Cognitive Processes Involved in the Recognition of Chinese Characters

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The Starting Point: Graphic Features

Long ago the Chinese people developed the habit of thinking in terms of images. They also formed the habit of writing and recognizing scriptforms in terms of images. In fact, these diverse cognitive processes – thinking, writing and decoding in terms of images – have been interacting and reinforcing one another for thousands of years, and, as a result, have played a significant role in shaping Chinese culture and the Chinese mind, and have become a part of the collective unconscious of the people.

Although today the Chinese characters are highly abstract and symbolic, the language still preserves its pictographic and ideographic prototypes, the parent script which evolved almost six thousand years ago. In other words, although modern Chinese characters are no longer actual drawings of objects, ideas, and images, they still have a blood relationship to these primitive forms. Their graphemes, configurations, or grapho-semantic radicals still bear direct semantic relation to their referents, so much so that it would be fair to describe the development of Chinese writing as an overlapping process as well as a gradual one.

Chinese characters are, in fact, so different from alphabetic scriptforms that many Europeans and Americans feel as though they are interpreting and drawing pictures when they learn to read and write the language.

The unique structure of the Chinese characters makes it interesting to speculate on the extent to which readers of Chinese rely on image or icon, or graphemic mediation, especially when compared to readers of alphabetic writing systems, who depend on phonemics (phonemic mediation). We would be justified in saying that

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the unique identity of Chinese rests in its graphic features and that these must be the starting point of any study or research on the psychological, physiological, or brain processes underlying the recognition or reading of the script.

Psychological Processes Involved in the Recognition of Chinese Pictographs and Grapho-Semantic Radicals

Modern Chinese characters consist of both grapho-semantic and phonetic compounds. The following analysis of the unique role played by the pictographs and grapho-semantic radicals in the formation of these compounds allows us to conclude that recognition of the script may start from the perception of the images or icons represented by the characters, or, from graphic and graphemic mediation. The processing mechanism where they are examined, analyzed, and likened, by analogy, to the prototypes (a description of typical instances of meanings and concepts) stored in the brain lexicon.

The difference between the psychological process involved in the recognition of Chinese characters on the one hand and that involved in decoding alphabetic scriptforms on the other may be due to the fact that recognition in the first case seems to follow a direct route, or have direct lexical access because the graphemes are semantically loaded, while recognition in the second case follows a phonological route, or has what is called indirect access because its graphemes are semantically empty. In other words, recognition of most Chinese pictographs involves visual-spatial or perceptual-spatial tasks – what some Chinese scholars call "visually ruled" tasks – while recognition of alphabetic scriptforms relies on phonologically based or rule-based tasks – what scholars call "phonologically ruled" tasks.

Metaphorically, the Chinese are raised in a cultural environment where visualization (literally looking and seeing) takes precedence over comprehension or deduction. The saying "Trace analogy so as to visualize meaning" and then "Forget the analogy once meanings are arrived at" best characterizes the Chinese mode of cognition and thought – intuitive, concrete, analogical, and imaginative. This saying also highlights the ways in which Chinese characters were invented, written, recognized, and acquired. In fact, the expressions "trace analogy" and "visualize meaning" are dialectically related in this context. In ancient times Chinese characters provid-

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ed the tools for illustrating analogy, they were born of analogy, and analogy was born of objects, meaning, or ideas. Analogy therefore became a tool for expressing and interpreting meaning. To "trace analogy" in this way was the prerequisite, while "to visualize meaning" was the objective.

This saying served both as a guide to the Chinese in inventing their writing system and also as a tool, enabling them to recognize and master that system. It has proved instrumental in the organization of cognitive activities and brain strategies, and has long been a psychological habit.

Pursuing the hypothesis that the recognition of Chinese pictographs takes a direct route, i.e., without intermediate phonological decoding, it may be supposed that the psychological process underlying recognition is primarily visual-spatial, perceptual-spatial, configurational, and gestural-visual. In other words, the recognition of Chinese characters, especially pictographs and graphosemantic radicals, is primarily intuitive, holistic, concrete, and analogical in nature. It is totally different from the decoding of an alphabetic system, which might be characterized as deductive, analytical, abstract, temporal, and linear. This unique psychological process obviously has to do with the iconic or pictographic nature of the script. The same psychological strategies may be involved in the recognition of ideographs as well, since these structures were, and still are, visual-spatial, perceptual-spatial, synthetic, and symmetrical.

