidelines, nevertheless we shall cover a sufficient range to allow us to address the two questions identified in the Introduction.

Shneiderman (1998: 74-75) gives eight 'golden rules' for the design of user-system interfaces. These concern:

1)
a) The maintenance of consistency in the interface.
b) The availability of shortcuts for the benefit of the frequent user.
c) The provision of feedback from system to user.
d) The structuring of user-system dialogues into exchanges, each of which has a clear opening and closure.
e) The elimination of errors or, failing that, a straightforward means of recovery from them.
f) The facilitation of the reversal (or undoing) of user actions.
g) The fostering in the user of the sensation of being in ultimate control of the interaction.
h) The avoidance of overloading the user's short-term memory.

Shneiderman (1998: 80-83) also offers more detailed guidelines for data entry and display. These echo the 'golden rules' and apply them to the particulars of the input and output processes, respectively. For instance, the principle of consistency is interpreted within the data entry guidelines as a call for regularity in the sequences of actions involved, the delimiters and abbreviations employed, and so forth. As regards the display guidelines, the same principle requires standardisation in terms of format, nomenclature, abbreviations, typographical conventions, use of colour, and so on.

Shneiderman's advice on the presentation of output is, in fact, divided into two parts:

2)
a) The organisation of the system's display.
b) The focussing of the user's attention.

Matters of format, nomenclature and so forth pertain to the organisation of the display. On the other hand, means of attracting attention include higher intensity, larger size, blinking, and such like.

Shneiderman (1998: 61-67) also presents a theory of design which is embodied in his Object-Action Interface (OAI) Model. Central to his model is a recognition of the following:

3)
a) Task objects.
b) Task actions.
c) Interface objects.

d) Interface actions.

An example of a possible task is the composition of a letter, on headed notepaper, inviting a job applicant to attend an interview. Here the object is the letter and the action is the writing process. If a computer is used to produce the letter, then the writer (or someone else delegated with the task) will need to create a file and type in the text. The file and text are objects used in interacting with the system, and therefore constitute interface objects. Likewise, the processes in which they are involved, namely file-creation and text-typing, are interface actions.

Frequently we find that objects and actions of either type are hierarchical in nature. For instance, composing a letter (or typing it into a word-processing application) can be broken down into smaller and smaller steps, ultimately focussing upon the insertion of each individual character. Similarly the resulting missive (or the text of the relevant electronic document in its computer-file) can be analysed into its constituent sentences, phrases, and so on, right down as far as the individual characters.

The OAI Model is applied by Shneiderman (1998: 567-580) to the design and evaluation of web sites. In this scenario the designer needs to identify various task objects and actions. For example, in the case of an e-commerce site, the objects could include a set of items for sale and the actions would then include the placement of orders. With regard to the interface, the objects would take the form of items such as icons or buttons, these functioning as metaphors for the task objects or actions. For instance, if books are on sale, then each book could be represented on screen by a miniature picture of its front cover, while the action of placing an order could be facilitated by means of a suitably labelled button. The metaphorical "pressing" (in actual practice, the clicking) of this button would constitute an interface action, and the button would, by virtue of its affordance, offer a handle for that action. Moreover, the objects and actions often form hierarchies. For instance, an item for sale will usually be one component of the total stock on offer, so that the former would be subordinate to the latter in a part-whole hierarchy. Evaluation of the web site could then include an assessment of the design of objects such as buttons (for instance, are their labels legible and unambiguous, and do the users of the site find buttons to be an effective metaphor for actions, or are they baffled by them?) and actions (for example, are they secure, and can they be easily undone?). Furthermore, where objects or actions form hierarchies, this may well have design implications. For instance, a set of alternative actions may be represented by the metaphor of radio buttons, in which case the grouping of the buttons (as components of a single part-whole hierarchy) can be evaluated (for instance, are they suitable spaced and are they clearly

distinguishable from other parts of the display?). Clearly, this approach relates closely to the general principles of USID.

3. THE SEMIOTIC PERSPECTIVE

The six semiotic levels in the OS model are as follows, starting form the most concrete:

4)
a) Physical world.
b) Empirics (concerned with physically detectable patterns).
c) Syntactics (concerned with abstract form or structure).
d) Semantics (concerned with the meanings encoded by formal elements and/or structures).
e) Pragmatics (concerned with the deployment of meaningful elements and/or structures in furtherance of the goals of communication).
f) Social world.

