The Inner Functioning of Words: Iconicity in Poetic Language

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Although it is generally believed that writing is the transcription of the union of sound and sense in speech which makes it appear to be a secondary mode of signification, it can be shown that the union of visual expression and content which constitutes writing is in reality the primary mode. The analysis in detail of several examples of Italian poetry will illustrate the special truth of this in the case of poetic language. The signification in unions of expression and content in poetry is visually motivated or iconic. To be iconic, a written sign need not be an isomorphic imitation of some real-world or natural shape; rather, its shape is the visual result of an "inner functioning" of words. The already culturalized world of meaning is the basis of the iconicity of the sign in poetry.

This study is in large part the practical, critical analysis of several texts of poetry in Italian with the intention of demonstrating that signs in poetic language are visual and that they may function independently of their relationship with spoken language. A Cratylian approach — signs are not arbitrary — will be followed, maintaining that poetic language is motivated in its visuality, that it is iconic in a fundamental way.

To say that a sign is motivated is not the same as saying that it is natural. The word *natural* is never free of ideological connotations and needs to be qualified if it is to be used at all. One should take note of what Umberto Eco (1978: Par. 3, *passim*) writes about iconicity and naturalness. If iconicity is to be taken solely as a quality of reference some sign may bear to a natural object whose shape is replicated in the perceptual form, the *expression,* of the sign, then, as Eco puts it, such a thing as iconicity is too problematical to be dealt with logically. It presents, among other things, contradictions hinging upon the differences observable among arbitrary expression forms (the words of different languages) referential to the same natural object. But there are some modes of sign production which involve a true motivation of the physical shape of the expression by the unit or units of *content,* the conceptual component of the sign, to which the expression is linked in the *sign-function.* There need not be some object in the natural world

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which imparts its own shape to an expression; a human mode of perception may determine that shape. The mode of perception may even impart some shape to the natural object which it does not have in nature, although for human purposes that shape remains entirely proper and acceptable. Eco's example of this is the drawing of a rhinoceros done by Albrecht Dürer: it errs in some details but is no less perfect an expression of "rhinoceros." The motivation of the iconic sign is not a natural, but a cultural phenomenon; units of content are humanly produced, cultural entities, not being part of the natural world.

Iconicity which is the result of cultural motivation has always been central to relations of signs in poetry. Futurist that he was, Carlo Belloli (1944, quoted in Solt and Barnstone, 1969: 41) denied historical precedent for his own kind of iconic texts which he called "audiovisual poems." According to Belloli, texts such as Apollinaire's "Il pleut," George Herbert's shaped stanzas, the *technopaignia* of the Alexandrian school (Klonsky, 1975), or any earlier manifestation of "visual" poetry, do not stand as forerunners from which his own poems trace their derivation. These earlier poems are for him merely texts whose external shape is intentionally stylized to resemble drawings of the objects the words tell about; they are naively mystical in intent, while in contrast his own poems are, he claims, the embodiment of "the inner functioning" of words. One has to agree that the iconicity of writing cannot be other than connected with some inner functioning of words, but one must also take historical instances of picture poems of all types definitely to be examples of the principle involved in such inner functioning, even though such poems may be done somewhat heavy-handedly, featuring mostly clever external effects. Not just picture poems, nor "audiovisual poems," but any poem will bear evidence of the inner functioning of words and will exemplify the principle of cultural motivation.

Poetry has been singled out for its directness of mediation between mind and world, achieved through its qualities of plasticity, its imagery, or perhaps its concreteness as an objective-correlative, to suggest some of the great variety of terminologies which have centered about the general aim of explaining what there is that characterizes the particular essence of poetry. The common factor underlying all such theoretical conceptions seems to be a foregrounding of the visually iconic attributes of the written sign in poetry. In other words, poetry pictures things, not in the sense that it tells about actions and feelings or describes in words the objects we see; but rather, its own physical presence amounts to a matter of true visual pattern and dimension.

Poets, both intuitively and consciously, have found written language to be much more than a technological device for the transcription of sounds. For poets, Cratylists all, as Roland Barthes (quoted in Merrim, 1981: 53) has called them, the meaning or the important information carried by language is identified with its physical substance. And not only poets (like Rimbaud) but Freud, too, as McKenna (1980: 219) has pointed out, look upon writing as "language as matter." Quoting Freud, "It is true in general that words are treated in dreams as though they were concrete things, and for that reason they are apt to be combined in just the same way as presentations of concrete things," McKenna (221) then adds: "Invisible to consciousness, language is visible in the unconscious and one can describe Freudian interpretation as an effort to make lanuage uninvisible."

Any poem has the potential of being perceived visually as a kind of picture. Whether this applies to all written language is not at issue at this point, but the case for the truth of this in poetic texts has been outlined effectively by Anthony L. Johnson (1977: 114–115), who holds that poetry differs from ordinary language by being the scene of operation of three hierarchical modes of generation of meaning which are: denotation, connotation, and anagrammatism. The first two, heavily involved with language, need to have little said of them here, but the third is central to the discussion because of the presence within it of what Johnson calls "iconico-graphic" modes of meaning generation. These are not usually consciously employed by the poet, but tend to be subliminal in their operation; as they are, in turn, in their reception by the reader of a poetic text. In this hierarchy of modes denotation has and must have primacy; if it did not, the other two modes might subvert it to the point of obliterating it, thus removing the preconditions for their own existence, and there would be no poetry, just "rhythmical gibberish." One might put this matter of the hierarchy of modes in a slightly different way: a word in a poetic text must somehow fit into the semantic scheme of a given language. The scheme is ordinarily the one belonging to the language in which the poem is written, but even in the case of foreign citations, where words in an unknown language may "mean" nothing (and here, it may be noted, when an unfamiliar foreign word appears in a text, the pure visuality of language will have its fullest impact), the reader will still usually be willing to assume that some semantic system is at work. The built-in semantic potential of a word is ultimately the only truly "natural" aspect of language. But this in no way precludes the operation of graphic and iconic signification within the word, for the anagrammatism of the written word will also always be present.


mus. te dominum confitemur.
eternum patrem. omnis terra veneratur.
tibi omnes angeli. tibi celi et universe

The simplistic premise of what is being proposed here is that when we read we *see*. Considerable importance should be given to the thought that the visuality of writing may be doing more before our eyes than just expressing language. In the semiotic system of language — in any semiotic system — content and expression never exist separately, but become realized at the moment they are joined together in the sign-function; in human language the joining together may be acoustic, as in speech, or graphic, as in writing. And while at times a close correlation between the acoustic and the graphic does exist, there are cases where the signification embodied in the graphic sign is simply beyond achievement in the elements of speech marked by it. For example, speech has no such thing as a capital letter: only in writing do such gestural distinctions as the attribution of special status to some of our nouns and the marking of the beginning of a new turn of thought become realized.