Brain Processes Involved in Deciphering Chinese Pictographs

Studies in neurological and mental functions, along with research on aphasia, amnesia, and hemispheric lesion or impairment have shown evidence that there are neurological correlates of language, and that linguistic performance depends primarily on the left hemisphere of the brain. It is widely an accepted fact that the two sides of the cortex perform different tasks and the two hemispheres of the brain are specialized in different cognitive processes; the precise distribution of these tasks varies according to whether one is right-handed or left-handed. Speculation on the lateralization and localization of cognitive and linguistic processes in the brain has recently been extended to incorporate the study of modes of recognition connected with writing systems. A growing wealth of theory, hypothesis, and experiment has shown that different writ-

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ing systems may favor different modes of neurological processing: pictographs and ideographs may favor an operation that is quite distinct from the one elicited by a phonological writing system (Hirata and Osaka 1967; Sasanuma, Itoh et al 1977; Hatta 1976,1981; de Kerckhove 1988; Tseng et al. 1984; Tsao 1988; Jones and Aoki 1988; Jia [unpublished paper]. My own research and clinical observations support this viewpoint: a tumor confined to Broca's area does not inhibit recognition of single pictographs upon loss of speech; in other words, impairment of language functions in the left hemisphere spared the mental functions of the right. The patient retained skills in the area of visual-spatial orientation, where the right hemisphere is dominant, and quite definitely retained his ability to recognize such features as characters, faces, and objects.

This observation led me to review the well-known findings in current research concerning cerebral dominance, or specialization in brain functions, which, I believe, provide a plausible explanation as to why different writing systems may favor different neurological processing strategies. The following table summarizes the well-established findings with respect to cerebral dominance or lateralization (Milner 1962; Bogen 1968–1969; Russell and Espir 1961; Kimura 1961; Gordon 1970; Krashen 1974; Lenneberg 1967).

Left Hemisphere	**Right Hemisphere**
language	features (of face, objects, etc.)
temporal order/	part to whole judgment,
time-related functions	gestalt/holistic/synthetic
logic, linear, analytical,	configurational, appositional,
digital, propositional	visual-spatial (relations),
	perceptual-spatial, analogic
deductive, abstract	intuitive, concrete,
	images, icons, graphs
semantics	music, dance, drawing,
	emotional balance
	non-verbal, visual

Obviously, the division labor in the brain is relative. Some scholars have convincingly proved that one hemisphere can perform the specific functions of the other, or that some tasks may require inter-hemispheric cooperation. Recent speculation disputes the theory of

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lateralization, alleging that the two hemispheres maintain a balance of reciprocal inhibition (Chiarello 1988) – that is, that each hemisphere specializes in certain specific cognitive domains and prevents the other hemisphere from processing information within those domains. Even this, however, seems to me to be in keeping with the hypothesis that one of the hemispheres is superior to the other, and primarily responsible for the functions listed in the above table.

From the hypothesis concerning the division of labor in the brain, we might tentatively conclude that the right hemisphere is largely responsible for processing the features of pictographs or grapho-semantic radicals, as it is specialized primarily in perceptual-spatial, visual-spatial, and relational tasks, as well as in synthetic or holistic mental activities. Similarly, the left hemisphere will be largely responsible for processing phonological scriptforms, as it is specialized primarily in tasks which conform to temporal order and are phonological (or phonemic), analytical, and abstract in nature.

Investigation into the Japanese writing system has provided the most convincing data in favor of this hypothesis, because Japanese has both pictographic and phonological scriptforms – *Kanji* and *Kana*. Speakers suffering from localized aphasia show evidence that, despite loss of the ability to recognize *Kana*, their ability to recognize *Kanji* is not impaired; damage to the one has almost no effect on the functions of the other (Sasanuma 1975; Jones and Aoki 1988). Accordingly, recognition of Chinese pictographs may favor processing in the right hemisphere. Ancient pictographs would be especially compatible with such right hemisphere processing because, from a historical perspective, the earliest characters were the closest to drawings and the least related to phonetic graphs. Furthermore, the early characters almost all belong to the category of high-frequency characters. Their frequency reaches almost 77.5 percent, sometimes even 99.48 percent. This suggests that ancient pictographs, like the high-frequency characters evolved from them, may have acted as an important reorganizing force on neurophysiological processes or the reading brain. They may have helped to elicit the processing strategies of the right hemisphere.

