ALPHABETIC LITERACY AND BRAIN PROCESSES

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Several relationships are explored in this paper to support the hypothesis that writing systems affect cognitive strategies at a deeper level of human information-processing thatn is generally accepted in present-day psychology. It appears reasonable to claim that the structure of orthographies is strongly correlated with the specific linguistic features of the languages they represent. The Greek alphabet developed in the high density area of different Mediterranean cultures and its lineage combines features of the Sumerian and the Egyptian scripts. However, it was worked out as an adaptation to the specific needs of the Greek language. The word "alphabet" presents enough ambiguity to warrant a category distinction between consonantal and vocalic types of alphabetic systems. Both types require different processing strategies. Among the indicators of such differences, it has been observed that both orthographies adopted different orientations. In almost all varieties of alphabets and syllabaries, consonantal systems have been written leftwards while vocalic ones have been written to the right. Why? The answer to this question may be found in different neurophysiological constraints imposed to the brain by different types of orthographies.

The object of this paper is to raise a basic question concerning the underpinnings of the Western culture. Did the fully phonetic alphabet invented by the Greeks circa 740 B.C. (for a discussion of a possibly earlier date, see Naveh, 1982) and still used today in Greece (and in the rest of the West in its latinized version) have a conditioning impact on the biases of specialized brain processes in our culture? Could the alphabet have acted on our brain as a powerful computer language, determining or emphasizing the selection of some of our perceptual and cognitive processes? This question has already been raised in terms of hemispheric specialization by Joseph Bogen (1975, p. 29):

Did the fully phonetic alphabet invented by the Greeks c.750BC... have a conditioning

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It is likely that some anatomical asymmetry underlies the potential for hemisphere specialization, but it is also clear that the extent to which capacities are developed is dependent upon environmental exposure. Although humans of any culture, so far as we know, have the potential for reading and writing, many remain nonliterate and thus fall short of acquiring the most special of left-hemisphere functions. Conversely, we can readily comprehend the concept of a society in which "right-hemisphere illiteracy" is the rule. Indeed, our own society (admittedly complex) seems to be, in some respects, a good example: a scholastized, post-Gutenberg-industrialized, computer-happy exaggeration of the Graeco-Roman penchant for propositionizing.

During the seventies, split-brain research gave rise to a number of scientific and popular theories, among which a book by Julien Jaynes (1976) called *The Origin of Consciousness in the Breakdown of the Bi-Cameral Mind.* In it Jaynes claimed that different aspects, including the invention and development of writing, of ancient Greek culture were responsible for the rise of self-consciousness in the Western world. Though this notion had already been entertained by different avenues of classical, psychological and anthropological scholarship, especially by Innis (1950), Onians (1951), Snell (1953), Havelock (1963, 1982), McLuhan (1963), Barbu (1972), Olson (1977) and Goody (1977), Jaynes' thesis was original because he was the first to have tried to bring neurological consideration where others had only made guarded references to psychological and cognitive changes. The reason why Jaynes' own attempt was largely inconsequential is that his speculations on the impact of culture were far too

impact on the biases of specialized brain processes in our culture.

general and could have been applied to any cultural ground, without making a specific case for the development of the Greek world. Jaynes' work is very controversial and, some (Earl Hunt, personal communication) claim that it is not sufficiently scientific to warrant consideration. However, it has been the object of a symposium on consciousness at McMaster University in 1983 and received critical attention from several scholars (Witelson and Kristofferson, 1986).

More to the point, neurologists have begun to compare the effects of brain lesions in different cultures and are discovering, for instance, that some Chinese and Japanese patients who have suffered specific brain injuries do not evidence the same reading and writing impairment as some corresponding Western patients (Sasanuma, 1975). The reason for that may be that their scriptforms are processed in a different way and that, in turn, this fact modifies the organization of their cognitive processes. A real contribution can be made by the neurosciences if it can be shown that specific features identified in orthographies such as, for instance, the orientation of the signs and the direction of writing, relate to neurophysiological constancies in processing, such as visual-field preference or sequential versus holistic processing. Then the uninterrupted observation of simple rules of orthographic lay-out over several thousand years could conceivably be explained by correlations between neurological and graphological features.