The illuminated capital in medieval manuscripts may seem a special case, but it really exemplifies a general principle. The relation of the capital to the semantic function of the word of which it was a part was usually overshadowed by the visual impact of the decorated letter. Figure 1 shows the capital "T" of the *Te deum* decorated by Giovannino de' Grassi in the book of hours of the Visconti family (Meiss, 1972) as the representation of an architectural space, a double-arched portal. Standing within each side of the portal is the figure of one of the two saints who are the supposed authors of the hymn, Jerome and Augustine. A connection is created between those conveying the sacred text and the text itself. The two authors are visually contained within the content of the text. In the case of a spoken utterance the text's producer is usually known (contained within the text) by acoustical presence in the context of sender and receiver; here, the presence is transformed into a visual one. This is an excellent instance of the iconic potential of writing, for it is nothing other than the letter "T" which performs this containment function by virtue of its very shape. An implicit signification residing within an alphabetic mark has been extracted and rendered explicit. The qualities of the illuminated capital, enhanced, to be sure, by the miniature painting, are ultimately the same as those possessed by any written sign, present in the most unadorned of letters: all the reader needs to do is to choose to see them.

Figure 1. Illuminated capital T by Giovannino de' Grassi in the *Visconti Book of Hours,* Millard Meiss, ed., New York: Braziller, 1972.

The signifying power of writing can be found in the shapes of the letters themselves. For example, human history is full of coded, symbolic significations of the circular shape (Peck, 1979). The circle is perhaps the most obvious example of an iconic shape, and it will be good to begin with it in the analysis of some actual examples of poetry which will show the visual or "iconicographic" processes of signification at the heart of writing. For human purposes the circle is a cultural shape already within our consciousness and ready to motivate the joining of expression and content in the sign-function. It is an important element of that reality we may call, in Eco's terms, our "previously culturalized content."

A most effective use of the circular shape of the letter "o" was made by the Czech poet Ladislav Novak (Williams, 1967: pages unnumbered) in a deceptively simple visual poem which may serve well as a first example. The poem consists of the single Latin word *gloria* arranged in special typography. (This suggests that it is a picture poem of the type of the shaped texts mentioned above, but it can be shown not to be the same thing at all.) A striking set of meanings may be evoked by this text, rendered approximately as:

O

G L R I A

One should note the combination of the circular shape and the superelevation of the letter. There is in such a combination the suggestion of the sun of revelation and grace, a possible outgrowth of a long tradition of meaning, along with the suggestion of the upward directionality of a hymn of praise toward heaven; or the raised letter may be an evocation of the elevation of the Host (shaped like "o") during the sacrifice of the mass; and not to omit another important possibility, in the context of song the raising of that particular letter, once again because of the shape it has, mimics the system of musical notation, especially as it is seen in early manuscript hymnals. Such factors, combined with the density of the connotations carried by the word itself in its historical context as a word in the ancient language of Catholicism and as the *incipit* of one of the most important segments of the liturgy, make this text a cogent religious poem.

The same word *gloria* appears at the beginning of a poem which Eugenio Montale included in his 1925 *Ossi Di seppia.* The first two lines of the text are:

Gloria del disteso mezzogiorno
quand'ombra non rendono gli alberi
(Montale, 1968: 68)

(Glory of full-spread noon when the trees yield no shade)

The letter "o" of the word *gloria* once again may evoke an image of the sun (later in the poem the Italian word for sun, *sole,* appears, and we see that it, too, contains the iconic letter). This image is reinforced in the subsequent appearance of the same letter in *mezzogiorno,* the word for mid-day. The brightness of the noonday sun, its parching, merciless heat is the predominant motif of the semantic component of this poem, what it appears that the poet would want us to think about as we read the text. The presence of the sun-shaped "o" in another word, *ombra,* which is "shade," the antonym of the sun, brings about the most striking effect of these lines. The shade, the thing that would be desirable as a relief from the scorching heat of the sun but is not to be had, since the trees cast no shadow at noon, has within its graphic substance the very shape of its opposing element. This is a cruel irony, one which fits quite aptly within this poem. The entire situation is rendered ironic by the traditional celebratory term *gloria,* which one expects to be expressive of joy, but which here is found as the opening of a text on the harshness and cruelty of life which is parched or scorched, and is only half over, as two later lines tell us:

Il mio giorno non è dunque passato:
l'ora più bella è di là dal muretto
(lines 6–7)

(My day then is not past: the best hour of it is beyond the wall)

Another illustration of the iconic power of the circular letter "o", but this time somewhat different in what it may evoke because it is functioning in very close rapport with another alphabetic sign, is to had be in the poem "Su" by Aldo Palazzeschi:

Le ultime finestre sotto i tetti
sono fatte a coni.
Anche le porte delle chiese
sono fatte a coni.
Come le vostre mani,
giovani che pregate,
sono giunte a coni.
I cedri,
i cipressi,
gli abeti dei giardini
sono coni.
Le ali delle rondini,
puntate per salire,
sono coni.
Coni dei tetti, coni delle mani,
coni delle porte, coni degli alberi,
coni dell ali,
coni, coni.

(Palazzeschi, 1973: 97)

(The topmost windows under the roofs are shaped like cones. The church doors too are shaped like cones. As your hands, boys who pray, are joined to form cones. The cedars, the cypresses, the firs of the gardens are cones. The wings of the swallows, pointed to soar, are cones. Cones in roofs, cones in hands, cones in doors, cones in trees, cones in wings, cones, cones.)

The references to objects which point upward, as would a geometric cone resting upon its base, seem to determine the theme of this poem as an evocation of upward movement, perhaps the direction of the yearning of the soul toward some divine or ideal destination, or some such traditional attribution of meaning to upward motion. Internal indications in the text like the mention of churches, prayer, and the cypress trees of Italian cemeteries and concomitant thoughts of an afterlife complement such a meaning. The line lengths of the text can be seen to change in such a way that the shape of the poem on the page (possibly an unconscious homage which Palazzeschi, contemporary of Apollinaire, made to the ancient forms of the *carmina figurata*) suggests several times the diminishing dimension of a cone observed with the eye moving from base to apex. This poem announces that it is not to be taken as a disquisition on a topic, but rather as a visual evocation of an image.

In Palazzeschi's text the scene of the most remarkable iconicity is the word *coni*. The letter "o" has already been singled out for the traditionally determined signifying power of its shape, but in this

word there is also found the letter "i", characterized by its linear and vertical configuration. We can discount for the moment that the spoken vowel sounds marked by these two letters may also be involved in some sort of phonetic iconism (Westcott, 1971: 421ff) and concentrate here on visual motivation: as the word *coni* is written in the conventional left to right direction, the motion from low to high is pictured as the progression from base ("o") to apex ("i") of the cone by the two graphic marks. (Following a different though related line of thought, we might connect "o" and "i" as symbols in as much as both suggest the notion of unity; and for this text the striving toward oneness is not to be excluded as its primary conceptual thrust.)