The Effect of the Artistic Quality of Chinese Characters on Brain Specialization

Certain other features of Chinese characters, especially pictographs, also support the theory that this type of script favors

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neurological processing by the right hemisphere. These features may be described as follows:

1. The structure of almost every character is well-balanced, proportionate, symmetrical, and square-shaped. This may induce psychological equilibrium, Gestalt, or holistic and synthetic modes of cognition, and therefore favor the specific functions of the right hemisphere.

2. Chinese characters originated from drawings or visual and iconic representations of objects, ideas, and images and, therefore, innately possessed artistic properties and the beauty of nature in their lines, forms, graphs, and configurations; thus they naturally became the rich soil on which the traditional Chinese art-form, or the mother of art in Chinese culture – calligraphy – grew up and developed. In fact, Chinese characters and calligraphy are of the same origin and have the same structure and nature; they share the same features and exert a similar influence on Chinese cognition and neurophysiological or brain processes. The implication is clear: Chinese characters may have elicited the same brain responses as Chinese art. In short, both Chinese script and Chinese art seem to possess the following characteristics, which may have had a strong effect on the right hemisphere of the brain:

a. The activity of writing, especially in ancient times, may be regarded as a kinetic art, practically an art of dance, as well as an art of forms and images. The reading and interpretation of the characters is virtually the interpretation and appreciation of dancing on the page. Writing itself is a kind of sport, or physical exercise, and it helps writers stay fit. According to data gleaned from an investigation on the longevity of ancient calligraphers and Buddhists, the calligraphers lived an average of 12.7 years longer than the Buddhists. This fact might be attributed to the exercise of writing the Chinese characters.

b. Calligraphy is an emotive art. For writers, it is an art of exporting emotions; as the saying goes, "Writings are actually pictures from the heart." For readers, it is virtually an act of importing emotions. The purpose of reading is not merely to appreciate and assess aesthetic beauty, but also to grasp the writer's feelings and attitude, since writing (the medium) itself conveys a message from the heart and the mind.

c. Chinese writing and calligraphy share the same function and have an impact not incompatible with that of kinetic and body language. When people appreciate the beauty of good writing, they

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often try, consciously or unconsciously, to trace the strokes in the air so as to recognize the meaning or to feel the configurational beauty of the characters. The kinetic outline of the hand or fingers in the air indeed helps the reader to recognize, appreciate, and even learn the characters effectively.

d. Even tools used to write Chinese characters have had a great effect on acquisition, recognition, and cognition, as well as on neurological, neurophysiological, or brain processes. The special tools – brush, ink, inkstone, and paper – have long served as independent media, enabling the handwriting to suggest the poise and flavor of a dancing stroke. Moreover, they help to imprint the writer's temperament and emotions (or what is called the temperament of the writing brush and the emotion of the ink and inkstone). Ink and inkstone also leave behind their fragrance, a fragrance that we smell, sense, recall or at least imagine when we look at the writing; each character stands out on the paper like a picture, indistinct, blurred, and beautiful, inducing a sense of haziness or vagueness on the part of the viewer. It is not uncommon that the color of these characters should seem to bear weight and that the smell should give an impression of physicality. All of this is likely to elicit synaesthetic responses.

If we take into consideration the historical fact that this phenomenon has been going on for thousands of years and that, in ancient times, the scholars were also civil servants, poets, and calligraphers, and that character-writing itself was a form of calligraphy, such a tremendous impact is easy to predict. Even six thousand years ago in the age of the Yangsha culture carvings and inscriptions were first written in brush and ink, as were the characters on tortoiseshell about three thousand years later under the Shang dynasty. It might be suggested that Chinese characters not only suscitate identical psychological and neurological processes, but also exert an identical influence on Chinese culture and the brain.

The Effect of Phonetic Loan Characters and Phonetic radicals in Grapho-Semantic and Phonetic Compounds on Neurophysiological or Brain Processes

Speculation about right hemisphere lateralization in the brain processing of Chinese script should not allow us to overlook the effect of the phonetic loan characters, which were formed and developed by phoneticization of the pictographs. As noted earlier, each

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Chinese character is a self-contained unit of form, sound, and meaning. Therefore, almost every Chinese character is a multi-coded word. The phonological element, including the phonetic radicals in the compounds, must have played an important role in structuring these characters and in guiding reading and recognition; consequently, the psychological, physiological, and brain processes connected with reading modes are probably very complicated.

