Title

Why Semantics Lags Behind Phonology in Word Indentification

Journal

Proceedings of the Annual Meeting of the Cognitive Science Society, 17(0)

Authors

Perfetti, Charles A.
Tan, Li Hai
Zhang, Sulan
et al.

Publication Date

1995

Peer reviewed

Why Semantics Lags Behind Phonology in Word Indentification

Charles A. Perfetti
644 LRDC
University of Pittsburgh
Pittsburgh, PA 15260
perfetti@vms.cis.pitt.edu

Li Hai Tan
640 LRDC
University of Pittsburgh
Pittsburgh PA 15260
tanl@vms.cis.pitt.edu

Sulan Zhang
641 LRDC
University of Pittsburgh
Pittsburgh PA 15260
sulan@vms.cis.pitt.edu

Mara C. Georgi
645 LRDC
University of Pittsburgh
Pittsburgh PA 15260
georgi@vms.cis.pitt.edu

Abstract

Because meaning is both the common outcome and the typical goal of language processing, including reading, semantic processes have received a privileged position, especially in cognitive science accounts that emphasize semantic, goal driven components in language. Even in accounts of written word identification, a "low-level" process, it is typical to assume that semantic outputs are achieved with optional contributions of phonology. Our goal here is to present evidence for an alternative perspective, one that gives phonology a central rather than a peripheral, optional role in word identification. We first briefly discuss a writing system comparison that is important to this perspective. We then summarize recent published and unpublished research that gives definition to our conclusion that phonology is a central and universal component of word reading.

Perfetti, Zhang and Berent (1992) proposed a Universal Phonological Principle (UPP) in reading, a set of three correlated principles concerning the role of phonology across writing systems. The central principle is that, in any writing system, encounters with printed words automatically lead to phonological activation. This activation includes phoneme constituents of the word and its pronunciation. We focus here on the second principle: Writing systems constrain the details but not the inevitability of phonological processing. The UPP claims that all writing systems, regardless of orthographic depth, lead to phonological involvement, although not necessarily mediation. Chinese is an important test for the UPP. (The idea that writing systems constrain word reading was proposed in the Orthographic Depth Hypothesis of Frost, Katz and Bentin, 1987.)

Chinese writing is usually considered a logography, i.e., a system in which the basic unit in writing associates with a unit of meaning (morpheme) in the spoken language. A pure logography would be controlled by a morphological principle, and reading would produce meaning without any reference to a word's phoneme constituents. In a pure logography, there is no letter-like unit; neither is there a syllable-like unit in the usual sense, making a logography in principle very different from both alphabetic and syllabary systems.

The idea that Chinese is a pure logographic system, however, has come under critical scrutiny. DeFrancis (1989), for example, argues that the phonological component in Chinese writing has been underestimated by the simple logographic analysis. Phonetic elements were not as important in earlier Chinese but the writing system has evolved, according to DeFrancis, into a system that is dominated by compound symbols that carry both semantic and phonetic information. Such compound symbols consisting of two single characters comprise a substantial portion of Chinese characters (82%, according to Zhou, 1978). Zhou estimates that 39% of these compounds contain a component with a pronunciation similar or identical to that of the compound, leaving 61% with a pronunciation different from that of the compound, a condition of possible interference. Thus the value of the phonetic compound in ordinary reading is unclear at this stage of research on Chinese reading. However, the argument that there is a significant phonological component for the Chinese writing system is beyond dispute. Moreover, whether there is a role for character components in word identification is not central for our argument -- which is that the retrieval of phonological word forms occurs as a routine part of Chinese reading.

Chinese Reading: No Semantics without Phonology?

The view that Chinese is a meaning-based logography has led to a corresponding idea about Chinese reading: The process is one of script-to-meaning. In this view, Chinese readers apply a visual-to-meaning route in which phonology plays no role. However, recent evidence suggests a rather different view of reading Chinese, one in which skilled Chinese readers activate phonology as part of the reading process.