1. The Lateralization of the Greek Alphabet

The theme explored in this paper was suggested by archeological observations concerning the direction of writing in the Ancient world from Sumer to Classical Greece. There was indeed a possibility that the direction of syllabaries and alphabetic systems could provide clues to the organization of some neurological processes involved in reading and writing. The main argument here is that when the Greeks borrowed their writing system from the neighbouring Phoenicians, they changed the direction of writing from their model's right-to-left orientation to a rightward direction. To write their own language with the 19 consonants and 3 semi-vowels of the Canaanites, the early Greek writers had to accommodate some of those letters to represent vowel sounds needed for their own vowel based morphemes. In so doing they created the first writing system based on a fully sequential phonemic representation. By comparison, ancient syllabaries and even the most sophisticated semitic scripts were approximations that required the reader to supply the oral context to decipher the text. What is implied here is that the reader of Arabic, for instance, or Hebrew, must supply the values of the vocalic intervals between the consonants. The problem of the reader of syllabaries is different in that, though the vocalic values are included —

either within the syllabic sign as in Japanese Kana or as stand alone vowels which constitute a full syllabic sign as in the Akkadian syllabary — the syllabic combination is not always systematic; some syllables, as will be shown below, must be contracted to enable the reader to achieve a consonantal grouping such as CCV. In the case of syllabaries the problem is not to supply missing vocalic values, but to eliminate them where they are superfluous.

One of the earliest scholars to hint at the cultural relevance of the relateralization of Greek writing was the Canadian cultural historian Harold Innis (1950) whose succinct description can serve as the ground for the evidence: "Following the Semites the Greek began by writing from right to left, but they continued in a boustrophedon style and finally, by the end of the fifth century, wrote from left to right and generally reversed individual Semitic letters".

According to A. G. Woodhead (1981), it is not possible, for lack of precisely datable evidence, to claim that all the earliest Greek epigraphs were written from right to left. Even in the eighth century B.C., now acknowledged by most scholars as the earliest period of extant Greek epigraphs, there may already have been some isolated instances of writing from left to right, just as there are later samples of writing in random directions following unspecified designs up, down and sideways. It is assumed that scriptforms were subjected from the beginning to a certain amount of experimentation which followed various trends in various places (Jeffery, 1961). However, the second period of Greek alphabetization is well documented. It is possible to date the appearance of what is known as the boustrophedon style to the beginning of the sixth century.

The boustrophedon was a stunning departure from previous models of scriptforms, as it was written continuously in both directions, to the right and to the left alternately in uninterrupted horizontal lines starting from the top to the bottom of the writing surface. There was no separation provided for individual words and no segmentation of any kind and the orientation of individual letters followed faithfully the alternate directions of the line.

THEBOUSTROPHEDONWASASTRIKINGDEPARTUREFROMPREVIOUSMODELSOFSCRIPTFO

ITFELEHTOTDNATHGIREHTOTSNOITCERIDHTOBYLSUOUNITNOCNEVITTERWSAWSIASMR

NUNINTERRUPTEDHORIZONTALLINESSTARTINGFROMTHETOPOFTHEWRITINGSURFACETH

KYNAFONOITATNEMGESONDNASDROWLAUDIVIDNIROFEDIVORPNOITARAPESNOSREFER

INDANDTHEORIENTATIONOFINDIVIDUALLETTERSFOLLOWEDFAITHFULLYTHEALTERNATED

A B O U T F I F T Y Y E A R S

A F T E R T H E B E G I N N I

N G O F T H E B O U S T R O P

H E D O N A N O T H E R S T Y

L E B E G A N T O A P P E A R

I N A T T I C A T H E R E G I

O N O F A T H E N S A N D L A

T E R I N O T H E R G R E E K

C O M M U N I T I E S T H I S

I S T H E S T O I C H E D O N

A W O R D D E R I V E D F R O

M T H E M I L I T A R Y T E R

M K A T A S T O I C H O U S W

H I C H M E A N S B Y O R D E

R L Y R A N K S W O O D H E A

D S A Y S T H A T T H I S N E

W G E N R E W H I C H I S E V

I D E N C E D O N A T H E N I

A N W A L L S A N N D S T E L

A S F R O M T H E M I D D L E

O F T H E S I X T H C E N T U

R Y R E Q U I R E D T H A T A

L L T H E L E T T E R S B E W

About fifty years after the beginning of the boustrophedon, another style began to appear in Attica, the region of Athens, and later in other Greek communities. This is the stoichedon, a word derived from the military term *kata stoichous*, which means "by orderly ranks". Woodhead says that this new genre, which is evidenced on Athenian walls and stelas from the middle of the sixth century, required that all the letters be written in the same direction to achieve an effect of orderly regularity according to the equidistant positioning of each individual letter.