The Chinese writing system is made up of several types of graphs: pictographs, ideographs, compound ideographs, loan characters, and grapho-semantic and phonetic compounds. Loan characters are borrowed on the basis of their phonetic values and serve mainly to indicate pronunciation. Originally each loan character represented a different, homophonous word. New and old characters may or may not be related semantically; those which have only a phonetic value, therefore, become what are called amorphous loan characters. To a great extent the phoneticized characters may be regarded as syllabic scriptforms or "quasi-phonetic graphs." These loan characters are possibly quite similar to the syllabic *Kana* in Japanese script.

What further complicated the matter in history was the development of the grapho-semantic and phonetic compounds, which were formed mainly by adding grapho-semantic radicals to the loan characters. Such compounds, however, eventually came to represent over 90 percent of the total number of Chinese characters. Here, the grapho-semantic radicals and phonetic radicals stand symmetrically, with the former approximately marking the semantic value and the latter indicating the value of the sound. Of the elements in this compound, the grapho-semantic radicals will probably elicit responses in terms of images, icons, or graphemes and graphs, while the phonetic radicals are most likely to elicit responses in terms of phonological forms or, at any rate, through an intermediate phonological stage. Some of the phonetic radicals, however, partially indicate meaning, while some indicate only pronunciation. The purely phonetic radicals might be compared to the syllabic *Kana* of Japanese, which are "quasi-phonetic graphs" in nature and effect; this is why grapho-semantic and phonetic compounds are also called morphemous and phonetic compounds.

Since there are numerous grapho-semantic and phonetic compounds, it follows that there should be many phonetic radicals. According to recent investigation, there are over one thousand

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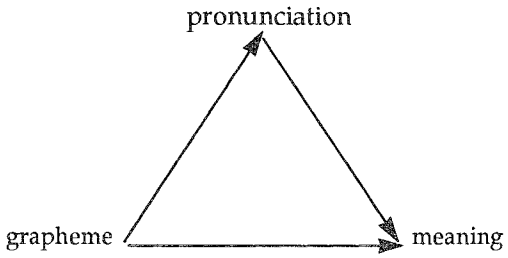
phonetic radicals altogether, which surely means that the role they play in recognition and cognition, as well as their effect, must be borne in mind. As both elements may favor the same psychological, neurophysiological, or brain processes as the syllabic *Kana* of Japanese script, it would be fair to say that, where Chinese characters are concerned, reading not only involves the right hemisphere but also the left, with its aptitude for apprehending phonological forms. In other words, both processes are required in order to read or recognize Chinese script and they may be underpinned by the two hemispheres of the brain or the interplay between the two. The typical assumption that the reading or recognition of Chinese characters depends mainly on images or icons underpinned by the right hemisphere seems to be based on investigation concerning the recognition of pictographs and ideographs. To some extent this assumption disregards the importance of the effect of the loan characters and the phonetic radicals in the compounds.



This diagram shows that the meaning of a Chinese character may be represented either by graphemes (or graphs), or by pronunciation (indicated by the loan character or the phonetic radical). However, the graphemes (or graphs) may represent meaning directly, whereas the phonetic loan characters or radicals indicate meaning indirectly.

The grapho-semantic and phonetic compounds which were formed and developed on the basis of the pictograms and ideographs, and through the intermediate stage of the phonetic loan characters, make up the majority of the total inventory of Chinese characters and constitute the main stream of the Chinese writing system. This category of characters, in fact, represents the inevitable and logical outcome of a long historical development

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and therefore should be the critical issue in any study of Chinese script in relation to psychological, neuro-physiological, or brain processes.

Of the grapho-semantic and phonetic compounds, which comprise over 90 percent of the Chinese characters, the grapho-semantic left and phonetic right is the most frequent configuration. So it can be asserted that the tendency towards the formation of grapho-semantic and phonetic compounds in the historical development of Chinese characters was, in fact, marked by tendency towards a configuration in which the grapho-semantic component became fixed on the left and phonetic component on the right. It is assumed here that the formation and development of this compound occurred in correlation with the division of labor in the brain over the course of the many years during which the reading and writing of Chinese characters was processed. If this hypothesis is valid, then this compound, together with the phoneticization of the pictographs – or the so-called phonetic load characters – and the subsequent formation and development of the grapho-semantic and phonetic compounds in general, may have played an important role in reorganizing neurophysiological processes and brain strategies.

