

Giyoo Hatano's Analysis of Psychological Tools

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Abacus • Kanji • Literacy • Numeracy • Psychological tools

Abstract

This paper focuses on the relation between two areas of research which owe a great debt to the work of Giyoo Hatano: the ways in which the use of the abacus mediates arithmetic problem solving and the way in which the use of the kanji writing system mediates the interpretation of unfamiliar words. These examples are related to L.S. Vygotsky's ideas about the ways in which particular kinds of mediational means can serve as psychological tools for accomplishing culturally valued problem solving. They also urge upon us the need to be cautious when we are tempted to order culturally valued mediational means in terms of a unilinear evolutionary sequence.

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As other contributors to this volume have commented, a special characteristic of Giyoo Hatano's thinking was his ability to bring fresh perspectives to the analysis of a wide variety of topics. He offered us fresh perspectives that nudged us, or forced us, to reconsider long-standing assumptions about human development. In this brief paper, I shall highlight two areas in his work that illustrate this special trait.

The first area is the way in which the ability to read kanji (in which the characters making up the writing system follow the principles of traditional Chinese orthography) influences the ability to read and interpret correct unfamiliar words. The (then) common sense idea he forced us to rethink is that there has been a unilinear evolution of writing systems that places logographic systems near the bottom/primitive end of the spectrum and alphabetic systems at the top. Thanks in no small measure to his work, we now understand that how efficient and powerful a particular orthographic system is depends on a great number of factors, including the oral language to which it is related, the cultural practices it fulfills, and the level of proficiency of the reader.

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The second area concerns his studies of the ways in which the skilled use of an abacus influences school children's skill in arithmetic problem solving. In the age of handheld calculators and computers that can easily accomplish a wide variety of arithmetic calculations, what could possibly make the use of an abacus of value in the development of mathematical thinking?

What unites these two examples, aside from the fact that both are relevant to acquiring the developmentally valued skills of literacy and numeracy, is that in each case, his analysis illustrates with special clarity L.S. Vygotsky's idea of a 'psychological tool.' From early in his career, Vygotsky [1926/1997] argued that:

The inclusion of a tool in the behavioral process, ... sets to work a number of new functions connected with the use and control of the given tool ... [and] ... reconstructs the whole structure of behavior just like a technical tool recreates the entire system of labor operations.

The most essential feature distinguishing the psychological tool from the technical one is that it is meant to operate mind and behavior. ... Therefore, in the instrumental act [using a psychological tool – M.C.] we see activity toward oneself, not toward the object. (p. 87)

Both the use of kanji by skilled readers and the use of an abacus by skilled school children illustrate this key feature of psychological tools, each in its own way, which depends critically on the functional system of which the mediated action is a part.

The Case of Kanji and Skilled Readers

To appreciate Giyoo Hatano's contribution to understanding the relationship between orthography, oral language, and reading proficiency, it is important to recall the common wisdom considering the historical evolution of writing systems as well as their social and cognitive consequences of circa 1980 when he began conducting his research.

During the 1970s, a number of influential publications, some of them by historical linguists interested in writing systems, some by psychologists and anthropologists interested in the cognitive consequences of literacy, and others seeking to understand the reason for the great difficulty that many American children experienced when learning to read, converged to bring about high levels of interest in the role of the particular orthographic principles embodied in different writing systems.

The case for a universal evolutionary sequence of orthographic principles was put forward in an influential book by Gelb [1963]. This commonly understood sequence was summarized in the following terms [Gleitman and Rozin, 1977]:

The history of writing, as we have sketched it, involves the use of successively more analytic units of language to correspond to the squiggles on the page (or rock). Change has always been in this direction: from the representation of ideas or meanings, to the representation of words and morphemes, thence to syllables, and then to the yet smaller alphabetic units of vowels and consonants ... popularly called phonemes. (p. 21)

The social and cognitive consequences that different orthographies were assumed to promote were most forcefully proposed by Eric Havelock [1976], who specialized in the study of literacy in ancient Greece. Because of the large number of graphic signs required to read and write Chinese, he wrote:

The *average* Chinese ... is limited in the number and variety of the statements he can read easily, because his ability to accommodate the shapes of a variety of symbols in his memory is also limited. ... It is even possible that the dominance of Mandarin, which makes unified communication available by non-acoustic means, may have inhibited any tendency to draw the spoken dialects together. ... This may explain the familiar paradox of a China both highly civilized and yet curiously 'backward' in a very special sense, and also the continuing difficulties which China is likely to encounter in being 'understood' by other cultures. (pp. 14, 15)

And by contrast, Havelock saw in the Greek alphabet a conceptual breakthrough that suffused Greek thought with far reaching cognitive and social consequences.