Phonology in Chinese Text Reading

The first point to make is that reading Chinese is not different from reading English in its use of phonology, once words have been identified. Earlier studies suggesting that Chinese readers show a reliance on phonological codes in memory (Tzeng, Hung, & Wang, 1977) and comprehension tasks (Tzeng & Hung, 1980), places reading Chinese in the same category as reading English, French, or Japanese. Phonological codes are activated in a working memory

system in support of comprehension (Baddeley, 1979; Levy, 1977; Perfetti & McCutchen, 1982; Slowiaczek & Clifton, 1980). More recently, Zhang and Perfetti (1993) report evidence that confirms the functional working memory locus of phonological processes in Chinese text reading using tongue-twisters, sentences or paragraphs that repeat initial phonemes (Haber & Haber, 1982; McCutchen & Perfetti, 1982).

Phonology in Chinese Word Identification and Lexical Access

According to the UPP, there should be a role for phonology at the earliest point permitted by the writing system. In a field that has long sanctioned a distinction between "pre-lexical" and "post-lexical" phonology, our claim, instead, is that word identification in Chinese is "at-lexical". Chinese reading suggests, perhaps in a way that alphabetic writing systems do not, that "pre-lexical" vs. "post-lexical" is a complex and perhaps a misleading question. More generally, all word reading events, including meaning access, involve word identification, and thus all word reading involves phonology.

According to the UPP, there should be phonological activation as the character is actually identified. Evidence comes from the priming experiments of Perfetti and Zhang (1991), which primed a briefly presented target character with a briefly presented prime character. These experiments varied the duration of the character prime and exposed the target for 35ms under an average 50% threshold. If the pronunciation of the prime is activated as it is recognized, it should be available to facilitate target identification. By 50ms of prime exposure, both semantic and phonological facilitation effects were found. Importantly, semantic effects were not found prior to phonological effects. In an experiment that assured the prime duration was sufficient for recognition (180 ms), very large phonemic effects (and smaller semantic effects) were found on naming times (Perfetti & Zhang, 1991; Exp. 4). In these experiments, there has been no instance in which a semantic effect precedes or is larger than a phonological effect. The implication for word identification is that the phonological form of the word represented by the character is what is identified and that prior activation of that phonological form aids identification.

The Time Course of Phonological and Semantic Activation

From the research we have reviewed so far, we cannot be sure about the processes that occur during silent character reading when the reader is attending to meaning. If there is no semantics without phonology, we expect some evidence for it in a task that focuses on meaning. We turn to two related aspects of this question: First, does phonological activation occur in a silent reading task in which phonology is not necessary and even detrimental? Second, what is the time course of activation of semantic and phonological information in single character word identification? If the identification of a word constitutes a highly cohesive binding of graphemic, phonological, and semantic information, neither phonological nor semantic components can be easily suppressed.

Perfetti and Zhang (1995) exploited interference as a window on these questions. In one task, the synonym judgment task, subjects were presented with successive characters and asked to decide whether the second character had the same meaning as the first. Here we looked for phonological interference. Some of the second characters had the same pronunciation as the first character, while having no meaning similarity. (See Table 1 for materials.) In the homophone case, the first character is pronounced [shi] and has the meaning "matter". The second character is also pronounced [shi] but has an unrelated meaning. The subject should say "No" to this pair of characters because they are not similar in meaning. In the corresponding control characters, the second character is again [shi] but now is completely unrelated to the first character. Time to reject homophone pairs could be compared with control pairs. If subjects can ignore the pronunciation of the characters in making a meaning judgment, then the times to reject homophone foils and control foils should not differ. However, if phonological activation cannot be bypassed, then the fact that the name of the two characters is the same would interfere with making a meaning judgment.

The second task, homophone judgment, used the same characters, but required the subject to make a phonological judgment. Here, the subject saw two successive characters and judged whether the second character had the same pronunciation as the first. The second character was either a control, having no similarity to the first character, or a synonym. (These materials are also in Table 1.) With the change in task, the correct responses are reversed. What was a "No" trial for a meaning comparison is now a "Yes" trial for a pronunciation comparison; what was a "Yes" trial for meaning is now a foil trial for pronunciation. The control trials are the same. Again the logic is that if semantic information can be bypassed in judging phonology, then rejection times for control and synonym foils should not differ. The important result of this basic interference situation is that native Mandarin speakers living in Pittsburgh showed phonological interference when asked to make a semantic judgment. They also showed semantic interference when asked to make a phonological judgment, but this effect was smaller (Exp. 1) and later occurring (Exp. 2).