The Reasons for Evolution

Why did grapho-semantic and phonetic compounds ultimately come to constitute the majority of Chinese characters? Why did grapho-semantic left and phonetic right compounds eventually make up the majority of grapho-semantic and phonetic compounds? These two questions have long puzzled Chinese linguists and scholars, although it seems that the first has now been answered. The second question, however, as yet remain unanswered. Grapho-semantic and phonetic compounds were formed and developed over the course of history to accommodate the needs of the Chinese language. That linguistic need alone, however, cannot account for the formation and development of the structure of the grapho-semantic left and phonetic right compound.

Historically, grapho-semantic and phonetic compounds followed, or even proved to be the inevitable and logical outcome of, the evolution of Chinese characters. Generally speaking, Chinese characters proceeded through three stages of development: pictographs and ideographs, loan characters, and grapho-semantic

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and phonetic compounds. Gradually, however, the grapho-semantic and phonetic compounds took precedence over all the rest and soon became the backbone of the entire system. As they were so apt to suit the needs of the Chinese language, they effectively controlled the number of characters and the basic (iconic) forms.

Since its origin, the category of grapho-semantic and phonetic compounds has steadily replaced all the other categories of Chinese characters. Under the Shang dynasty (1600–1100 B.C.), it accounted for about 20 percent of the 9,000 characters inscribed on the tortoiseshells which have been handed down to us. More and more of these compounds continued to appear, and under the Eastern Han dynasty (250–220 B.C.), they amounted to about 82 percent of the total 9,353 characters. Under the Ching dynasty (1644–1911) the number again increased to 8,057, constituting approximately 90 percent of all Chinese characters. At present, 90 percent or more may belong to this category, although exact data are not available. It seems logical to conclude that the evolution of Chinese characters inclined towards the formation and extension of grapho-semantic and phonetic compounds.

It was a considerable time before the configuration with grapho-semantic radicals placed on the left and phonetic radicals placed on the right became the predominant structure. In ancient times, this category was invented both by adding grapho-semantic radicals to the phonetic loan characters or radicals, and also by adding loan characters to the pictographs. At first, however, the positions of the grapho-semantic and phonetic radicals were not fixed; these were free elements, that is to say, either element could be placed anywhere in the character: at the top, on the right, on the left, in the middle, or at the bottom. Even the orientation of the radicals was free, i.e., they could face any direction: left, right, upward, downward, forward or otherwise. By the Chou dynasty (1600–1100 B.C.), however, the positions of these elements had begun to be fixed: the grapho-semantic radicals were placed on the left and the phonetic radicals were placed on the right.

Eventually grapho-semantic left and phonetic right compounds became the most common structure in that category and therefore were the most numerously represented among the various character configurations. According to some statistics, the top and bottom structure – where either radical can be placed at the top or at the bottom – represents only 22 percent of the total. The middle or circumjacently – represents an even smaller number: 7 percent of the

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total. Clearly, the historical development of Chinese characters has shown a very marked tendency towards the formation of the grapho-semantic left and phonetic right compound. This structure now makes up the majority of all grapho-semantic and phonetic compounds and accounts for the majority of all Chinese characters. The significance of formation and development of such a structure must be considered. It cannot be regarded as an accidental event in history.

The Role of Brain Processes in the Formation of Compounds

This section sets forth the hypothesis that the formation and development of grapho-semantic left and phonetic right structures was brought about by the interaction of the stimuli provided by those structures and the brain processes underlying reading and recognition modes. This interaction between the characters and brain processes may well have been going on ever since the introduction of the grapho-semantic left and phonetic right compound. In other words, Chinese characters, as external stimuli, must have corresponded to or correlated with neurological or brain processes in such a way as to allow the script to be read and decoded as effectively and as quickly as possible. Thus the grapho-semantic left and phonetic right compound may have been a reorganizing force in neurological or brain processes. At very least, it may have had an effect on cerebral organization where reading was concerned.

From studies and research investigating brain specialization, we know that, in both eyes, the optic chiasma splits the visual fields vertically into a right visual field (RVF) and a left visual field (LVF). The light in the LVF of both eyes falls on the right of the retina in both eyes, while the light in the RVF falls on the left of the retina in both eyes. The optic nerve from the right side of the retina of both eyes extends to the cortex of the occipital lobes of the right hemisphere of the brain, while the optic nerve from the left side of the retina of both eyes connects with the cortex of the occipital lobes of the left hemisphere of the brain. This suggests that the RVF of both eyes is processed by the right hemisphere. More simply, the right hemisphere is faster and better at processing information presented to the LVF and the left hemisphere is faster and better at processing information presented to the RVF.