R. P. Austin (1938) suggests that the guiding principle of the creation of the new style was the need to align the vertical traces of each individual letter to insure a vertical continuity from the top to the bottom of the writing surface. The search for a geometrically precise equidistance is evidenced in some epigraphs by faint traces of a grid pattern on the stones that bear the inscriptions. The stoichedon style was incompatible with the bidirectional practice of the boustrophedon because one of the criteria of its regularity and lapidary beauty was the alignment of the vertical segments of all the same letters which reappeared in the text. Since the vertical segments in several letters, notably B, Γ, E, K, and P, are not centered, but to the left of the character, such letters when presented in the retrograde direction of the boustrophedon would appear to the right and disturb the alignment. This theory is plausible, but there is no direct evidence to support it.

The choice of this initial orientation was not stablized one way or the other at the inception of the style. There are several vestigia of stoichedon from the middle of the sixth century to the end of the fifth which are written leftwards although the majority read rightwards. The third and last phase of the incipient alphabetization of Greece took the shape of a bureaucratic decision which was taken in Athens in 403/2 by Archinos, then the archont of Athens, to homogenize the writing of official documents. This decree, according to Austin and Woodhead, merely reinforced and institutionalized the existing predominant trend of writing from the left to the right from the earliest beginnings of the stoichedon style.

Reviewing the developments of Greek writing, one can tentatively conclude that the first period of alphabetization demonstrates a condition of lateral indeterminacy biased by a pronounced tendency to follow the pattern imitated from the Semitic models (Jeffery, 1961; Woodhead, 1981). The second period is marked by an ambilateral practice which seems to have also applied to the orientation of individual letters. At this point, in spite of the well established practice of word breaks in the Phoenician models, there is no attempt at chunking words, sentences or even paragraphs: letters follow each

other in a single continuous snaking sequence from the top to the bottom of the writing surface. The third period introduced the final stage of rightward laterality which we still observe today after 2,500 years.

The explanations provided for this mysterious though orderly development of Greek epigraphy range from considerations of esthetics (Austin) to possible changes in the posture and the writing material of the scribes. To be sure, there are material and cultural reasons for these shifts of direction, and they have been propounded convincingly by several authors (Sirat, 1976; Jackson, 1981). Other scholars such as Etiemble (1973) throw up their arms and claim that the orientation results from a combination of chance and the inertia of custom.

By and large chance occurrences, custom and material causes would be satisfactory explanations for the changes if there were sufficient reasons to believe that serendipitous processes with serendipitous results were always at work. However, one thing which should have alerted us long ago to take the matter seriously is the fact that among all Semitic (that is, consonantal scripts and their derivates numbering about 50) there is not a single one which at any time has been written consistently in any other direction than to the left (de Kerckhove, in press). Conversely, there is hardly a single vocalic script, among several hundreds, which has not been either written rightwards outright, or soon been reverted to the rightward direction within a hundred years after its initial appearance. Beside the Greek, there are other cases of initially leftward orthographies such as the Etruscan and the Latin alphabets and the Ethiopic syllabary, which were reoriented rightwards, but only after they began to include fixed signs for vowels. I might add that almost all syllabaries, which by definition must include signs for vowels, are written rightwards. The main exceptions are Japanese Kana and Korean Hangul which were written leftward until recently when both forms adopted the rightward direction in the wake of westernization. These exceptions are interesting for different reasons. If my theory is correct, both should have been written rightwards in the first place; however, Japanese Kana was invented long after the Japanese had adopted the Chinese characters (which now constitute the body of Kanji signs) and consequently would follow the direction of their established writing system which was leftward. The case of Hangul is even more interesting in that these characters can be considered either as syllabic structures or, more to the point, as modified ideographic structures. In this case there would be little resistance to follow the pattern of the Chinese script which is known to have strongly influenced the Korean system. This is particularly plausible as the script was written vertically until the recent westernization.

Thus there are so few exceptions to the general rule correlating consonantal alphabets with a leftward direction and vocalized scripts with a rightward one, that I have been led to investigate whether the brain, not the culture, was primarily responsible for the determination of the direction (de Kerckhove, 1981, 1982, 1984b). This hypothesis, which is testable on a purely logical level, may have profound socio-cultural implications if it is also tested at the neurobiological level.

2. Contextual Versus Sequential Orthographies

To understand what role the brain may have to play in coding and decoding orthographies, we must first be clear about the relationships between oral languages and their scriptforms. The morphemic structure of Semitic languages is based on a division of labour between vocalic and consonantal sounds. By and large the consonantal sounds mark the lexical value of individual words while the vocalic intervals modulate their relationships, that is, their grammatical roles (Lafont, 1984; Sampson, 1985). This is the reason why vowel signs are not indispensable in Semitic scripts. It is almost always possible to recognize the meaning and the structure of the line of writing by the order of the consonants, provided that the reader can supply the vocalic sounds by contextualizing the consonantal signs. This economy of signs is not available to Indo-European languages such as Greek or Latin because the morphemic structure of their vocabulary includes vocalic sounds to distinguish one word from another. For example, whereas the radical for the word "writing" in Hebrew is fully expressed by the three consonants K-T-B, the radical of the same word in Greek, ΓΡΑΦ requires the vowel α (Jurdant, 1984).