The more general question is the time course of semantic and phonological activation. In the interference paradigm, the standard view of Chinese reading predicts only semantic interference. This standard view, the *meaning-without-phonology* hypothesis, is disconfirmed by the phonological interference results just described. There is a weaker interpretation of the standard view, however, on which it

Table 1: Examples of materials from Perfetti and Zhang, 1995.

		Pronunciation	Translation	Correct response	
				Synonym Judgment	Homophone Judgment
Homophone	事	[shi]	matter		
	视	[shi]	see	NO	YES
Control	清	[qing]	clear		
	视	[shi]	see	NO	NO
Synonym	看	[kan]	look at		
	视	[shi]	see	YES	NO

assumes only that semantics is privileged (first-accessed) rather than the only information accessed. This retreat of the standard view implies the *meaning-first* hypothesis. Semantic information is available independently of the character name and precedes phonological information. Our contrasting view is the *phonology plus meaning* hypothesis, noncommittal on time-course but clearly asserting that there should be no semantics without phonology.

This time course question, in the interference paradigm, is tested by varying the SOA between the first character and the second character. At very short SOAs, there is little time to get full information from the first character, so the subject should be selective if possible. If a semantic judgment is required, then the subject should go for semantic information. Perfetti and Zhang (1995) varied SOA between 90 and 260 ms. For the shortest duration, this means the first character was viewable for only 80 ms, plus 10 ms ISI, prior to the presentation of the second character, a duration at the margins of correct character identification. Is there some duration at which only semantic interference but not homophonic interference is obtained?

The answer is no. In the meaning judgment task, homophone rejection took longer than control foil rejection at each SOA. Thus, even at 90 ms there is phonological interference. However, in the phonological judgment task, meaning interference did not appear until 140 ms. Combining the results allows estimates of time course functions from 90 to 310 SOA. Figure 1 shows a phonological interference function, measured in the synonym judgment task, and a semantic interference function, measured in the homophone judgment task. Phonological interference is the difference between homophones and controls, and semantic interference is the difference between semantic and control foils. As can be seen, semantic interference emerges later than phonological interference.

With due caution concerning across-task comparisons, the time course data are incompatible with both the *meaning-without-phonology* and the *meaning-before-phonology* views; they are consistent with the *phonology plus meaning* hypothesis.

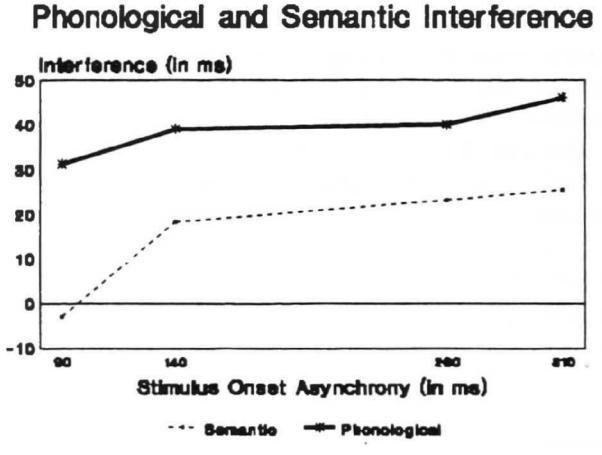

Figure 1: The time course of semantic and phonological interference.

Time-Course 2: Semantic Vagueness

We turn finally to a study that helps illuminate why phonological activation does not lag behind semantic activation. The heart of the argument is that the relationship

between form and meaning is more context-dependent and more variable than the relationship between form and form. Word identification in both English and Chinese provides access to various kinds of information, in particular access to a specific phonological object and something about meaning. But there is a striking gap between "phonological object" and "something about meaning". The phonological form of a word is well specified; the meaning of a word is not. Word meanings can be reasonably considered as ranges of values that are filled in by contexts.

Not only are words ambiguous in meaning, the interpretations of their potential meanings depend on context. For example, *safe* has a range of meanings: Noun. A place to keep valuables. Adjective 1. being free from harm. Adjective 2. Baseball: Judged to have reached base ahead of an attempted putout. These three meanings are not unrelated, so one might argue for some economy of semantic organization, compared with word forms that are fully polysemous with unrelated meanings. So much the better for our argument, which is that, even for a word like *safe*, which appears to have a single meaning with extended referential possibilities, there is not a single reliable semantic value that is a good candidate for a context-free meaning retrieval.