As discussed above, the right hemisphere more readily processes or deciphers configurations, images, icons, or features and the left

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hemisphere more readily recognizes speech forms and phonological forms (see also de Kerckhove 1988). Consequently, it seems likely that grapho-semantic radicals may be processed more efficiently by the right hemisphere and phonetic radicals more efficiently by the left. In other words, when the grapho-semantic radicals are placed in the left visual field of both eyes, they will probably be processed more effectively than when they are placed in the right visual field. Likewise when the phonetic radicals are placed in the right visual field of both eyes, they will probably be processed more effectively than when they are placed in the left visual field. Therefore it seems plausible that the formation and development of the grapho-semantic left and phonetic right compound should correlate with neurological processes, or the division of labor in the two hemispheres of the brain, or that the compound be the outcome of the stimuli it created and the selectivity of the brain.

The development of this compound – from the stage when either of the radicals could be placed freely to the stage when the placement of both radicals was essentially fixed – was, virtually, a long historical process of trial and error, or hypothesis-test-adjustment with regard to scriptforms or to physiological selectivity on the part of the brain. The final fixing of the grapho-semantic left and phonetic right could not have been accidental or arbitrary – there must have been a casual or correlational connection between this structure and the lateralization of the brain.

We should not, however, overlook the effect that this scriptform may have had on the reading brain throughout the long period of interaction and development. The grapho-semantic left and phonetic right compound may have served as an effective environmental conditioning agent that predisposed its lateralization in the reading brain. In other words, the Chinese reading brain may have been sufficiently stimulated by this compound so as to participate in the normal reading process. Viewed in this light, the compound may have played an organizational role in brain strategy.

Brain Processes Involved in the Formation of Writing and Reading Direction: Vertically from the Top and Horizontally to the Left

To recapitulate, the obvious linguistic fact to emerge is that the grapho-semantic left radicals in the compound indicate meaning directly while the phonetic right radicals indicate pronunciation.

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The resultant hypothesis – that the most efficient and most accurate comprehension may be achieved when the grapho-semantic radicals are placed in the LVF (because in this way they can directly address the right hemisphere of the brain, which carries the primary responsibility for deciphering features) – allows us to explore answers to the following question: Why were Chinese characters originally arranged, i.e., written and read, vertically from top to bottom and horizontally to the left.

At the heart of the matter, speed and accuracy in comprehension depend, among other factors, on whether the reader can make the best use of contextual cues to help "words into consciousness by associative links from those which are really seen" (Huey, in Henderson 1982: 337). According to Huey, more can be read to the right than to the left of the point of fixation. "The words on the far right, although dimly seen, are helped into consciousness and preserved in the memory by associative links from those which are clearly seen" (Huey 1908: 61). (Personally, I tend to believe that this view applies primarily to the reading of alphabetic scriptforms). The point about helping words into the consciousness by contextual facilitation is essentially concerned with the role played by contextual cues, specifically semantic and syntactic connections. Obviously, there are syntactic grounds for expecting or predicting completion, for example, with noun phrases like *a glass of water*, *a cup of tea*, or *a soft drink*, but not with an activity verb like *read* following the verb *drink*. Likewise, semantic rules play a role in associative contextualization and reading speed. There are such examples as *doctornurse*, but not *doctorcarrots*. Syntactic or semantic relatedness buys speed and accuracy in reading. Conversely, semantic and syntactic unrelatedness retards reading and inhibits comprehension.

The question now would appear to be how the characters might be best arrayed – horizontally, vertically, or otherwise – so as to establish "associative links from those which are clearly seen." Since it is the grapho-semantic radicals, not the phonetic radicals, which are considered to play the most important semantic and syntactic role in facilitating reading speed and comprehension, the direction Chinese readers will eventually adopt will depend on the arrangement or contextualization specifically of the grapho-semantic radicals. Thus, ideal comprehension will be achieved only if the grapho-semantic radicals are placed in such a way that they are the first to strike the LVF, thereby encountering the reader's eyes and

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directly addressing the right hemisphere, which is specialized in feature recognition.