How, then, do the principles of USID identified above fit into this framework?

Because the principles of USID, as embodied (for instance) in Shneiderman's 'golden rules', are all centred around the facilitation of an effective process of communication between user and system, it is evident that they are directly related to the level of pragmatics. Let us expand on this statement.

Consistency within the interface is intended to reduce the scope for confusion, and therefore to support efficient interaction. Feedback, likewise, is supposed to help the user maintain a clear idea of what is happening. Shortcuts have the potential to save time, and thus aid efficiency; and the same is true of easy error-recovery and straightforward reversal of the user's actions. Taking into account users' psychological propensities, such as the desire to feel in control of events, to know when a particular part of a dialogue has been successfully concluded and to be presented with manageable units of information at a time, is also helpful to the successful conduct of communicative interaction, in that it makes allowance for the audience of the system-user communication, this being an important factor in communicative effectiveness.

However, the impact of the principles of USID are felt not only at the pragmatic level of semiotics but at other levels as well. For instance, the organisation of the system's display involves the level of syntactics. To take an example, choices of nomenclature, (such as whether or not to use

technical terminology in messages from the system to the user) constitute options among formal elements (in this case, words). As for the devices for gaining the user's attention, these may well involve the level of empirics, as is the case with effects such as blinking, which is based on a time-varying pattern in the physical display of an information-bearing element. Of course, the pragmatic level is implicated as well, in that the success of the communication could be impeded by inappropriate choice of vocabulary or by the failure of the user to notice an important piece of information.

The interface objects in Shneiderman's OAI model are, from the semiotic point of view, signs which generally denote the corresponding task objects. Being signs, they are amenable to treatment in terms of the six-level framework. Taking as an example the 'Send' button in an email system, this may be described in the following way:

5)
a) Physical level:
   Group of pixels.
b) Empiric level:
   Visible shape.
c) Syntactical level:
   Icon capable of being distinguished from other icons and of being combined with other icons.
d) Semantic level:
   Carrier of meaning.
e) Pragmatic level:
   Instrument of user-system communication.
f) Social level:
   Tool to help the user accomplish an interpersonal action.

Looking more closely at the semantic level, we find several aspects of meaning at play here. First of all, as already implied, we see a relationship of denotation between the button icon and the task object, but because the object denoted is not an actual button but the (abstract) trigger for an action, it is a metaphorical rather than a literal kind of meaning that is involved. Moreover, inasmuch as the button icon acts as a handle for an interface action, its semantics are bound in with the semantics of the action concerned, so that the interface object comes to have a meaning-by-association with the related action and vice versa. Put differently, the affordances of the interface object, which enable it to act as a handle on the related action, may be regarded as connotations, which serve to bring to mind the action concerned. Furthermore, in addition to denotation, connotation and metaphor, we may also find other kinds of meaning exuding from interface objects. For

instance, labels attached to icons may have socially-oriented implications. The label 'OK', for example, is a relatively informal piece of English, and thus lends a comparatively informal tone to the interaction. Similarly, a label such as 'Please press to continue', which contains the politeness-marker 'Please', adds an extra touch of social meaning which would be absent if the politeness-marker were omitted. Whether the politeness-marker is really necessary is another matter; but if it is included then it contributes to the meaning of what is written and affects, in turn, the mood of the pragmatics of the interaction.

The idea of hierarchy, which is incorporated into Shneiderman's OAI model, is also very familiar in semiotics. Texts composed of language, images and music, or multimedia combinations of these, can all be analysed into components or constituents. Furthermore, signs can be classified in a hierarchical manner. The best-known typology is that of Peirce, in which signs are divided into the familiar trichotomy:

6)
a) Symbols.
b) Icons.
c) Indices.

Recently, Purchase (1999: 249) has proposed that icons be divided into two subclasses:

7)
a) Concrete icons.
b) Abstract icons.

Concrete icons have a close physical resemblance to their denotata, as for instance in the case of a photograph. An example of a more abstract kind of iconic representation would be a diagram.