There are three structural features which help to distinguish the systems of the Greek and the Phoenician alphabets: the presence of characters for the sound of vowels, the orientation of the written line to the right, and a relative indifference to word and sentence segmentation. This last difference, subject however to great variations over time and space, comes from the fact that Semitic scripts must depend upon word separations, whereas in vocalic alphabets and syllabaries such segmentations are largely optional. These distinctive features are not aribitrary. They are extremely relevant to what follows. But in order to reach a satisfactory explanation for such peculiarities, we have to go somewhat deeper than the surface correlations between sight and sound. Here is a set of propositions which should serve to ground speculations concerning some cognitive processes involved in coding orthographies (Figure 1).

FIGURE 1. EIGHT PROPOSITIONS ON CODING PHONOLOGICAL SCRIPTS

1. Speaking is acting symbolically on auditory representations
2. Reading/writing is acting symbolically on visual representations
3. Because phonological writing is based on a visual representation of auditory sequences, it is bound structurally to present characters in sequences
4. The linguistic structure of Semitic languages requires that the emphasis of phonological representation be placed on the visual representation of consonantal sounds alone
5. The linguistic structure of Indo-European languages requires that both vocalic and consonantal sounds be visually represented
6. To decipher consonantal alphabets it is necessary to combine the symbols by contextual sequence, that is to supply the auditory component
7. To decipher vocalic alphabets it is sufficient to combine the symbols by contiguous sequence
8. Likewise, to decipher syllabaries it is necessary to combine the symbols by contiguous sequence, but it is also necessary to monitor the meaning by context.

1. We can claim that one of the properties of any oral language is to enable man to act symbolically over and above his ability to behave pragmatically. One can structure one's activity either by gesture or by speech, or both. Acting symbolically, however, implies an articulation of differentiated elements which have to be combined in an orderly fashion.

2. We can also assume that writing — any kind of writing — by emphasizing the representation of human experience in articulated forms further refines and strengthens this capacity to act symbolically. In fact, writing enables man to act on representations. Except for Braille and other specialized systems, writing is usually a visual representation of speech or thought. However, it is quite a different thing to act on speechforms than to act on the iconic representation of their semantic contents.

3. Phonological writing, as opposed to ideographic or other pictographic writing forms, emphasizes the process of representation by redoubling it: indeed, phonological writing represents language which in turn represents experience. Phonological writing is a visual representation of an auditory representation. Because the auditory representation of language consists of an ordered succession of sounds, its visual presentation must perforce also evidence the orderly succession of characters which address the individual sounds. This is the principle of the sequence or the principle of linearity.

4. However, the structure of Semitic languages, because it reserves the use of consonants alone to distinguish the lexical values of individual words from each other, has led the inventors of Semitic orthographies to place an emphasis on those characters (i.e., the consonantal ones) to represent speech visually. This implies that the vocalic sounds — which are not used for lexical oppositions but are necessary, nevertheless, for the full expression of oral speech — are left in abeyance in Semitic scripts. They are the intervals between the consonants and they have to be supplied by the reader.

5. The structure of Indo-European languages requires that the vocalic components of linguistic sounds be included in the visual representation of the language because they are just as critical as the consonantal components to discriminate between different words at the lexical level. The inclusion of vocalic sounds represented by characters for vowels in the phonological orthographies of Indo-European languages (that is, in alphabets and in syllabaries) implies that no only the lexical values but the grammatical values also are both represented in the scripts. Consequently, there is no need for the reader to supply its oral context to decipher the written line. The auditory dimension of the text is adequately represented by the sequence of visual characters in alphabets and syllabaries alike.

6. Because they are structurally bound to an equal degree to represent the sequence of the phonological articulations of oral speech, Semitic as well as Indo-European scripts must present their characters in succession, namely in a linear sequence. However the sequence in Semitic scripts is not linear to the same extent as it is in Indo-European alphabets and syllabaries. In order to decipher Semitic scripts, because the reader has to supply the missing elements (the vocalic intervals), he or she cannot directly combine the sequence of letters as they appear on the line of the script. The consonants are "written" and the vowels are "oral". By reading the decipherer of Hebrew or Arabic "gives life" to the text. He or she relates the shape of the letters to sounds which are given, not by the text (that is, the succession of the letters themselves) but by the global context which these letters summon. Therefore, the exact decipherment of the line of script depends not only upon the sequential order of the characters, but also upon the contextual order of the words which alone permits the reader to choose safely among different potential interpretations of any single group of letters. This is the principle of contextuality.

