

REVIEW ARTICLE

A Componential Approach for Bilingual Reading and Comparative Writing System Research: The Role of Phonology in Chinese Writing as a Test Case

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The special circumstances of bilingual and second language literacy learning offer investigators an important additional vantage point from which to better understand the components of reading ability. Cross-writing system comparisons complement this perspective. Comparing writing systems and how children learn to read through the medium of each system provides for tests of a number of hypotheses currently under discussion. One particularly instructive series of tests involves the contrast between alphabetic and nonalphabetic writing systems. This review of the research will examine proposals related to the role of phonology in word identification with a special focus on the morphosyllabic/logographic Chinese orthography. A componential, or modular, approach to the study of reading ability will be evaluated in relation to claims made from different perspectives on the question of the activation of phonological representations in reading. In particular, is the Universal Phonological Principle, proposed by C. Perfetti, compatible with a modular approach to the study of reading ability?

Keywords bilingual literacy; orthographic knowledge; modularity; Chinese; writing systems; Universal Phonological Principle

Introduction

Research on cross-language comparisons provides special opportunities and vantage points for a better understanding of the components of reading ability. These comparisons can approach the analysis of skills and abilities from two different perspectives: the study of reading development in bilinguals (including

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here the subset of individuals who are second language [L2] learners) and the comparative study of reading across language and writing systems among monolingual literacy learners. An assumption that ties these two approaches together conceptually is that the research in reading in any single language is relevant in every way to L2 and bilingual literacy. The same underlying cognitive structures form the foundation for reading ability. Conversely, the findings from bilingual literacy will help us better understand the components of reading ability in general. For beginning L2 readers, imbalances and uneven development provide opportunities to examine the relevant components and subcomponents.

The review of the research will begin with the following: (a) a brief overview of theoretical approaches to the study of reading that have made reference to the concept of modularity, followed by (b) a discussion of the current state of investigations in the field of bilingual and L2 reading, giving examples of how a componential approach might be relevant to a number of ongoing research problems. Cross-language and cross-writing system comparisons will present us in the concluding sections (c) and (d) with a complementary viewpoint on the same issues—in particular, comparisons that involve nonalphabetic writing systems. Central to all of the above will be an assessment of the Universal Phonological Principle (UPP) and the related Universal Writing System Constraint (Perfetti, 2003; Perfetti & Dunlap, 2008) and how they might be understood in relation to one or another version of the modularity hypothesis. The important claim of the UPP is that the activation of phonology in (silent) reading cannot be bypassed in the use of any writing system.

The assessment of these models of reading is the primary objective of this review. The problem of determining which aspects of literacy are universal and which are specific to each writing system is still not well understood, and much work is still needed to even conceptualize all of the critical research questions coherently. The last two sections will give readers a glimpse into this difficult task. As we will see, the study of the Chinese writing system, how it differs from alphabetic systems, and how it does not, holds one of the most important keys to this problem. For discussion purposes, an overview of the general approach of componential analysis, associated with the notion of modularity, will be presented as one way to frame the relevant issues. The specific purpose of this overview is to set the stage for a proposal: If future research shows that the UPP and the Universal Writing System Constraint are correct, this result would be consistent with a modular approach to the study of reading. On the other hand, if Perfetti's theories cannot stand up to future disconfirming evidence, this would seriously call into question central pillars of the modularity hypothesis,¹ not just

in the area of literacy. As such, the problems of bilingual literacy learning and cross-writing system comparison (in particular, the contrast between alphabetic and morphosyllabic Chinese systems) present a critical test for an important debate in cognitive science.

The Componential Approach

There are a number of ways in which reading ability might be analyzed componentially, and the concept of modularity has been used to frame the various problems that arise in this type of analysis. This review of the research will do the same. Although certain versions of the modularity thesis remain controversial—in particular, those among them that we might characterize as “strong bottom-up” versions—it is important to keep in mind that there exists a broad diversity of views among researchers who favor one or another componential/modular approach to the study of language ability. Even if historically the concept traces its roots to Universal Grammar-oriented theories, there is no reason for insisting that the general idea of modularity is incompatible in every way with other schools of cognitive science. Keeping this in mind might turn out to be especially useful in the research on a complex ability such as reading. This section will provide an overview of a modular approach to the study of reading not for the purpose of making the claim that it is the most correct or comprehensive framework for literacy research. Rather, a more narrow claim will be offered for discussion: The main idea underlying the UPP—that activation of phonology in (silent) reading cannot be bypassed, even in nonalphabetic writing systems—follows from a componential/modular perspective on both the architecture of language and literacy knowledge and the processing of written language. Although Perfetti has not explicitly drawn this connection, the questions related to how linguistic knowledge structures interact in the deployment of an ability like reading are central to this claim. If his hypotheses prove to be incorrect, this would spell trouble for modularity (for strong and weak versions alike). Thus, current and future research evidence that is inconsistent with the UPP would lend support to holistic and integrativist theories of literacy (e.g., “whole language” theories).