An alternative classification of signs pertinent to USID is proposed by Andersen (1997: 216-229). This typology is based around the following properties:

8)
a) Permanent and transient properties.
b) Action and handling facilities.

A button, for instance, is characterised by certain permanent properties, such as its shape and size, and generally also by the transient property of briefly undergoing inversion when clicked. Its ability to respond in this way

to a user action affords it its handling facility, and in addition it can act upon other signs so as to provoke changes in them, for instance by causing a new item to appear in an on-line shopping basket. A button is distinguished from, for instance, a layout sign such as the grid of a spreadsheet, which has no transient features, offers no means of user-interaction and does not provoke changes in other signs.

As we have just seen, certain kinds of sign are dynamic (that is to say, subject to change along the temporal dimension). This fact makes it possible to regard not only interface objects but also interface actions as signs. For instance, the clicking of an 'OK' button that serves to place an order as part of an on-line commercial transaction is a semiotic interface action which stands for the task action of requesting the relevant commodity or service. In terms of the six-level framework it may be described as follows:

9)

a) Physical level:
   Depressing and releasing of the mouse button, and brief change of values of the relevant pixels.
b) Empiric level:
   Pattern of mouse button movement in the vertical dimension, and brief inversion (or other change) in the appearance of the group of pixels representing the 'OK' button.
c) Syntactical level:
   Selection, from among the elements arranged on the screen, of the particular button concerned, rather than any other, for example the 'Back' button.
d) Semantic level:
   Decision by the user to place an order.
e) Pragmatic level:
   Instigation of the commercial transaction.
f) Social level:
   Incurring of an obligation by the purchaser to pay the vendor if and when the latter supplies the relevant commodity or service.

It seems, then, that concepts and principles that are important from the point of view of USID can be fitted quite comfortably into a semiotic approach. In showing how this can be done, we have addressed the first of our two central questions. Thus, in the light of the above observations, an IT system designer working on the basis of OS should be able to appreciate how USID principles can be integrated into the OS analytical framework. It is time, therefore, to move on to the second question, namely how semiotics

can help to deepen our understanding of the USID principles themselves and the way in which these are put into practice.

4. THE SEMIOTIC CONTRIBUTION

In order to illustrate how semiotics may cast additional light upon USID principles, let us consider the principle of consistency. (This has been selected on the grounds that it probably offers the clearest example of the points at issue and has therefore been the most closely examined by the present authors.) What becomes apparent when viewed from the OS perspective is that the principle in question can be applied at several different levels, and has different practical consequences, depending on the level concerned.

Consistency at the level of empirics relates to physical patterns, such as character shapes. For instance, a higgledy-piggledy mixture of fonts would reveal inconsistency at the empiric level. At the level of syntactics, consistency can be attained in matters such as structural regularity. For instance, whenever a set of buttons for 'Play', 'Record', 'Stop', 'Rewind' and 'Fast-forward' are displayed, these should be laid out in the same sequence. At the semantic level, consistency demands the avoidance of contradictory statements. For instance, it is no good saying in one place that a special offer applies to people who buy five or more items, and in another place that it is available to purchasers of over five items. As for the pragmatic level, consistency can be sought in properties such as the tone of the user-system dialogue. For instance, an incongruous mixture of formality and informality should be eschewed.

The contribution of the semiotic perspective here is threefold. First of all, it makes it clear how a single term (such as 'consistency') can mean different things in relation to different levels in the hierarchy. This in turn helps to organise our thinking when designing or evaluating a system, motivating us to consider the implications of design principles at the various levels. In addition, realising that several levels are involved ought to serve to alert us to the fact that inter-level relationships need to be given consideration.

Here are some examples to illustrate how inter-level harmony may be cultivated:

10)

a) Pragmatic and semantic levels:
   Attempting to educate children about a particular topic (such as the danger of talking to strangers), starting out on the basis of concepts that they are likely already to understand.

b) Pragmatic and syntactical levels:
Highlighting of important pieces of information, by means of unusual orderings of elements within sentences.
c) Pragmatic and empiric levels:
Highlighting of important pieces of information, by means of colour.
d) Semantic and syntactical levels:
Systematic reference to a particular set of concepts, by means of a consistent vocabulary.
e) Semantic and empiric levels:
Name denoting an antique shop, displayed in an "olde worlde" kind of script.
f) Syntactical and empiric levels:
Two-dimensional tabular arrangement of data, supported by a correct alignment of rows and columns in the screen display.