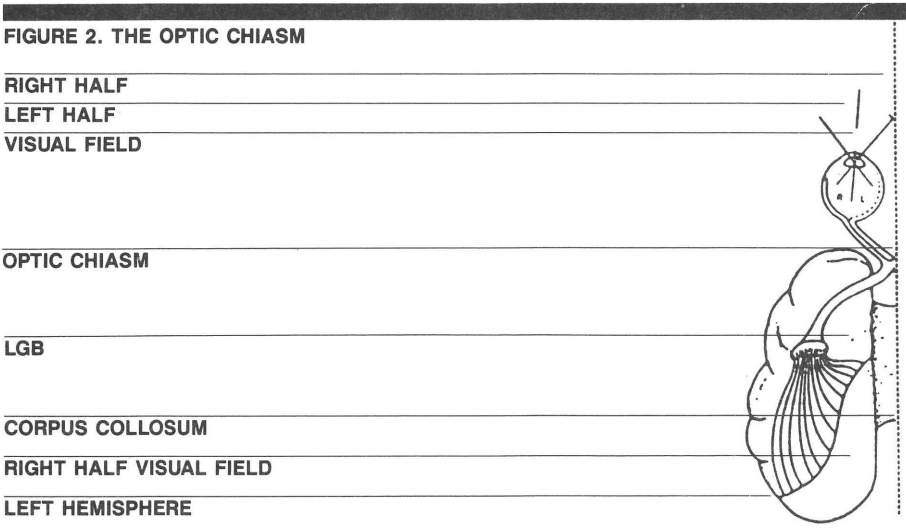
7. To decipher vocalic alphabets and syllabaries (that is, merely to access the auditory representation of meaning, independently of the semantic values of the text) it is sufficient to combine the shapes of each individual letter into syllabic units and then to further combine

these units along the linear sequence of the letters. This implies that, for the purpose of decipherment at least, the reader does not need to rely on the meaning of the whole sentence or of its context, but merely on an abstract process of letter recombination. This property enables the alphabet to preserve both the content and the linguistic structure of "dead" languages such as Latin or Classical Greek, or, in the case of the exacting Indic syllabaries, to preserve even the complex phonological values of dialectal variations over millennia (Lafont, 1984). The reading process of Indo-European alphabets and syllabaries is ruled by the principle of sequential contiguity which does not and cannot apply to decoding consonantal alphabets.

8. Likewise, to read syllabaries the principle of contiguity is predominant. However, because syllabaries are meant to represent as exactly as is possible the phonological sequence rather than the combined lexical and grammatical structures of speech (Lafont, 1984), they cannot be as clearly detached from the oral context as is the case for alphabets. In the case of syllabaries both principles of contiguity and contextuality are brought into play, but the first one to be applied in all cases is that of contiguity to enable the reader to combine the syllabic symbols into a sequence of sounds. The reason why — in spite of the sophistication of the phonemic analysis implicit in some syllabaries such as the Indic or the Korean Hangul, or even the Ojibway/Cree systems — these orthographies have remained faithful to the principle of syllabic as opposed to phonenic division, is precisely because they are meant to emulate phonology not merely to represent it as is the case for Indo-European alphabets.

Assuming that reading phonological sequences which do not include letters for vowels is really a different thing from reading fully phonetic sequences, it is conceivable that the different direction evidenced

FIGURE 2. THE OPTIC CHIASM



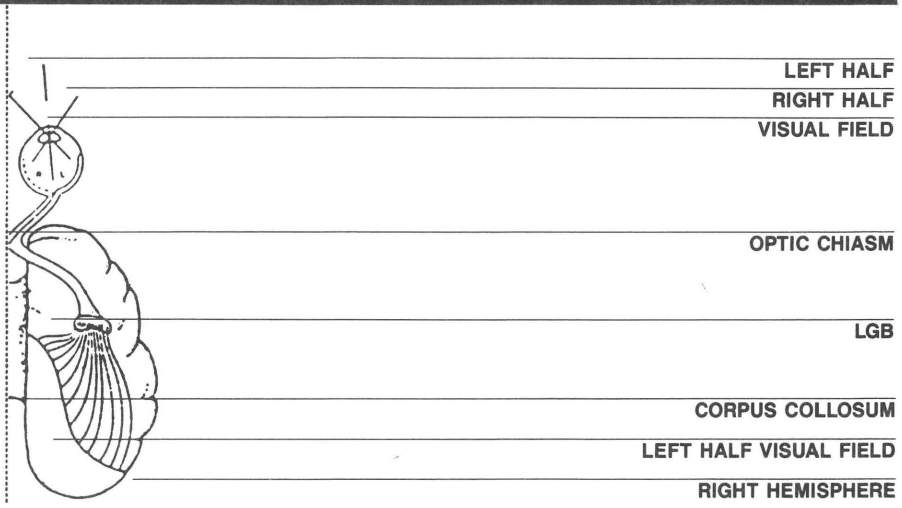
by the lay-out of the scripts not only reflects important differences in physiological processing but also provides a reliable indication concerning at least the lateralization, if not the precise location of whatever process is involved.