Atomism and alphabet alike were theoretic constructs, manifestations of a capacity for abstract analysis, an ability to translate objects of perception into mental entities, which seems to have been one of the hallmarks of the way the Greek mind worked. (p. 44)

Further:

The Greek system by its superior analysis of sound placed the skill of reading theoretically within the reach of children at the stage where they were still learning the sounds of the oral vocabulary (p. 45) ... [creating] a revolution that was both psychological and epistemological. (p. 49)

Overall, Havelock [1976] was claiming that mastery of the alphabetic principle was a more evolved, abstract, mode of representing oral language that provided the cognitive underpinnings of modernity, science, history, and progress. By contrast, the Chinese orthographic system, because of its presumed concreteness and the large memory demands put upon its users, was assumed to be a restricted cognitive tool that impeded modernization.

Meanwhile, in the United States, intensive research into the sources of difficulty that led many children to fail to learn to read proficiently had generated the suggestion that the task could be simplified by first introducing children to the task of reading using an artificial set of graphemes corresponding to syllables [Gleitman & Rozin, 1973]. The basic logic underlying the Gleitman-Rozin approach was that it should be possible to teach children that reading involves identifying sound/grapheme correspondences using syllables (because they are more naturally and easily communicable units of language than phonemes) without requiring them simultaneously to solve the problem of discovering correspondences at the more abstract level of the phoneme. Then, once the children had mastered the practice of reading at the syllabic level, they could be introduced to the idea that alphabetic signs provide a more economical way of identifying written-word/spoken-word correspondences because there are so many fewer alphabetic signs than the thousands of syllabic signs that would be necessary for reading in English. These researchers succeeded in showing that inner-city children who had failed to acquire alphabetic literacy could in fact be taught to read using graphic signs that corresponded to syllables, although so far as I know, their suggestion that beginning reading instruction using a syllabary has not been tested.

All of these lines of research were of interest to me when I met Giyoo because the issue of the orthographic form of a written language and the consequences of literacy had arisen in the work that Sylvia Scribner and I conducted in Liberia in the mid 1970s. Vai is written as a syllabic script and is learned in informal settings. While its use was subject to restrictions resulting from a combination of cultural factors

such as privileging its acquisition by males, the absence of means of mass production of documents, and the fact that the Arabic alphabet was the language of choice in Quranic schools, and English in government schools, the fact that the syllabary appeared to be learned with ease and used for a significant range of practices clearly resonated with Gleitman and Rozin's research. Moreover, the Vai use of their syllabary coincided with their notable role in Liberian society as entrepreneurs, suggesting social consequence of their literate practices.

Consequently, it was natural for me to take an interest in research on literacy in Japan when I visited there as a guest researcher in 1980. The Japanese use both a syllabic system and a logographic/morphographic system. The syllabic system, called kana, consists of 71 basic signs and 33 compounds (there are actually two syllabic systems with almost the same number of signs, i.e., cursively written hiragana for traditional Japanese words and square katakana for representing foreign words and names). It had been widely reported that most young Japanese children arrive at school already knowing most of the syllabic, hiragana, system, further supporting the assumption that the syllabic level provides easy access to the idea of reading for meaning [Sakamoto & Makita, 1973]. The logographic/morphographic system, kanji, that is based on the traditional Chinese orthography, is as extensive as the Japanese vocabulary, but children are expected to learn 900 characters by the time they have completed the 6th grade, approximately 2,000 kanji are considered necessary for 'common use' and those who go on to college are expected to acquire mastery over a great many more.

Nor do the apparent complications of learning and using kanji stop here. Most kanji combine a phonetic element with the basic ideographic character and most kanji words are made from the combination of two or more kanji, rendering them, in effect, compound words. There is certainly a lot to learn! Moreover, in the United States, the advent of microcomputers at the time was creating great excitement about their use to facilitate the acquisition of writing abilities, but owing to the large number of kanji and the then restricted capacities of microcomputers, computers were not in wide use in Japanese schools.¹ In light of all these considerations, Havelock's [1976] comments about the deficiencies of using an ideographic system, even one supplemented by phonetic clues, appeared not implausible. But such a conclusion would be sadly mistaken.