What kind of lexical process "extracts" just the right meaning from a word? The literature on word disambiguation oscillates between a view that selective access of word meaning is impossible and one that allows at least dominant meanings of ambiguous words to be preselected by a context. (See Simpson, 1994.) Evidence usually depends on responses to single words that are associates of one or the other meaning of the ambiguous word. Although such associations do not constitute the meaning of a word in any deep sense, they are what is detected within a few millliseconds of the exposure of a word in these priming experiments. So for *safe*, associates such as "money", "jewels", "out", etc. might appear, either selectively or all at once.

This glut of meaning associates stands in strong contrast to the single phonological form connected to *safe*. The phonological object /seyf/ isn't just an "associate" of *safe*, it is its unique identity. Reading processes take advantage of this reliable form rather than merely accepting the vagaries of meaning. Phonological form thus becomes the foundation for whatever meaning comes along. This may be as true in Chinese as it is in English, according to the UPP.

In recent research, Tan (1994) demonstrated the importance of semantic vagueness on Chinese word identification in a masking paradigm. The basic idea is that isolated word meaning varies from relatively precise to relatively vague. That is, the lexical semantics of words with vague meanings are more context dependent than are words with precise meanings.

Our extension of this meaning vagueness hypothesis employed a brief exposure priming task. Subjects, native Chinese speakers, were asked to name Chinese characters (single word compounds) that were preceded by primes presented very briefly for between 40 and 110 ms. Primes were of five types. A baseline control number sign (#), an unrelated word, a graphically similar word, a semantically similar word, and a phonologically similar word. The basic question concerned time course: Given our evidence for rapid phonological and somewhat slower semantic activation in an interference paradigm, could we observe the same time course effects in brief exposure priming and would we find that the time course of semantic priming depended on the semantic precision of the primes?

The results of the experiment are shown in Figure 2 as difference scores, the difference between each mask type and the number-symbol baseline. The graphic prime produced a pattern of facilitation followed at longer SOAs by inhibition which was eliminated by the longest SOA. Most important, we see a replication of the faster activation of phonological information over semantic information, and a difference between precise-meaning primes and vague-meaning primes. For precise-meaning primes the time course of semantic and phonological effects replicates what we found in the interference experiments: Phonological effects were found by 43ms, but semantic effects were delayed by 14ms. However, for vague-meaning primes, the lag of semantic activation was further increased by about 28ms.

Thus we have clear evidence that semantic information sufficient for facilitation effects depends on the precision of meaning associated with the prime. If we can generalize this observation across paradigms, we have a general principle that accounts for a time-course difference between the activation of phonological and semantic information: Phonological activation precedes semantic activation because it is bound more reliably to printed symbols (form-form binding) than is semantic information (form-meaning binding.) We expect this to be true across writing systems, because it depends, not on details of lexical access, but on a functional analysis of the role of phonology in word understanding.

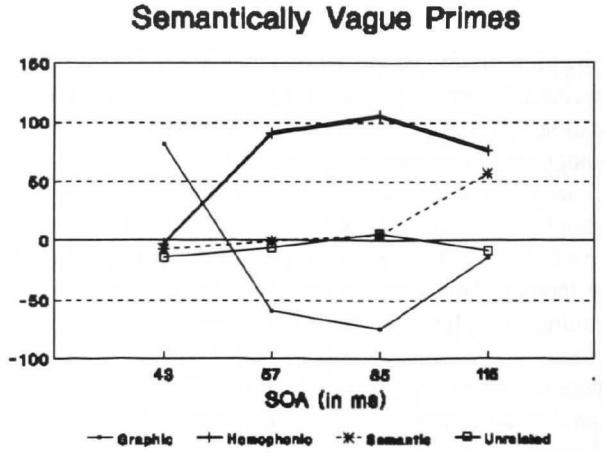

Figure 2a: The difference scores for semantically vague primes.