3. Direction of Writing and Brain Specialization

Neurological investigations over the last twenty years, especially in aphasiology and amnesiology (Geshwind, 1968, 1972; Krashen, 1972; Galin, 1974; Marcel et al., 1974; Kinsbourne, 1982), have shown that the lateralization of cognitive processes is a critical issue to distinguish the differences between specific tasks performed in different areas of the brain. It is well known that each hemisphere largely controls the opposite side of the body. For instance, it is known that the right hemisphere of the brain is better equipped to deal with objects presented in the left-visual field, while the left hemisphere processes faster the objects which are presented in the right visual field (Kimura, 1966, 1969, 1973; Tzeng, 1982).

The reason for this is, first of all, anatomical: it is the phenomenon known as the optic chiasm (Figure 2) which requires that the visual field of each eye be split vertically, with the right visual fields of both eyes being controlled by the left hemisphere of the brain, while the left visual fields of both eyes are controlled by the right side of the brain. More specifically, it appears that within the visual system of a normally lateralized subject, the right hemisphere is better at deciphering icons and images, while the left side of the brain is better at analyzing sequences (Krashen, 1975; Moscovitch, 1983).

These preliminary, rather crude observations first led me to speculate that, all considerations of posture and writing material put aside



(for discussion on writing postures and neurological correlates, see Levy and Reid, 1976, and Shanon et al. 1978), iconic and pictographic writings might favor a kind of neurological processing which would be quite different from that which is elicited by phonological systems. This notion is already receiving ample support from a growing literature on Japanese aphasiology and alexia. The Japanese are indeed ideally suited to provide evidence on matters related to writing because, they, and they alone today, share with the ancient Akkadians the privilege of using together two systems of orthography: the iconic Kanji and the syllabic Kanas. Localized aphasias among the Japanese give evidence that if a given lesion destroys the ability to decipher one system, it occassionally has little or no bearing upon the ability to decipher the other (Jones and Aoki, in press; Sasanuma, 1975; Hatta, 1981; Tzeng, 1983).

But there is more. Some thirty years ago, also intrigued by the conflicting reports on the effects of different types of aphasias, the linguist Roman Jakobson (Jakobson and Halle, 1956) compiled enough evidence to regroup the major effects in two categories that matched his own linguistic categories. He classified the effects of brain lesions into disturbances of relationships of *similiarity* and of *contiguity*. In the first instance, the patients seemed to be unable to bring together different words, notions or images into a coherent whole. However, though without showing evidence of understanding it, they could easily decipher whatever reading material they were presented with. The other group could relate different objects or words by observing their correspondances and similarities, but they could neither read, nor even put together a single sequence of simple letters. Since that time, data has poured in from neuro-biologists and, recently at the University of Toronto's Memory Disorders Unit, from amnesiologists (Schacter et al., 1984; Schacter, 1985), to show that indeed people need at least these two processes to read, think or speak, and that they are located in different parts of the brain.

To be sure, the controversy is not that such processes are not differentiated, but rather that they are in localizable areas of the brain (for a review of the controversies over brain localization see Corballis, 1980, 1983). That indeed is another matter altogether. I do not pretend to resolve it here, but only to make a workable suggestion. Let us recall the clinical evidence that feature detection is best performed by the right hemisphere if objects are presented to the left-visual field, while the left hemisphere's analytical processing abilities are enhanced if the objects are presented in the right-visual field (Kimura, 1966, 1969; Tzeng 1981, 1983; Tzeng and Singer, 1981; Moscovitch, 1983). The suggestion is that with a consonantal alphabet the reader requires from his or her brain rapid feature detection to facilitate contextual relationships. This is something akin to establishing

what Jakobson called the relationship of similarity, which for the present purpose I would like to rename relationship of *contextuality*. It stands to reason that such scripts that depend primarily on feature detection will require less reaction-time from the brain if they are written to the left rather than to the right of the visual-field. The reason being that, appearing first and moving into the left-visual field, they will be addressing by priority the most appropriate part of the brain.