Giyoo Hatano's Approach to the Virtues of Kanji

In a rarely cited article, Hatano, Kuhara and Akiyama [1981] raised what appears to be an obvious question: Since the number of kinds of syllables is limited in the Japanese language because no two consonants appear consecutively, the 71 kana are enough to effectively represent any Japanese word. Therefore, one might ask: isn't the use of kanji unnecessary?

¹ The situation has now changed because the enormous increase in computing capacity of physically small computers has enabled the creation of systems for writing texts with kanji in a relatively efficient manner.

In starting to answer this question, Hatano referred to an article by Robert Glushko [1979] who had begun to raise doubts about the common wisdom about a uniform evolutionary sequence in the efficiency and power of orthographic systems. Of particular importance to Hatano was Glushko's suggestion that the value of a given orthographic system might differ depending upon the nature of the oral language it was representing and the degree of proficiency of the reader/writer. He noted that evidence had shown that experienced readers are able to comprehend a text rendered in kanji more quickly than in kana. Might kanji actually have cognitive advantages for people who have become adept in their use?

Such a possibility had been hypothesized by Suzuki [1975] who argued that for technical terms, many of which are translations of terms from one of the European languages, the use of kanji would be more likely to allow understanding than either kana or an alphabetic language such as English. First, such technical terms are generally represented with two or more kanji; they are compounds, constructed much as technical terms in English which combine Greek or Latin morphemes. Second, the kanji used to represent the terms have distinct semantic references already known to readers.

To test these ideas, Hatano presented 30 unfamiliar technical terms to three groups of Japanese college students and one group of American students. The Japanese students were presented the terms in one of three ways: as kanji, as kana, or in their English alphabetic representation. The American students were presented the terms only in the English alphabetic representation.

Examples of the kinds of words presented included the terms *limnology* and *piscivorous*. I could not define either of these words appropriately. The best I could do in the absence of any formal training in Greek or Latin was to figure out that *limnology* was probably a kind of science (*ology*) and that *piscivorous* probably had something to do with fish and eating (by thinking of terms like *omnivorous* the meaning of which I do know).

Hatano found that Japanese college students were virtually always able to interpret the kanji representation easily, and could most often figure out the terms from the kana (but they did so in a mediated fashion, using the kana to retrieve mentally the appropriate kanji and then using that mental kanji representation to infer the meaning of the technical term). However, the Japanese students could rarely figure out the meaning of the terms when represented in the English alphabet, even though they could read English. The American students were only half as capable of figuring out the terms as the Japanese students reading kanji, experiencing the same difficulties that I had when confronted with limnology.

This and related research [Kuhara & Hatano, 1981] led Hatano to the plausible conclusion that 'experienced readers of Japanese have, in addition to the usual mental lexicon of words, a mental lexicon of kanji or the corresponding morphemes as building blocks for compound words. ... The two lexicons can be used most effectively in combination, producing a flexible, large vocabulary' (p. 33).

In short, in Vygotsky's terms, kanji provide Japanese readers with a set of psychological tools which are helpful in cultural practices that involve understanding the meaning of unfamiliar, technical vocabulary translated from another language. Given the course of Japanese history, this is no small advantage, and certainly requires us to rethink universal evolutionary accounts of modes of oral language representation in writing systems.

Why Learn to Use an Abacus Expertly?

The second kind of psychological tool to which Giyoo Hatano devoted a great deal of attention was the abacus [Hatano, 1982, 1997]. As is well known, abacus experts, people who have devoted thousands of hours practicing and have achieved a high rank within the national organization of abacus enthusiasts, are able to carry out arithmetic operations with dazzling speed. So automated is this ability that they can both calculate (say) large sums and carry on a conversation at the same time. And, of special interest when considered as psychological tools, they can carry out such operations when no physical abacus is present. In vygotskian terms, they have so thoroughly internalized the use of the abacus that it has become a 'mental abacus.' Moreover, there is recent evidence that the use of a mental abacus is associated with activation of specific areas of the brain.