The revelation of such a correspondence between graphic image and conceptual content in a rather ordinary word can be the point of this poem by Palazzeschi. This is borne out by the relationship of the word *coni* ("cones") to the singular form of the word which is *cono.* The singular form is totally absent from the text (although its nearly identical image is mirrored in the third person plural of the verb "to be," *sono,* which appears five times); the singular form would not have the same effect, even though its semantic referent is still the same geometrical figure. One has to ask why the plural of the word is used when the singular might serve just as well to convey the idea of a cone, and the answer has to be that it is not really the *conceptual idea* in a word that figures importantly in this text so much as it is the *perceptual shape* of the word. Another question that may be put is why the plural seems to cohere with the rest of the poem beyond the obvious, pragmatic reason that the speaker compares multiple objects (roofs, hands, windows, etc.) with multiples of their prototype shape, and the plural, of course would make for the most logical connection. In poetry reasons of logic in semantics and grammar, certainly valid enough to the aim of comprehension, are not the only kind. In Palazzeschi's text the plural appears instead of the singular and reverses the logical imperatives of semantics: it is not because there are plural objects seen that we have the plural of the word, but that with the plural being so vital to the iconic functioning of the poem, only those objects which are multiple could possibly be allowed to serve as referents. The human habit of working from the inside outward, from mode of perception to object perceived in the world, which was referred to above appears to be functioning in this instance. In the internal context of this poem the plural is the motivated form. The singular may do no more than suggest the semantic concept of a cone and the extension of the word to its referent in the world, but the plural brings with it the full potential of the graphic sequence of its

two vowels. If we can see this, we are beginning to grasp what is meant by the inner functioning of words.

Poetry, where iconicity seems to rule, demands that certain words be present while others be omitted, as is the case with *coni* over *cono.* While one may not yet state fully systematic, universal laws, Johnson, who is only at the point of giving "theoretical preliminaries," writes (1977: 97) that it would be impossible to maintain that iconic rules are not at work. To maintain this one would have to fail completely to notice that in the Palazzeschi text the vowels "o" and "i" appear with great frequency throughout (within certain words the sequence of the two is exactly as it is in the key word: "sotto i tetti," "vostre mani," "giovani," "rondini"), making their presence in *coni* much more significant. One would also have to fail to notice that whenever the *sono* look-alike for the other form of *coni* appears, it is at the beginning of a segment which terminates in *coni.* And one would have to cast aside as insignificant the fact that when the verb which denotes the motion of rising occurs, it is *salire* (not *montare, ascendere,* or some other nearly synonymous Italian word), the tonic vowel of which is the iconic "i" of upward directionality.

"Nostalgia," a poem by Palazzeschi's much better known contemporary, Guiseppe Ungaretti, typifies his early production as a participant in the avant-garde of poetry of the era of the First World War. While the text displays innovation in its violation of prevailing codes not only in the omission of punctuation and the use of irregular, strophe-like groups of phrases, but also in its abandonment of traditional Italian metrics, there are certain principles of order and a relationship of the parts of the poem to its internal context which are definitely and most forcefully at work, and they are almost entirely iconic in nature. The elements of the text are far from randomly placed (there is no obvious attempt to achieve the effect of the "parole in libertà" of the Futurists of the time), despite the illusion of freedom or individual whim which is created whenever a poet chooses to go against the grain of the dictates of form prevalent in his time. The logic of conventional syntax is observed by Ungaretti, though he dispenses with the usual punctuation. The poem has upper-case letters at the beginning of each of the five short strophes, an initial indication that in this text graphic qualities will be of primary importance:

Quando
la notte è a svanire
poco prima di primavera
e di rado qualcuno passa

Su Parigi s'addensa
un oscuro colore
di pianto

In un canto
di ponte
contemplo
l'illimitato silenzio
di una ragazza
tenue

Le nostre
malattie
si fondono

E come portati via
si rimane

(Ungaretti, 1969: 854)

(When night is about to disappear shortly before spring and rarely does someone pass by A dark color of weeping thickens over Paris At a corner of a bridge I contemplate the limitless silence of a thin girl Our sicknesses fuse And as though carried away we remain)

It is immediately evident that the semantic structures of the poem pivot about several evocative images that employ language in a degree of violation of the rules of ordinary usage: the night disappears just before spring, not dawn; weeping or sorrow has a color, the dark color of thickening clouds; the persona of the text contemplates a girl's limitless silence (here it is impossible not to notice an approximate reinscription and condensation of the famous phrases "interminati spazi," "sovrumani silenzi," and "infinito silenzio," endless spaces, superhuman silences, infinite silence, from Leopardi's *Infinito*); the persona and the girl are joined by a blending of their sicknesses; as they are carried away they remain where they are. While figurative elements of this type could not be said to be unheard of in the centuries-old tradition of rhetorical expression through metaphor, their concentration within the space of this one text has something of a "modern" ring to it. Each of the images just noted is set off from the rest by syntax, but an even more effective division is achieved by the blank spaces occurring between the textual blocks. At the same time that such a visual separation is brought about, there is another

visual device which tends to join together what has been divided. A pattern of simultaneous disjunction and conjunction, the pause which is not really a pause, may be an iconic analog of the conceptual oxymoron which brings the text to a close.

The principal connecting link from one strophe to another is a graphic one. It has, incidentally, a phonetic counterpart as well. It is found on a level of microstructure at which phonemes and graphemes usually work together, but it can be shown that in this poem the graphic elements are well able to stand on their own with a system of articulation peculiar to them. Four of the five strophes contain words which have some arrangement of the two letters "c" and "p" in them. In two instances in the first strophe the letter "c" is not to be found; The letter "q" appears instead. In Italian as in English the phonetic values assigned to "q" and "c" are identical, but it is not required that one insist on phonetic identity to find a relation between the two letters. One need only note that the contrast between lower-case "q" and "p" (the optional case to the contrast of "c" and "p" in this text) is realized by nothing other than the reversal of the two graphic marks to form a mirror-image. This presents us with a case of difference based upon similarity, a relationship totally in harmony with the conceptual paradoxes of continuity and discontinuity in the poem's imagery. The force of a purely visual contrast in the "q/p" alternation heightens the graphic over the phonetic in the distinction of "c" and "p". The alternation of "c"("q") and "p" is seen to continue from the second to the third strophe with the repetition of the graphemes in these words: "colore" / "pianto" / "canto" / "ponte" / "contemplo".