Conversely, if we accept the existing clinical evidence that the right-visual fields of both eyes are better suited to effect sequential combination than the left-visual fields, then the need to facilitate the left brain's access to the order and arrangement of complete letter groupings may have been sufficient to determine the pattern of rightward orientation of coding and decoding vocalic scripts. When one is reading a vocalized alphabet, one should summon primarily the brain's ability to process contiguous sequences. This process, in turn, is akin to establishing what Jakobson calls relationships of contiguity. Ultimately, the rightward direction of the scripts must follow because the most urgent task of the brain, in this case, is to combine the signs together, a task best performed by the left hemisphere, and presented in optimal conditions if the line of writing is proposed to the right visual field.

A parenthesis should be opened here to dispel a possible misunderstanding concerning foveal vision which, of course, is the operative visual mode for reading. To be sure, the scanning process of reading, irrespective of saccadic movements of the eyes, depends on focusing, even for short periods of time, on the narrowest area covered by the line of writing. At that point and, presumably, at every point where both eyes begin their saccadic movements, the foveal vision is strongly involved. And of course, there is no evidence to indicate that foveal vision is susceptible to laterality preferences. On the contrary, standard neuro-anatomy suggests that the information presented to the fovea of both eyes is distributed to both hemispheres at once. This, however, does not invalidate the argument, because reading horizontally is a dynamic process requiring eye movements to scan the surface of the line in one or the other direction. It is the scanning process which is affected by preferential decoding strategies rather than the visual system per se. Though this suggestion is more applicable to horizontal forms of writing, it is interesting to note that even in the case of vertical scripts like Chinese or Egyptian hieroglyphic, in the composite characters which contain both pictographic and phonological clues, the former are placed on the left and the latter on the right of the sign. This feature should be investigated to find out whether the habitual scanning process may affect foveal vision itself.

To return to the principal argument, modern Arabic or Hebrew which have to give precedence to the iconic features of groups of characters over their sequential order would spontaneously favor the left-visual field (for further investigations in the correlations between scriptforms and visual field preferences, see Bryden, 1978; Silverberg et al. 1979). Conversely, Greek, Latin, Cyrillic and all other phonetic scripts, which can fully rely on the contiguous combination of the letters without the need to depend primarily upon the proper separation and the order of groups of letters, would favour the right-visual field and be written rightwards (for other avenues of investigations along the same general lines, see Debes, 1979; Taylor, 1983).

Conclusions

Summing up the above observations, here are the major hypotheses:
1. Different types of orthographies affect different processes of the human brain in differing proportions.
2. All orthographies elicit at least two fundamental responses from the brain, the recognition of the shape of the letters and the analysis of their sequences.
3. The aspects concerning the shape tend to be processed preferentially in the left visual field, while the aspects relating to the sequence tend to evoke a more accurate and faster response from the right visual field.
4. Thus contextual relationships requiring speed of feature detection may involve more readily the specific properties of the right hemisphere.
5. Contiguous relationships requiring speed of feature connection would conversely involve more readily the special abilities associated with the left hemisphere.
6. The Indo-European alphabets and syllabaries differ from Semitic consonantal alphabets by the fact that they attempt to present a visual analogue of the complete sequence of oral speech. It gives precedence to contiguous over contextual relationships in the coding and decoding processes. It is the priority given to the sequencing over the contextualizing of the characters which determines neurophysiologically the direction of these orthographies to the right.
7. Conversely, it is the priority given to feature-detection and contextualizing which determines neuro-physiologically the direction of Semitic consonantal alphabets to the left.
8. Finally, the Indo-European alphabets differ from syllabaries, but only marginally, in that the latter require almost to the same degree contiguously and contextually bound decoding processes to be deciphered. This explains why a small percentage of the world syllabaries have been, for a period of time, written to the left.

The implication behind these observations is that even though we can assume that both hemispheres always collaborate in the production of mental representations of the world "out there", they contribute different and complementary processes in differing proportions according to the kind of training and development they have been subjected to (de Kerckhove, 1984b). Thus when the brain has been trained by a fully phonetic code, it is conceivable that it will develop according to biases which are characteristic of the special abilities of the left hemisphere and which would not be so pronounced in non-literate conditions. If the developing mind has been exposed to the alphabet or to an environment strongly conditioned by a literate culture such as ours, the complex interactions normally engaging both hemispheres during instances of information processing are likely to be ruled predominantly by the left hemisphere.