Despite these impressive facts about abacus use, Giyoo Hatano was very circumspect in his evaluation of the importance of children acquiring high levels of skill in the use of an abacus. Such skill, he believed, was highly compartmentalized, constituting a form of routine, rather than adaptive, expertise. As he [1982] phrased his reservations in an early paper on this topic:

In conclusion, we assume that though practice in most culture-specific procedural skills tends to produce routine experts, with developed special processes involved in their performance, it usually doesn't facilitate development of corresponding conceptual knowledge, nor competence under a new set of constraints even in the same domain. (p. 17)

Giyoo Hatano did not restrict his studies of the abacus as a psychological tool only to the context of contests of calculational speed. He investigated the way in which acquisition of skill in abacus use entered into the process of acquiring skill in mathematics as well [summarized in Hatano, 1997]. In the main, this research affirmed his belief that as a psychological tool, abacus skill was a form of routine expertise and one that was highly compartmentalized. For example, children with extensive abacus skill nonetheless committed typical errors in paper-and-pencil subtraction and high-level skill in abacus use did not help students to judge whether paired sets of numbers were equal or not (for example, 9 tens and 9 units versus 8 tens and 10 units). If abacus skills generalized at all to promote development of arithmetic ability, certainly it should aid in such operations so closely tied to calculation; but they do not.

However, in some cases, he did find advantages attributable to abacus skill. For example, abacus users were better at writing an expression for word problems such as 'There were 20 girls and 16 boys in Hiro's classroom. How many pupils were there altogether?' On the basis of this and similar results, he concluded that when abacus users show an advantage (e.g., when this psychological tool is useful beyond the narrow bounds of calculation for the sake of calculation), it is because the component skills that are acquired in abacus learning are also component skills in the arithmetic problem in question. In effect, he was arguing (citing the work of Robbie Case) that the highly automated mastery of calculation skills freed up mental working space to allow students to 'concentrate on higher-order processes including monitoring of the steps of executive strategies for checking answers' [1997, p. 227]. In addition, he suggested that their expertise gave abacus users confidence in their problem-solving abilities in addition to the benefits of reduced mental work necessary to

carry out lower-level arithmetic operations quickly and accurately. Instrumental skill has its place in problem solving, he concluded, the challenge was to create the right balance in the right way.

The Tasks We Have Been Bequeathed

In this, as in his other areas of research on human development, Giyoo Hatano provided us with a model of a skeptical yet sympathetic human being at work, of research as a process of inquiry, or re-searching, searching again, for deeper understanding of problems we thought we might have already understood thoroughly. So it is with his work on psychological tools.

With respect to the special power to be found in different writing systems, the story is far from over. In a fascinating twist of circumstances, current technological developments in Japanese literacy affirm *both* the idea of an evolutionary progression from ideogram to syllabary to alphabet *and* inversions of this evolutionary sequence in the right combinations of circumstances. Thus, while it was just beginning to be possible for Japanese people to use kanji on large, very expensive computers when Giyoo Hatano was carrying out his research on this topic in the 1980s, in the 1990s increases in computing power widely enabled the use of computers for writing in mixtures of kana and kanji. Moreover, today, on ubiquitous cell phones as well as computers, one finds Japanese people typing in kanji through a system in which they use the Roman alphabet to call up kana and kana to call up kanji, sometimes using all three systems in a hybrid system of effective communication where the final product involves all three scripts at once.

Nor has the line of research on the way in which the psychological tool of a mental abacus may influence further mathematical development come to an end. If Giyoo Hatano's speculations about the way in which children's abacus expertise could become part of a functional system of problem solving are correct, there is the still troubled domain of word problems to be investigated. If abacus skill could help children deal more intelligently with very simple word problems in which the operations were specified in a tiny script (there are 16 boys and 14 girls, how many students altogether?), how might it enter into the problem solving of more complex word problems? How much emphasis on proficiency in subskills is too much or too little to promote conceptual understanding for what kinds of problems? Here is a vast territory to be explored, a territory for which Giyoo Hatano has provided us with models for how to continue his journey into the future. The words of the English poet, Tennyson, seem an appropriate description of this process.

... all experience is an arch wherethro'
Gleams that untravell'd world, whose margin fades
For ever and for ever when I move.
Tennyson (*Ulysses*)

Giyoo Hatano provided us with an image of that arch. The journey is now ours.

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