There is no "c/p" alternation in the fourth strophe. Instead, the graphemes "l", "m", and "n" are found in increased number. In the fourth strophe graphemes predominate which were foregrounded earlier in a key phrase of the third strophe: "l'illimitato silenzio." This phrase seems, in turn, to have concentrated those three graphemes in one place after they had appeared scattered within words in which the "c/p" alternation had been most obvious, such as "qualcuno," "colore," and "contemplo." The final strophe contains a return to the alternation of "c" and "p" in the words "come portati."

Ungaretti's poem is about an emotional state. We do not see emotional states themselves, but only indices (smiles, tears, etc.) of their presence. The "pianto" (weeping) and the "Nostalgia" of the title make it evident enough that the emotion one deals with in the poem is sorrow of some kind. In Italian the word for sorrow is *dolore*. This word is not found in the poem. It should be noted, however, that a close approximation of the word (and here we have a situation not unlike the one seen in the Palazzeschi text above, where the absent word

cono was approximated by its look-alike *sono*) does in fact appear in the word *colore*. Through the presence of *colore* instead of *dolore* an appeal to sight is made: conceptually, the word asks the reader to see the color of weeping ("colore di pianto"), but perceptually, it does indeed allow the reader to see sorrow, both as an emotional state and as an absent word, without really seeing either. The clue that the reader is being asked to rely on what is visible about language in order to transform an emotional state into a code of perception is given by the insistent repetition of the "c/p" alternation as just outlined, leading up to the point at which "colore di pianto" finally appears. After that point in the text the alternation of the graphemes continues a little longer until there comes a word denoting the action of the persona: it is *contemplo,* the only action word which is specifically manifested in the text with the "I" as its subject, and in a strictly visual emphasis it comes at almost precisely the mid-point of the poem. It need not be pointed out that the word is a composite of both structures which have been shown to figure largely in the poem, "c/p" and "l/m/n", the latter being the preannouncement of "l'illimitato silenzio," the object of the direct contemplation of the persona. Is it possible to contemplate silence? To do that is perhaps something like seeing without really seeing; that is to say, in some way heretofore plausible only to the mystical mentality one may see something which is really something else. This poem seems to suggest that we can do that in spite of the paradox implied. In its iconic functioning the key verb of the text offers a solution to the situation of paradox: the verb contains its own object in the form of a visible index of shared graphemes.

While the demonstration of the inner functioning of words in poetry has been done with Italian texts of recent date, the translations of which have shown clearly enough that what is true for the graphic system of Italian may not be carried over into English in exactly the same way, nevertheless the same principles seem to be at work in different periods in history and in other languages as well. A single example may have to suffice at this point. A passage in *As You Like It* is frequently quoted in connection with the ancient metaphor of the *liber naturae,* but it is equally pertinent to the discussion at hand as an illustration of the pervasiveness of the visual, iconic functioning of words in poetry:

> And this our life, exempt from public haunt,
> Finds tongues in trees, books in the running brooks,
> Sermons in stones, and good in everything.
>
> (Act II, Sc. i, quoted in Lee, 1977: 5)

It does not seem at all fortuitous that in these words the three elements of nature which are mentioned ("trees," "brooks," "stones") as having language ("tongues," "books," "sermons") in them do in physical fact *contain* elements of the visual substance of the words which denote language: [T]ongue[S] in [T]ree[S]; [BOOKS] in [B]r[OOKS]; [S]erm[ONS] in [S]t[ON]e[S].

Such visual reinforcement of semantic values is more than a mere device. This is not a pun in the pejorative sense. It is, rather, a pun in the best sense of the word: that is, the pun which manifests the essential principle of iconic structure in language. The poetic function of a language may be so inextricably tied to its given system of iconic functioning that it cannot readily be translated into another language in any exact way; but the same iconic principles of inner functioning and motivation apply in all written languages.

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The Mind's Eye and the CRT Terminal: Towards a Diagrammatic Interface

Jeff Nickerson

The differences between humans and computers are drastic. The most significant for this discussion is the difference between the parallel processing of humans and the sequential processing of current machines. We can take advantage of parallel processing by combining the eye with the CRT. Computer memory is presented in a virtually simultaneous manner on the screen, and the image there presented is processed in parallel by the human visual system. The CRT is not only an input port to the eyes, but also a model of the mind. Renaissance practitioners of mnemonics appreciated the screen-like nature of human memory. This leads to a visual comparison between the Renaissance memory systems and the current trend toward windows on the CRT. It is appropriate to look at the sign process. We look at current interfaces in terms of Peirce's most used trichotomy, that between Icon, Index, and Symbol. Current interfaces involve mainly symbolic signs, with the recent addition of low-level iconic signs. Missing from the interfaces as a main component are the indexical signs and their realization through more sophisticated iconic representations.

> *A concept is the living influence upon us of a diagram, or icon, with whose several parts are connected in thought an equal number of feelings or ideas.* (Peirce 7.467)

The rapid spread of personal computers has stirred interest in making the computer easier to use. Since using a computer is essentially a process of handling signs, a look at the interface from the perspective of semiotics is revealing. This discussion concerns the visual aspect of the interface, calling on the nature of the visual system, the history of mnemonic techniques, the nature of the technology, and the nature of signs, in order to establish the significance of an interface emphasizing diagrams.

The Visual Realm

Given the specialized circuitry our minds possess, it is not surprising that we can imagine the world as well as see it (Figure 1). We can

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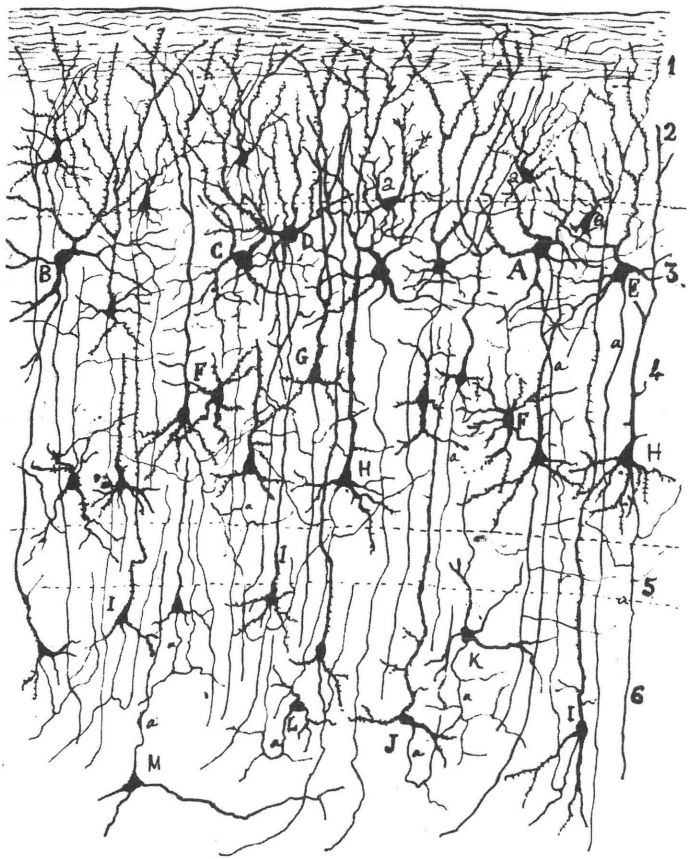
remember or construct images in our mind's eye, altering and examining them at will. Whether these inner images are intrinsic to thinking, or whether they are mere manifestations of some deeper structure is a question that has excited controversy (Kosslyn). Whatever the case, the imaging capabilities of the mind are not new, and the history of their recognition and use are instructive.