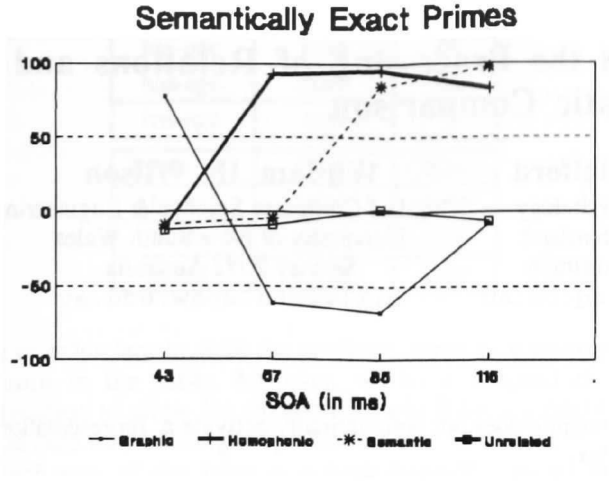

Figure 2b: The difference scores for semantically exact primes.

Acknowledgements

This research was partially funded by a grant to the first author from the National Science Foundation (SBR-9223125).

References

Baddeley, A.D. (1979). Working memory and reading. In P.A. Kolers, M.E. Wrolstad, & H. Bouma (Eds.), Procession of visible language. Vol 1 (pp. 355-370). New York: Plenum Press.

DeFrancis, J. (1989). Visible speech: The diverse oneness of writing systems. Honolulu: University of Hawaii.

Frost, R., Katz, L., & Bentin, S. (1987). Strategies for visual word recognition and orthographical depth: A multilingual comparison. Journal of Experimental Psychology: Human Perception and Performance, 13, 104-115.

Haber, L.R., & Haber, R.N. (1982). Does silent reading involve articulation? Evidence from tongue-twisters. American Journal of Psychology, 95, 409-419.

Levy, B.A. (1977). Reading: Speech and meaning processes. Journal of Verbal Learning and Verbal Behavior, 16, 623-638.

McCutchen, D., & Perfetti, C.A. (1982). The visual tongue-twister effect: Phonological activation in silent reading. Journal of Verbal Learning and Verbal Behavior, 21, 672-687.

Perfetti, C.A., & McCutchen, D. (1982). Speech processes in reading. In N. Lass (Ed.), Speech and language: Advances in basic research and practice (pp. 237-269). New York: Academic Press.

Perfetti, C.A., & Zhang, S. (1991). Phonological processes in reading Chinese characters. Journal of Experimental Psychology: Learning, Memory, and Cognition, 17, 633-643.

Perfetti, C.A., & Zhang, S. (1995). Very early phonological activation in reading Chinese. Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,

Perfetti, C.A., Zhang, S., & Berent, I. (1992). Reading in English and Chinese: Evidence for a "universal" phonological principle. In R. Frost & L. Katz (Eds.), Orthography, phonology, morphology, and meaning (pp. 227-248). Amsterdam: North-Holland.

Simpson, G.B. (1994). Context and the processing of ambiguous words. In M.A. Gernsbacher (Ed.), Handbook of psycholinguistics (pp. 359-374). New York: Academic Press.

Slowiaczek, M.L., & Clifton, C. (1980). Subvocalization and reading for meaning. Journal of Verbal Learning and Verbal Behavior, 19, 573-582.

Tan, L.H. (1994). The activation of early phonological code before access to meaning in written Chinese. Unpublished doctoral dissertation, University of Hong Kong.

Tzeng, O.J.L., & Hung, D.L. (1980). Reading in a nonalphabetic writing system: Some experimental studies. In J.F. Kavanagh & R.L Venezky (Eds.), Orthography, reading and dyslexia. Baltimore: University Park Press.

Tzeng, O.J.L, Hung, D.L., & Wang, W. S-Y. (1977). Speech recoding in reading Chinese characters. Journal of Experimental Psychology: Human Learning and Memory, 3, 621-630.

Zhang, S., & Perfetti, C.A. (1993). The tongue twister effect in reading Chinese. Journal of Experimental Psychology: Learning, Memory, and Cognition, 19, 1082-1093.

Zhou, Y.G. (1978). To what degree are the "phonetics" of present-day Chinese characters still phonetic? Zhongguo Yuwen, 146, 172-177.