Issues related to the concept of modularity come up in the discussion of a number of important questions in the research on literacy and bilingualism, for example:

1. Can a useful distinction be made between explicit knowledge and metalinguistic awareness, on the one hand, and implicit knowledge, on the other?

2. In reading, how do the different subsystems of grammar come online and how do they interact with the other (nonlinguistic) knowledge structures and processing mechanisms that are specific to reading? In relation to bilingual readers, this topic is related to the question of the differentiation between first language (L1) and L2 systems.
3. What are the essential points of contention in the debate opposing holistic social-constructivist theories and those that emphasize the importance of mastering the subskills of word identification?
4. How do we understand the concepts of pathway, circuit, and network, and might they be compatible with models that conceive of components? In this regard, what might be some points of contact between connectionist and modular approaches to the study of reading ability?

Let us take each of these points in turn, beginning with question 1 above. A basic assumption underlying modular approaches is that not all knowledge of language, for example, is of the same kind. Especially when considering complex abilities, an important distinction is between metalinguistic explicit knowledge and implicit knowledge. The phonological level, being the most basic for reading, appears to reveal this distinction most clearly. Arguably, the phonological competence that young children attain in their L1 depends on no kind of deliberate attention to form, negative evidence, or application of deliberate learning strategy. From this point of view, the early spontaneous and universal emergence of phonological competence would be the hallmark of an innately preprogrammed cognitive specialization (Petitto, 2007). Assessments of metaphonological knowledge show evidence of developmental trends that are not spontaneous and universal, correlating (as implicit phonological competence does not) with literacy learning (Castles & Coltheart, 2004; Hu, 2004; Liberman, 1999; Morais & Kolinsky, 2001).

The question of how the subsystems of language are deployed and how they interact with other cognitive domains in reading (question 2) assumes that reading ability can be analyzed (“fractionated”) into subsystems or autonomous components in the first place (Stanovich, 2003). To clarify terms here, “interaction” and “interactive models” imply something very different from “integration.” An “integrativist” model would reject all versions of modularity, whereas interaction assumes connectivity and interface among components. In fact, any conception of a modular/componential architecture that omits interfaces would be impossible. The proposals of Stanovich (2000), Shatil and Share (2003), and Leiken, Share, and Schwartz (2005) are perhaps the most explicit proposals in the field of reading research along these lines and serve as another important

starting point in our discussion. Contrary to strong constructivist assumptions, demarcating processing at the word identification level from that at the text comprehension level is important for understanding how different networks of components come together in each case. For word recognition, encapsulated processing applies in a manner that is different from how higher order strategies are brought to bear on the tasks of sentence and text comprehension, according to this view. Thus, reading ability is seen as internally complex and structurally diverse.

The long-standing issue of “phonological mediation” in lexical access, following Stanovich’s (2000) approach, would now seem to be more tractable. Especially in regard to our topic—cross-language and cross-writing system literacy—an analytical method of studying how phonological structure interfaces with the other subcomponents of word recognition skill should uncover interesting patterns of variation from one orthography to another. At the same time, this approach should help us refine exactly what a UPP (Perfetti & Liu, 2005) leads us to claim about what is invariant in how children learn to read. The specific claims about what is invariant and what is not then could be tested in both L1 and L2 literacy.

The overall idea of the UPP is that learning to read consists of learning how a writing system encodes the spoken language system associated with it, as opposed to encoding meaning directly. “Word reading activates phonology at the lowest level of language allowed by the writing system.” As a corollary, the “identification-with-phonology-hypothesis places phonology as a constituent of word recognition . . . that the identification of a word is the retrieval of its linguistic identity (phonologically specified morpheme of word)” (Perfetti & Liu, 2005, p. 195). Thus, the study of how phonological structure interfaces with other subcomponents of word recognition should be relevant to the claims of the UPP.

For all of the above, so far, Jackendoff (2002) has offered a usable model of language processing that appears to be particularly apt for the study of complex abilities. Its main virtue for this purpose is that it embraces interactivity (recalling that this is not the same as holistic integration) in both feed-forward and feed-back. Modules each maintain their own domain-specific computational properties, specialized for phonological structure, syntactic structure, and so forth, with interface components doing the hard work of coordinating in performance the corresponding networks and connections. Performance of language tasks is effected so rapidly and automatically that complex literacy skills, for example, appear superficially to behave like modules themselves.

The problem of the role of context is related to Stanovich's (2000) discussion of degrees of autonomy and encapsulation—how the different components of reading ability comply with their specialized functions. The findings from research on the differential effects of context and background knowledge are proposed to be consistent with the general notion of domain specificity: For the efficient processing of information provided to the lower level decoding modules, significant advantages accrue if they are insulated to a certain degree, free from having to compute inputs from all possible sources. Context and background knowledge do not “preselect” the output of word recognition but rather intervene primarily in the subsequent stages of the reading process (Perfetti, 1992; Stanovich & Stanovich, 1999). In short, modularity in no way excludes top-down interaction; rather, what it proposes is that input computations do not have unlimited access to the higher level domains (Coltheart, 1999).