From the ancient Greeks up until this century, those studying rhetoric were exposed to mnemonic techniques for improving memory. These techniques involve linking pre-memorized spaces or images to other images that in some way represented the object in question (Figures 2a, 2b). A speaker would walk around a building, memorizing a certain direction of movement. In each room he would imagine an object corresponding to a concept he wished to discuss. A concept such as war that was to be discussed as a second topic might be represented by a sword placed mentally in the second room to be walked through (Yates).



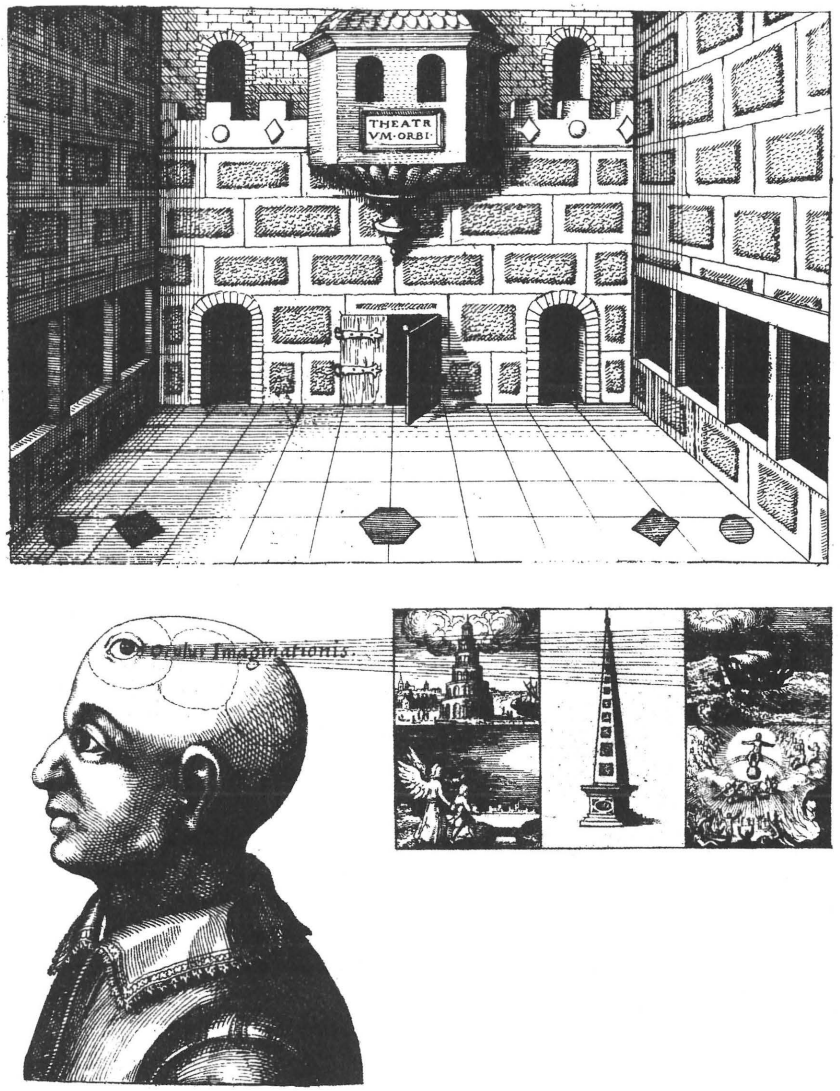


Figure 2a, 2b. The theatre memory system of Robert Fludd, circa 1625. The mnemonic practioner would pre-memorize the biblical images of 2b, which are arranged according to the windows of the stage-set 2a.

Figure 1. Visual cortex of a rat, drawn by Santiago Ramon y Cajal in 1888. The numbers identify cellular levels.

The more we find out about the psychology of the mind, the more the mnemonic techniques once taught as an integral part of rhetoric make sense. Research in cognitive psychology affirms what introspection tells us. The mind can remember images far easier than abstract concepts, hence the efficacy of representing the concept of war by a sword. The mind has a good spatial memory, so that the placing of objects in rooms or in windows of a facade take advantage of a psychological ability (Paivio).

From Simonedes to Leibnitz there were many famous practitioners of the art of memory. Cicero, Descartes, Lull, Bruno, and Leibnitz were familiar with the techniques. The practitioners of mnemonics, especially Bruno and Leibnitz, had high hopes for a universal language based on spatial, visual systems (Yates). We may realize their hopes through the displays of our computers, which will spread the conventions that make language possible.

The Computer Realm

The computer grew out of a need to automate the process of precise calculation. One of the earliest calculating devices, the abacus, would be described today as a dynamic memory device, with tactile input and graphic output. Embedded in the use of the abacus are the important concepts of the principle of position and the zero. The word algorithm for a period of time referred exclusively to positional numeration, before expanding into its current, more general usage (Dantzig). So this early device manifests a very important concept in a visual form that can be manipulated and changed. And this device was meant to be used in a strict manner that became an automatic program in the minds of those who used it extensively.

Mechanical devices were created to do the actual steps of addition and subtraction, but the harder tasks of multiplication and division were automated by Leibnitz. Leibnitz, in the earliest commentaries on user interface, said the computer should be used as a timesaver, to relieve good minds from the drudgery of calculation. He also suggested the machine would help in generating tables for curves, a foreshadowing of the eventual development of modern computers out of a need for ballistic calculations (Goldstine).