As will be apparent from these examples, cross-level harmony may involve either adjacent or non-adjacent levels in the hierarchy.

The semiotic perspective can confer its analytical benefits not only upon USID principles, but also upon some of the concepts used in the realisation of those principles in practice. For instance, the provision of feedback from system to user will involve the use of items such as error messages, such as a report of an empty disk drive when attempting to attach a file to an email communication. An error message is an interface object, and might be characterised semiotically along the following lines:

11)
a) Physical level:
Group of pixels.
b) Empiric level:
Visible shape, with properties such as legibility.
c) Syntactical level:
Arrangement of text and perhaps an abstract icon, which should be properly constructed.
d) Semantic level:
Carrier of meaning, which should be an accurate description of the situation.
e) Pragmatic level:
Instrument of system-user communication, which should be appropriate in style and tone.
f) Social level:
Impediment to the user attempting to accomplish a task, which should therefore delay and interfere with that task as little as possible.

This kind of analytical description may serve as a reminder of the range of considerations which the system designer needs to bear in mind. In addition, there are cross-level harmonies to cultivate. For instance the choice of terminology in the message (terms being formal elements with associated meanings) needs to accord with the aim that the message be intelligible to the user (intelligibility being a matter of pragmatics, as it is highly context-dependent; see Connolly (1986) for discussion).

By way of a second example, let us imagine that a system is being designed in which the user has to be offered a means of undoing, when necessary, an incorrect entry of numerical data-items into a table. There are, of course, various ways in which this undo facility could be accomplished, but let us suppose that it is going to involve highlighting the offending entry in the table and over-typing it with the correct number. This process is an interface action, and might be characterised semiotically as follows:

12)

a) Physical level:
   Moving the mouse to position the cursor at the start of the appropriate cell; depressing the mouse-button; moving the mouse to drag the cursor across the cell, reversing (or otherwise changing) the values of the relevant pixels; releasing the mouse-button; and striking the appropriate keys to enter the correct number, restoring to normal the values of the relevant pixels; and displaying the new characters.
b) Empiric level:
   Pattern of mouse-button movement in the vertical dimension; trajectories of mouse and cursor; inversion (or other change) and restoration of the appearance of the relevant group of pixels; pattern of key movement in the vertical dimension; and shapes of new characters.
c) Syntactical level:
   Selection, from among the elements arranged on the screen, of the particular cell concerned; and replacement of the data in that cell with fresh data.
d) Semantic level:
   Identification of incorrect number; and correction of this.
e) Pragmatic level:
   Highlighting the cell on which attention is focussed; and communicating the desired change to the system, with the result that it is put into effect.
f) Social level:
   Taking a step to progress the user's activity in the context concerned.

The interface action should be (physically) comfortable, and the (empiric) pattern of movement should be quick and efficient. The (syntactical) sequence should be logical and the (semantic) content or meaning of the action should be clear. It should have the expected (pragmatic) outcome and should advance the (socially situated) activity in which the user is engaged. Furthermore, inter-level harmony is once again incorporated, for instance in supporting the (pragmatic) highlighting by the (empiric) inversion of the relevant cell in the display.

A remark needs to be made at this point about the social level of the semiotic ladder. The term 'social' has been interpreted rather broadly in the present paper, to encompass the individual's relationship with other people within the broader context of any organisational grouping that might be relevant.

In the two examples just given, the analysis of the object or action into levels has been accompanied by the statement of design-related recommendations appropriate to the level concerned (such as the desirability of physical comfort and empiric efficiency). This illustrates how the recognition of the different levels at which interface objects and actions may be viewed exposes the need to take different kinds of design decisions in relation to each level, while maintaining harmony among them all.