It is apparent that, when read or written horizontally, the characters present temporal separations, because the reading sequence is inevitably interrupted by the phonetic radicals. When the characters are read vertically, however, contextualization is almost continuous. In a horizontal sentence, the phonetic radicals, which, as we have already established, do not directly reflect meaning, may oblige the reader to make a conscious or unconscious effort to articulate the character aloud. In contrast, the best possible contextualization of the grapho-semantic radicals, which bear the semantics of each character, is effected through a vertical arrangement. It is on account of the specific structure of the characters that vertical reading most effectively facilitates speed. Every character occupies the same space, every character is square in shape, and every compound is equally divided vertically within its square space; as a result, the grapho-semantic radicals (most of which are placed on the left) can easily be aligned on the right. Thus it follows that syntactic and semantic relatedness can be established on the left; this may be reinforced by the fact that reading proceeds horizontally to the left. Strictly speaking, even if the reader perceives only the left-aligned radicals, he can probably decipher them, roughly grasping the meaning, because the grapho-semantic left radicals give priority to feature recognition.

By adopting this reading direction, it is possible to present the grapho-semantic left radicals first to the LVF, so that ". . . appearing first in the LVF, they will be first addressing that part of the brain most appropriate for feature recognition" (de Kerckhove 1988). Hence, a vertical arrangement and a left reading orientation appears to correlate with what Bersted assumed to be true about left-field advantages for identical visually-imaged stimuli. If the characters are laid out vertically so that the grapho-semantic radicals are aligned on the left and reading proceeds from right to left, it should be possible to obtain optimal contextualization, optimal semantic and syntactic relatedness, and, consequently, maximal speed concomitant with accurate comprehension.

An interesting point that should not escape our attention is that grapho-semantic and phonetic compounds with a top and bottom structure – i.e., where the grapho-semantic and phonetic radicals stand either at the top or at the bottom – comprise about 23 percent of the total number of Chinese characters. This structure is sec-

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ondary only to that of grapho-semantic left and phonetic right compounds. The high frequency of this structure may well be due to the obvious fact that, besides the position with grapho-semantic radicals on the left and phonetic radicals on the right, it is the only arrangement which allows the grapho-semantic radicals to be presented to the left visual field first, despite the fact that grapho-semantic radicals do sometimes appear at the bottom.

In summary, it is fair to conclude that reading and writing orientations for Chinese characters in context may have corresponded to neurophysiological (brain) processes, or to specialization (the division of labor) in the two hemispheres. The very direction in which the characters are written and read – vertically from top to bottom and horizontally to the left – may have resulted from the interplay of the stimuli created by the characters and brain processes, or the selectivity of the brain. This may imply that the grapho-semantic left and phonetic right compounds did indeed play an important role in cerebral recognition functions.

The Chinese Mind: From Brain to Culture

The foregoing conclusion naturally occasions speculation as to whether the introduction of the loan characters, and especially the introduction of the grapho-semantic left and phonetic right compound, into the Chinese writing system which in ancient times had such an extensive impact on literacy – had comparable repercussions on the Chinese mind, the cultural environment, and the brain. It may well have been partially responsible for the unique contribution China has make to world civilization.

The theory that the development of this compound may have corresponded to or met certain requirements of the brain may also serve to explain why Chinese characters have survived several thousands of years of testing and still remain vital today. We may tentatively suggest that the introduction of the loan characters and the grapho-semantic left and phonetic right compound, which was based on the pictograph and which passed through the intermediate stage of the loan characters, may have, in its own way, contributed as much to world civilization as did the introduction of the vowel sound into the consonantal Phoenician alphabetic script-system by the Greeks. Each of these two modifications may have had an immense impact on culture, thought, and the brain, as well as on the writing system.

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In addition, the suggestion that the reading process, owing to the multicoding of Chinese characters, may depend upon the interplay or synthetic activities of the two hemispheres would appear to be a further reflection of the synthetic or holistic mode of thinking of the Chinese.

It is generally assumed that the relationships between language, society, and culture, and the social rules, norms, and cultural values which derive from those relationships comprise the foundation upon which each society builds and develops its own structure and sociocultural reality, way of life, and so on. It may also be assumed that a culture in a given society shapes its writing system according to the features of its language. The writing system in turn further defines and molds the culture which created it, or at least affects the organization of that culture. On the one hand, literacy, as a reflection of language, illustrates its own cultural environment, especially the prevalent mode of thought. On the other hand, as an active force, it promotes and reinforces sociocultural reality, in particular the established mode of thought. In this sense, the medium transcends its boundaries and becomes, to some extent, an influential shaper.