Peirce was the first to suggest the use of electricity for the computer (Burks). But it was Von Neumann and Turing who defined the electronic digital computer as we know it today. The model of a computer has changed little; it is still seen as a deterministic machine that reads and writes. Change has only taken place in the technological

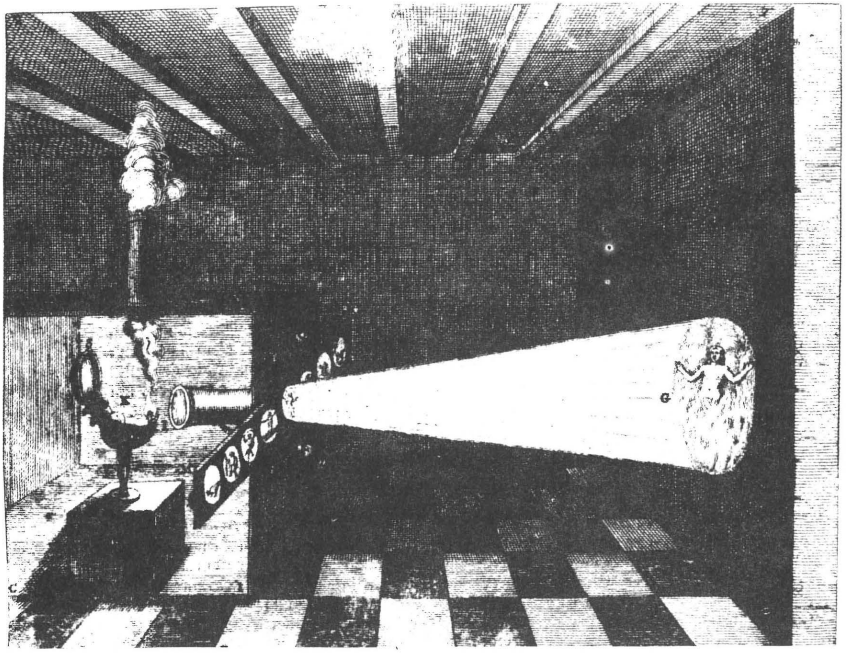


Figure 3. An illustration by Athanasius Kircher of the magic lantern, 17th century.

methods of reading and writing, change resulting in the present CRT terminal.

The modern CRT functions as a bitmapped graphic screen, in effect a visible array of computer memory. Each cell is given a light intensity value; the eye synthesizes these memory cells into an image, whether the image be a diagram or a page of text. In this way the CRT functions as an output device from the computer. Input to the computer can be made through a mouse, a pointing instrument that rolls across a flat desk area. The mouse allows the user to make choices directly off a CRT, speeding up and spatializing the interface.

The CRT has already been championed as a new model for the mind (Kosslyn). For a period, the mind was compared to mechanical devices: wheel-spinning, gear-meshing, hand-ticking machines. And internal images have been described as shadows on the wall, theater, paintings, photographs, and cinema, which all stress the dream-like, passive side of thought (Figure 3). Now the computer in conjunction with the CRT terminal forms the current model of the mind. It is an external object that is much closer to our conscious imaginings. Elements of both clockwork and cinema are involved, with the addition of the interactive qualities of the computer.

Signs

Interaction, whether it be between two people or a person and a machine, occurs by means of signs. We shall look at the visual realm in reference to Peirce's most fundamental division of signs, that between Icon, Index, and Symbol. This trichotomy explains the relationship of signs to the exterior (dynamic) objects that determine them. We concentrate on the Iconic and Indexical signs in order to point out the possibilities of the visual computer interface.

A *Iconic Signs*

An Iconic sign is a sign that represents its object through similarity. Peirce describes a further breakdown of iconic signs into images, diagrams, and metaphors:

> Those which partake of simple qualities, or First Firstnesses, are images; those which represent the relations, mainly dyadic, or so regarded, of the parts of one thing by analogous relations in their own parts are diagrams; those which represent the representative character of a representamen by representing a parallelism in something else, are metaphors. (Peirce 2.277)

A1 *Images*

Images are the lowest level icons. They are mainly mimetic, such as a drawing of an object (Figure 4). In current computer vernacular, the term icon refers only to these kind of signs, such as a line drawing of a file folder or an eraser. Such images have the advantage of being memory devices that can be used by non-readers, but also suffer from the possibility of misinterpretation. As soon as the object they represent is frozen by convention, they lose their iconic qualities and take on the role of symbols.

There is a current emphasis on this lowest level iconic sign, which is seen as an antidote for the over-symbolic nature of the older interfaces. The problem in the current interface is in the under-use of the really important visual signs, diagrams.

A2 *Diagrams*

A diagram is analogous to the object or process which it represents. The analogy is generally carried out by mapping a certain characteristic of the object onto a dimension of space. The diagram can appear analogous through its spatial connection (Figure 5). Peirce describes the diagram as being topological; the skeleton of set relationships.

The concept of projecting a characteristic onto a spatial dimension can be extended into projecting onto the time dimension. While on the

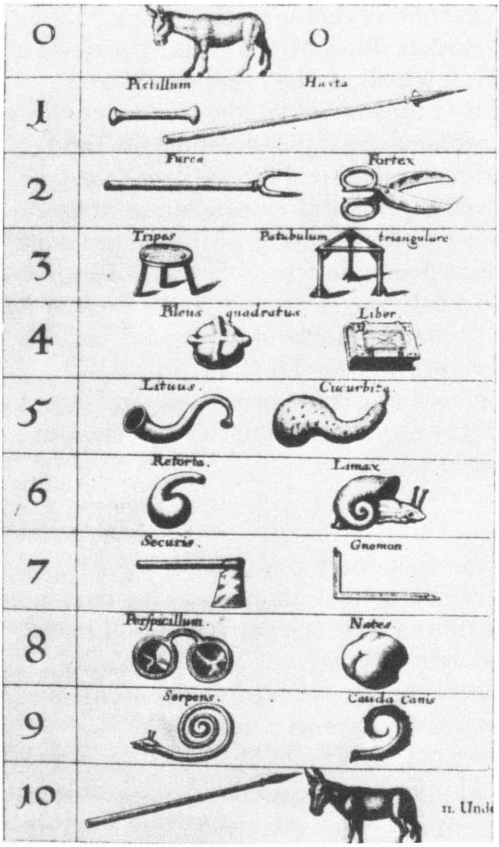
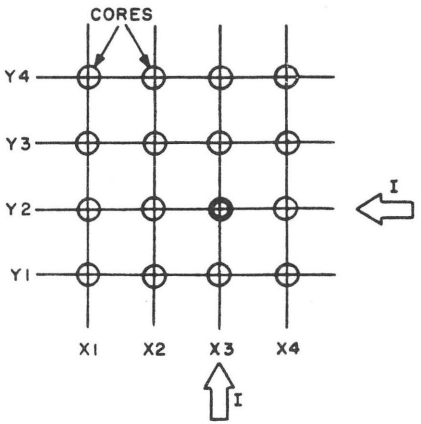


Figure 4. Robert Fludd's *Numerorum Descriptio,* 1617.

Figure 5. A diagram used to explain core memory. The topology of the lines is similar to the topology of the computer circuits.



printed page an arrow may indicate flow, using a computer a point may move across the screen. Another alternative mapping projects onto an auditory dimension. That which can be represented by a rising line can be represented by a tone of increasing frequency. These kinds of alternative projections are impossible in print, and a currently unused but potentially powerful tool for the user interface.