The same kind of thinking can be applied to the design of interfaces for more novel technology as well, for instance mobile WAP phones with small screens. In a case such as this, it might happen that there was insufficient space to display the whole of a text message at the same time, and that consequently the text needed to be scrolled horizontally across the screen, with only part of the message visible at any one instant. From a semiotic perspective, the chief consideration would be to facilitate successful communication, and this would require the tailoring of the lower levels in such a way as best to serve the pragmatic goal of communication. Accordingly, the syntax of the message would need to be kept simple, in order not to overburden the user's memory with long sentences that were only partly visible at a given moment, and the font size would need to be chosen in such a way as to balance legibility against maximal utilisation of the available display space.

We have seen, then, that semiotics can aid our understanding of USID principles and of the interface objects and actions employed in putting those principles into practice. Thus, we have now addressed the second of the two questions posed in the Introduction.

5. CONCLUSION

In this paper, we have attempted to bring together two alternative approaches to USID, namely those based on HF and OS respectively. The result has been to develop a synergy between the two approaches, which brings potential benefits to the designers of user-system interfaces.

It now remains to continue the application of the semiotic ladder to the analytical process as it applies to both the 'golden rules' and other UISD criteria. Our overall aim is to build an evaluative framework that can answer questions such as: 'Is this a good UI?' and 'Does this UI communicate well?' A further aim is to expand the concrete definitions of user interfaces which currently exist at the physical and empiric levels, up though the layers, using current design practice to guide and the semiotic ladder as a framework. This should, ideally, allow for further user interfaces to be defined at the pragmatic, or even social, level and all design steps in levels below to be automatically performed. Generalising this work from a quality of User Interface to a quality of Model, in the sense of Krogstie (2001), is another future aspect of this work.

REFERENCES

Andersen, P.B. (1997) A Theory of Computer Semiotics, Cambridge University Press, Cambridge, UK.

Connolly, J.H. (1986) Intelligibility: a Linguistic View, British Journal of Disorders of Communication, 21, 371-376.

Connolly, J.H. (2000) Accommodating Natural Language within the Organisational Semiotic Framework, in Proceedings of the Third International Workshop in Organisational Semiotics, University of Staffordshire, Stafford, pp. 1-13.

Dix, A., Finlay, J., Abowd, G. & Beale, R. (1998) Human-Computer Interaction, 2nd edition, Prentice-Hall, London.

Jorna, R. & van Heusden, B. (1996) Semiotics of the User Interface, Semiotica, 109, 237-250.

Krogstie, J. (2001) A Semiotic Approach to Quality in Requirements Specifications, in Proceedings of the IFIP WG8.1 Working Conference on Organisational Semiotics, Montreal QC, July 23-25, 2001, Montreal, pp. 191- 205.

Lansdale, M.W. & Ormerod, T.C. (1994) Understanding Interfaces: a Handbook of Human-Computer Dialogue, Academic Press, London.

Liu, K. (2000) Semiotics in Information Systems Engineering, Cambridge University Press, Cambridge, UK.

Nadin, M. (1988) Interface Design: a Semiotic Paradigm, Semiotica, 69, 269-302.

Newman, W.M. & Lamming, M.G. (1995) Interactive System Design, Addison-Wesley, Wokingham.

Preece, J., Rogers, Y., Sharp, H., Benyon, D., Holland, S. & Carey, T. (1994) Human-Computer Interaction, Addison-Wesley, Wokingham.

Purchase, H.C. (1999) A Semiotic Definition of Multimedia Communication, Semiotica, 123, 247-259.

Shneiderman, B. (1998) Designing the User Interface: Strategies for Effective Human-Computer Interaction, 3rd edition, Addison-Wesley, Reading, MA.

Stamper, R. (1991) The Semiotic Framework for Information Systems Research, in Nissen, H.E., Klein, H.K. & Hirschheim, R. (eds.), Information Systems Research: Contemporary Approaches and Emergent Traditions, North-Holland, Amsterdam, pp. 515-527.

Stamper, R. (1996) Signs, Information, Norms and Systems, in Holmquist, B., Andersen, P.B., Klein, H. & Posner, R. (eds.), Signs of Work: Semiosis and Information Processing in Organisations, de Gruyter, Berlin, pp. 349-397.

Sutcliffe, A.G. (1995) Human-Computer Interface Design, 2nd edition, Macmillan, Basingstoke.