According to this assumption, the pictographic and ideographic writing system of the Chinese, which has evolved over three thousand years and still maintains a blood relationship with its primitive form, may have acted as a powerful agent, affecting culture and thought patterns and inducing specialization processes in the reading brain.

Bearing in mind the interactional relationship between the structures inherent in the Chinese writing system and the reading brain, we should also pay attention to the impact of recognition patterns on thinking, value systems, and other aspects of Chinese culture.

As has already been explained, the semantics of Chinese characters are made relatively clear either by pictographs or by ideographs. In other words, Chinese characters correspond almost directly to the object or thought, virtually bypassing any intermediate stage involving abstract thinking and logical reasoning. This was especially true in ancient times. Unlike alphabetic script readers, Chinese readers obviously preferred visual spatial decoding strategies to phonological ones. By extension, the pictograph or ideograph may be regarded as a sort of concrete, imaginative, and pictorial concept. To some extent, it has the shaping force of intuition, vision, wholeness, telepathy, and common sense. Seen from

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this perspective, the visually-imaged characters of the Chinese writing system may be compared with drawings created for artistic purposes: the Chinese characters may induce the same response in the brain as drawings, as well as encourage the development of similar thought patterns.

In addition to the direct correspondence between graphemes and meanings or morphemes, however, there is also a direct relationship between graphemes and cultural concepts, perceptive and cognitive beliefs. That is, the graphemes of the pictographs and ideographs are themselves cultural facts. Iconic graphemes are iconic morphemes, or rather value systems, perceptive and cognitive beliefs, social norms and rules. The archetypal character 王 /*wang*/ "emperor," for example, can be used to account for man's relationship with nature. According to the saying "crossing the three horizontal lines (三) vertically in the middle makes the character 王 (emperor)." Originally, the three parallel lines represented heaven (the line on the top), man (the line in the middle), and earth (the line on the bottom). When crossed vertically through the center, man and nature are brought into harmony. This world view – a vision of the oneness between man and nature, or man's dependence on nature – is thus instilled in the reader's mind. This was especially true in ancient times when pictographic graphemes were simply pictorial drawings. Significant too, is the fact that in ancient times everyone may have been able to read these drawings; as a result, Chinese characters had a great effect on almost the entire population.

Furthermore, the graphemes themselves may also represent abstract notions, or abstract cultural concepts and values, which formerly helped to program the way people behaved. For example, the character which denotes time, *shi*, shows that under the warm sun, the seed sprouts out of the earth. This character was regarded as associated with coming and going, or, the cycle of the four seasons. What is implied is that man must adapt to changes of season or to changes in his social environment. Again, this illustrates the population's belief in the harmony between man and nature.

In addition to this world view, the early pictographs instilled in the readers' minds an awareness of abstract cultural concepts or value systems which guided conduct in society. Even though these characters are no longer interpreted in the same way today, the impact they made in the past is still felt. For example, the character which denotes "peace" was originally a pictorial drawing of a

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woman under a roof and behind a closed door, kneeling on the floor cleaning. It is suggested that if a women undertook this occupation in the home, order and peace would ensue for the family and the country. Nobody today attributes the original meaning to this character, but the ideology and philosophy left by the Chinese literary tradition are still influential in modern China, especially in the country.

In fact, the cultural concepts, value systems, social norms, and rules contained in Chinese characters have long had a definite function and have truly become mental entities in the minds of their readers. The terms in which they have helped the reading brain to organize, classify, and systematize information are concrete, analogical, holistic, and imaginative rather than analytical, linear, abstract, and deductive. Indeed, for thousands of years, they have helped to form what today we call Chinese culture.

Although scholars comprised only a small percentage of the population, they were always preeminent in formulating the philosophy and ideology which underpinned the Chinese way of life. As almost all the members of the ruling group in ancient China were scholars, it is not hard to imagine the prominent role they must have played in shaping Chinese culture.

We would be justified in saying that the non-reading brain, as in the illiterate, was conditioned by the action of the reading brain. We would also be justified in saying that this unique writing system, this unique medium, has been a sort of message, so much so that it indeed supports the claim that Chinese literacy is the mother of Chinese culture.

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