Pitts and McCulloch, in discussing the brain, write about "a useful general principle which we may call the exchangeability of time and space. This states that any dimension or degree of freedom of a manifold or group can be exchanged freely with as much delay in operation as corresponds to the number of distinct places along that dimension."

In the computer we have a crude analogue for the brain which allows us to perform the kind of exchanges the brain accomplishes. The time domain can be profitably used for the purpose of extending the dimensions of the user interface.

A3 *Metaphors*

A Metaphor is a general diagram that encompasses a series of mappings. Metaphors for the user interface have changed as the technology has improved. We have moved from the papyrus-scroll model, in which information streamed vertically off onto a roll of printer paper, to the current desktop metaphor, in which one is presented with an electronic version of series of pages on a desk.

This desktop metaphor is not a satisfying one; it suggests a certain kind of civil service drudgery. Many other metaphors are possible, all emphasizing a particular aspect of the interface. A model of the interface as that of a roomful of blackboards would suggest that not only text, but also diagrams might be scribbled on the board in the quest for the solution to a problem. A model based on the dashboard of a car would suggest a highly interactive, highly visual interface.

B *Indexical Component*

The above analogy between a dashboard and a computer screen brings forward the concept of an interface linked to the real world. Peirce sites a barometer or a weathervane as being diagrams that function as indexical signs. The list of such indicators can be extended to include speedometers, gas gauges, clocks, and all the other instrumentation we rely on to give us information about the world (Figure 6).

These instruments detect changes in the immediate environment, yet there exist broader, long term indexes, such as economic indicators. When one manipulates abstract lines on the computer termi-

nal, one is playing in the realm of possibility. When one generates a chart from statistics supplied by the marketplace (Figure 7), one brings the diagram into the realm of actuality. The power of such indexical signs is obvious, if only from their extensive use in science and business. Yet the user interface has not taken advantage of the computer's ease in generating such signs.

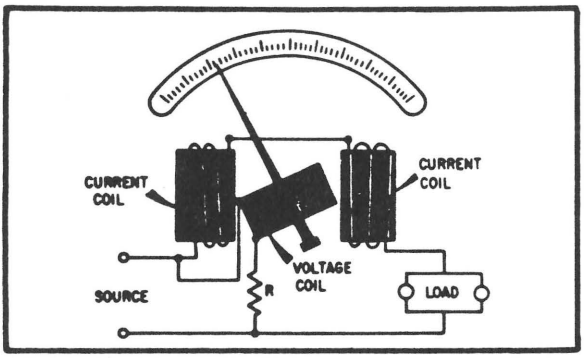
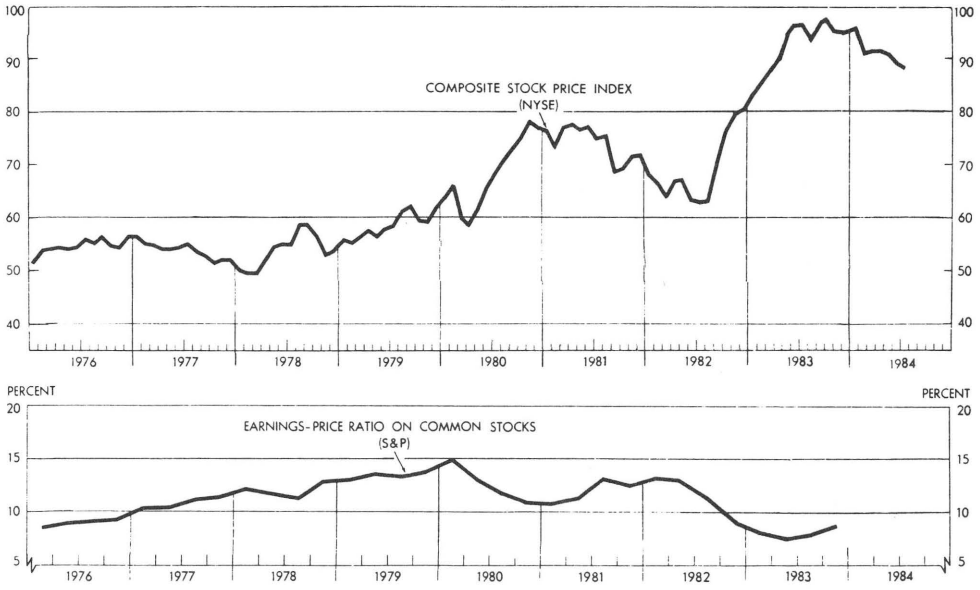


Figure 6. A wattmeter circuit, an example of an indexical sign generated electronically.

Figure 7. An economic index.



In a footnote about the indexical characteristics of language, Peirce writes:

> Once a logician had to construct a language de novo — which he actually has almost to do — he would naturally say, I shall need prepositions to express the temporal relations of before, after, and at the same time with, I shall need prepositions to express the spatial relations of adjoining, containing, touching, of in range with, of near to, far from, of to the right of, to the left of, above, below, before, behind, and I shall need prepositions to express motions into and out of these situations. For the rest, I can manage with metaphors. (2.290)

Peirce points out that prepositions are indexical in that they refer to a situation relative to the observer. This passage suggests a kind of visual language that links to the rest of the world through indices.

Significance

The diagram represents precise information in such a way that the human mind can determine the information's significance (Figure 8). Peirce writes:

> For a great distinguishing property of the icon is that by the direct observation of it other truths concerning its object can be discovered than those which suffice to determine its construction. Thus, by means of two photographs a map can be drawn, etc. Given a conventional or other general sign of an object, to deduce any other truth than that which it expicitly signifies, it is necessary, in all cases, to replace that sign by an icon. (2.279)

The importance of the icon is tied to the concept of similarity, which in turn is tied to the concept of continuity. Peirce saw the importance of this continuity, and more recent research in semiotics, mathematics, and computer science is affirming his concern (Nadin). In the field of neuroscience, the brain is being modeled as a continuous manifold of high dimensionality (McCullough, Anderson). Its nature is analogue, its algorithms statistical. In contrast, the computer is discrete, digital, sequential. If, as Peirce claims, discovery involves replacing symbols by diagrams, then the computer cannot discover anything. The computer can, however, display information in the form of diagrams that can be observed and manipulated by the human user. And the computer can compute statistics, which can provide the user with further refined information (Nadin).