Why is this selection of laterality so important? Precisely because we are dealing with the processing of language. The mental organization and representation of language implies the structuring of thought itself. It is not indifferent to cognition whether language evokes images and attitudes directly or whether it is analyzed in the mind. It has been said (Galin, 1974; Krashen, 1975) that, just as visuo-spatial relationships would require a greater involvement on the part of the right hemisphere, temporal sequences are processed mainly by the left hemisphere. This is a useful way of distinguishing the properties attributed to each hemisphere. Assuming that there is some validity to such a distinction, the overarching consequence of the hypothesis presented above would be that vocalized alphabets may have brought reading and writing in line with speaking as effects of the timing properties of the left hemisphere. It has become a commonplace that oral languages are processed mainly by the left hemisphere. Some neurobiologists (Krashen, 1975; Nebes, 1975; Kinsbourne and Lempert, 1979; Changeux, 1983) suggest that speech finds its place in the left hemisphere, not ontogenetically, but because the left brain's timing processes reflect and accommodate the serial nature of the production and the reception of linguistic sounds. If that is indeed the case, it can also be suggested that the adoption of vocalized alphabets may have more than any other system promoted and reinforced reliance of left hemispheric strategies for other aspects of psychological and social information processing.

Thus for those people who are learning to use the Greek or other fully phonetic alphabets, the serial and timing properties associated with the left hemisphere in normally right-handed people may be given a special emphasis on the ground rule of processing. Such properties which favour bit-by-bit analyses of items or chunks of information could eventually be deemed to rule the coding and decoding opera-

tions involved not only in reading and writing, but also in "thinking". It is a matter of whether, in the mind, language is processed as "oral", that is as evoking immediate and direct responses, or as "written", that is as an object of mental scrutiny and interpretation.

Thanks to the complete alphabetic sequence, the reading brain can rely on the succession of letters without having to check its interpretation with reference either to the oral rendition of the text, or to the immediate context of the statement, or to the situation of the reader. It is this level of abstraction which enables language to be processed in the mind as "written" rather than as "oral". Because of this release from the obligation to contextualize, the reader can understand the text by a purely conceptual use of language. The written word will refer not to a reality, not to an image of reality, not to an idea of reality, but first of all to a mental image of a sound which itself can eventually yield an idea or an image of reality.

Furthermore, the principle of combining letters to form syllables and of combining syllables to form words, enables the reader/writer to perceive and use each level as a separate unit. As Lafont (1984) has suggested, the invention of the Greek alphabet opened the era of grammar. There is, in Plato's *Phedrus*, a revealing comparison drawn between the letters of the alphabet and the organization of concepts: just as letters constitute a finite set of modular structures which can be combined to form a higher level of modules, each alphabetically written word automatically acquires the status of a separate concept and such concepts, if need be, can be ordered together in abstract sequences before they are put to the task of describing a given reality.

In Western philosophy, which is predicated on a written rather than an oral tradition, what most people call "thinking" is a predominantly conceptual and sequential activity. It is the ability to organize concepts in chains and sequences. "Speed" reading (that is, registering written information at high speed) appears to be more relevant to our culture than "deep" reading, which is restricted to hermeneutics and literary criticism. The order and succession of concepts generated by reading are more important, more "significant" than their full elaboration in the imaging processes. As Plato's philosophical investigations into the nature of discourse and, later, Descartes' *Méthode* for scientific enquiry amply demonstrate, the literate bias has been to break down information into parts and to order such parts in a proper sequence.

Metaphorically, one could say that this was the beginning of artifical intelligence. There is not much which is "natural" about Western intelligence. Indeed, I am considering the possibility that the adop-

tion of the alphabet by Western cultures has had a reordering effect on the brain and the whole nervous system of literate people, including their sensory modes (de Kerckhove, 1981, 1982), an effect comparable to changing the program of a computer. With full phonetization, writing seems to have acquired a precision, a flexibility and a paradoxical meaninglessness comparable to computer programming codes. I do not mean by this that alphabetic writing turned people into computerized automatons, but that it made language available for a kind of information processing which is, technically, and especially in scientific investigations, very close to a mathematical model.

In evolutionary terms, with the Greek alphabet, the development of writing was moving further and further away from the context of immediate experience and taking its place as the abstract code of reality. It became possible to read meaningfully strings of visual speechforms which contained radically new ideas, concepts or notions, some of which could even be completely foreign to the reader, because he or she did not have to depend upon previous knowledge to decipher them. Hence the origin of the first truly comprehensive scientific investigations which were dependent upon a system of archival recording which was not bound to the traditional usages of oral speech, but only to the specialization of reliable written documents based on progressively more reliable empirical observations. This conclusion has intuitively and tentatively been reached by many scientists and cultural observers and its consequences for the reinterpretation of cultural differences and historical developments may require a paradigmatic shift in scientific and scholarly investigations.

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