Windows as Frames

The best way to represent statistics is through the diagram, and the best way to calculate them is often from different levels of globality, or different frames, or different degrees of resolution. The computer

x	$e^{-x^2}\int_0^x e^{t^2}dt$	x	$e^{-x^2}\int_0^x e^{t^2}dt$
0.00	0.00000 00000	1.00	0.53807 95069
0.02	0.01999 46675	1.02	0.53637 44359
0.04	0.03995 73606	1.04	0.53431 71471
0.06	0.05985 62071	1.06	0.53192 50787
0.08	0.07965 95389	1.08	0.52921 57454
0.10	0.09933 59924	1.10	0.52620 66800
0.12	0.11885 46083	1.12	0.52291 53777
0.14	0.13818 49287	1.14	0.51935 92435
0.16	0.15729 70920	1.16	0.51555 55409
0.18	0.17616 19254	1.18	0.51152 13448

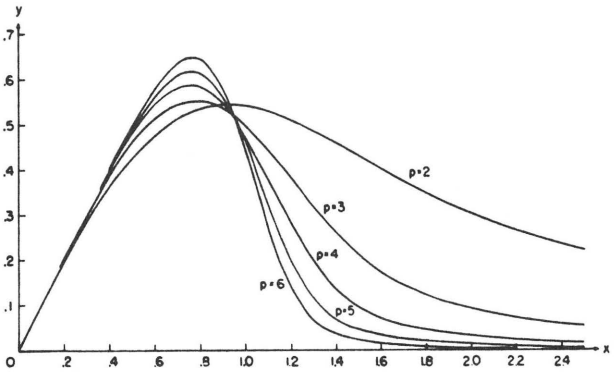


FIGURE 7.2. $y=e^{-x^p}\int_0^x e^{t^p}dt.$

$p=2(1)6$

Figure 8a, 8b. A table of values as it might be stored in computer memory, compared to a diagram of the same values as it might be displayed for a computer user.

should present its stored information and the results of its calculation in a form which will allow the mind to assess significance. Such a presentation takes advantage not just of the symbolic powers of language, but also of the continuous, parallel, multi-level nature of the mind. Peirce writes:

> All necessary reasoning without exception is diagrammatic. That is ,we construct an icon of our hypothetical state of things and proceed to observe it. This observation leads us to suspect that something is true, which we may or may not be able to formulate with precision, and we proceed to inquire whether it is true or not. For this purpose it is necessary to form a plan of investigation and this is the most difficult part of the whole operation.... But the greatest point of art consists in the introduction of suitable abstractions. By this I mean such a transformation of our diagrams that characters of one diagram may appear in another as things. A familiar example

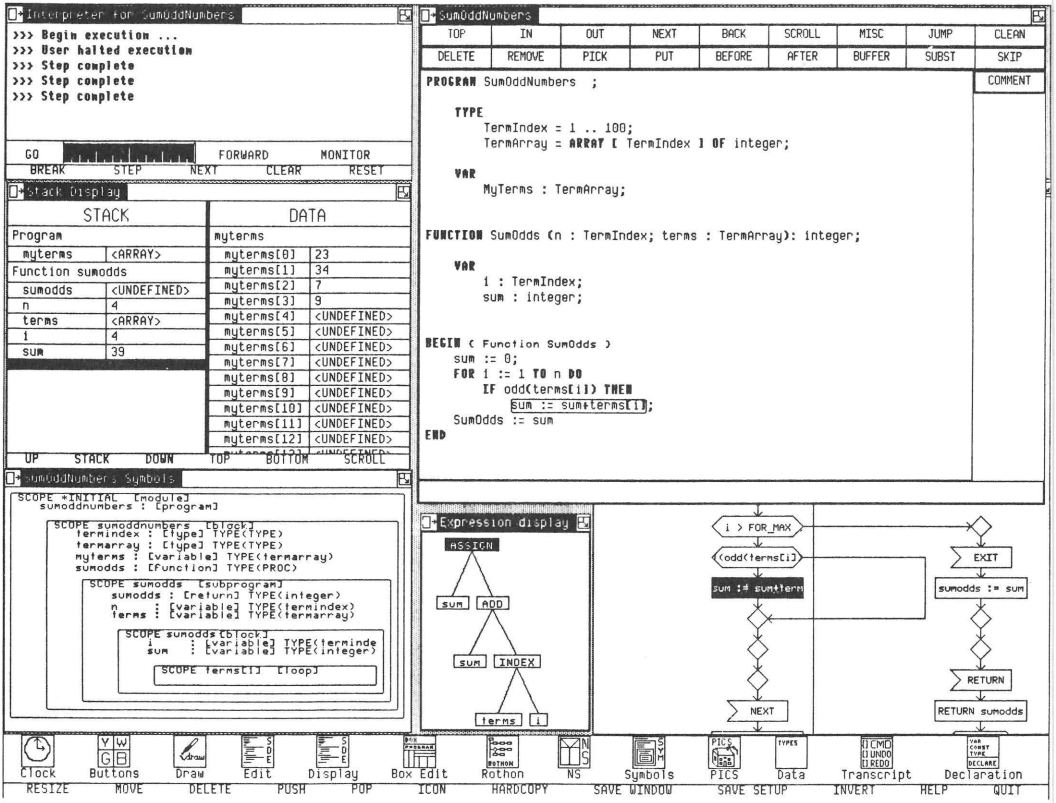


Figure 9. Steven P. Reiss's Programming Environment, illustrating the sophisticated use of windows with diagrams.

is where in analysis we treat operations as themselves the subject of operations. (5.162)

This passage suggests an interface in which a particular relationship, or diagram, is treated as an object, a node, in a higher level diagram. The human being is able to simultaneously keep both views in mind, the level and the meta-level, the details and the overview. Computers are notoriously bad at such tasks, but this process of framing is at the root of intelligence. Framing can be implemented in the interface with windows on the screen, simultaneously presenting the details and the overview, and allowing the user to steer through whatever level of detail is appropriate at a given point in time.

While windows exist in current interfaces, the software that uses them is still primitive. Outline processors are an attempt at a multi-

level interface, but these programs must be moved from their verbal emphasis to a more visual perspective if full utility is going to be gained from presenting windows in parallel.

Windows in the interface allow for multiple viewpoints based not only on hierarchy, but also on other criteria such as the location of certain data on the machine. The end effect is virtual parallelism, in which windows correspond to processes, in which one feels like one has many simultaneous jobs going and many different options for giving input or receiving output (Figure 9).

The user has the ability to create his own environment, an environment that becomes a kind of personal memory system, an environment that allows him to spatialize the sequential and linear nature of the machine.

The user interface should be tailored to take advantage of the human mind's abilities. The computer has precision, but cannot assess significance. The best kind of interface allows the user to determine significance, and steer the machine to the next set of retrievals or calculations. Such an interface makes use of the diagram, a form of iconic sign that allows new information to be deduced from it. Such diagrams can be tied to the actual world through indexical signs in the form of labels, or they can be determined by indexical data in the same way the direction of a weathervane is determined by the wind. Finally, a user needs an interface that allows for attacking multiple problems simultaneously, and attacking individual problems from multiple perspectives.

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