A different dimension of componentiality poses a problem for researchers when there are two languages. Accumulating evidence now supports the hypothesis that separate linguistic systems, which correspond to knowledge of specific languages, begin to differentiate in bilingual children, early in development (Kovelman, Baker, & Petitto, 2008). Conceivably, a similar differentiation would unfold in L2 learning (Genesee, 2002; Paradis, 2004). However, as an autonomous cognitive domain, separate from the grammatical components, conceptual structure appears not to undergo this kind of division, remaining independent and “shared in common.” See Francis (2004, 2008) for alternatives for modeling this relationship in bilingualism based on Jackendoff's Tripartite Parallel Architecture and Cheung and Lin (2005) for a proposal along the same lines.

The problem is now applied to the development of literacy in two languages, or in an L2. Which aspects of reading ability turn out to be language-specific and which form part of a Common Underlying Proficiency (Cummins, 2000)? For example, phonological competence *per se* would differentiate between the L1 and L2 (or L_a and L_b in simultaneous bilingualism); but are some aspects of phonological *processing* skill and explicit metalevel phonological knowledge “available” from a common store, so to speak, in bilingual/cross-language situations?

In regard to question 3, strong top-down holistic theories of reading also tend to conceptually integrate language acquisition and literacy learning, rejecting the dichotomy between speech as a product of biological evolution and literacy as a cultural innovation. Opposing views point to research findings demonstrating that key aspects of metalinguistic awareness, which correlate with literacy, do not emerge “naturally” and spontaneously, as all

aspects of speech-related phonological competence, for example, do. Liberman (1999, p. 108), in arguing against the idea that learning to read should proceed just as children “learn” to understand language, made the observation that:

Phonemic awareness does not result from learning to speak because the primary representations of the phonetic module are already perfectly suited for the other processes of the language specialization. These primary phonetic representations do not get attention because they do not need it, and they do not need it because . . . they need not be converted into something other than what they already are.

According to this view, core linguistic competence (and the ability to use language in face-to-face conversational discourse) is biologically primary, part of our “species endowment” and a constitutive primitive of human cognition. The ability to read and write is a secondary achievement, historically (the mastery of a “technology of language” to paraphrase Ong, 1982). It is also a secondary achievement developmentally in children (Perfetti, 2003; Pesetsky, 1996).

A contrasting assessment of the merits of modular and connectionist approaches (question 4) is far beyond the scope of this review. However, one observation needs to be made before proceeding to the next section. The research on reading development has drawn the lines of debate in a way that perhaps is surprising. For example, on the question of the role that phonology plays in word identification and the learning of grapheme-phoneme correspondences, connectionist and modularity-oriented researchers tend to come to the same conclusion: that strong top-down constructivist theories that minimize the importance of orthography-phonology mapping are seriously flawed (Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001; Seidenberg, 2005). This coincidence between seemingly very divergent paradigms should motivate reflection on which aspects of each approach lead to this kind of convergence on specific applied problems. One possibility to explore might be related to the distinction, proposed earlier, between *interaction* and *integration*. A number of investigators have argued that there is no compelling reason for viewing connectionist methods and modularity as counterposed in all respects (Norris, 1990; Pinker, 1999). In the basic research on word recognition, for example, it is noteworthy that despite highly divergent approaches (Coltheart, Rastle, Conrad, Langdon, & Ziegler, 2001; Plaut, McClelland, Seidenberg, & Patterson, 1996), conclusions and implications for literacy learning, and teaching, diverge much less than we might expect.

Linguistic and Nonlinguistic Components in Bilingual Reading

In their review of the research on reading in an L2, Grabe and Stoller (2002) highlighted the persistent themes around which, it appears, a measure of consensus has begun to coalesce. Pertinent to our discussion of the analysis of reading ability into its knowledge and processing components are the following:

1. the distinction between tacit knowledge of language and metalinguistic knowledge;
2. how knowledge of L1 orthography influences L2 decoding (e.g., in transfer and interference);
3. findings related to the language threshold hypothesis (LTH).

An interesting aspect of the distinction in item 1—"implicit-explicit" in the previous section—is that, on the one hand, L2 readers will often have an advantage in the development of higher order literacy-related metalinguistic knowledge—in particular, older learners already literate in their L1. In contrast, they will tend to be limited, to one degree or another, in their ability to fully exploit core grammatical knowledge in reading, for which the L1 reader has tacit knowledge, available online rapidly and automatically (Cummins, 2000; Grabe & Stoller, 2002; Walter, 2004). Depending on the circumstances, L1 and L2 reading each might recruit resources in different proportions from the same knowledge structures.

The research on L1 writing system knowledge and L1 linguistic knowledge influences on L2 reading, related to item 2, has contributed to the discussion of broad theoretical problems concerning the mental architecture of bilingual competence (Wang, Koda, & Perfetti, 2003). How should the mutual influences between the L1 and L2 linguistic systems be modeled? This kind of interface (or interaction) would be different from the access that L2 and bilingual readers have to a common store of higher order, metalinguistic, and discourse-level knowledge structures. Included among the latter might also be the reading-specific abilities—in particular, in the domain of phonological processing and phonological awareness, which research suggests are readily accessible (termed "transferable" in the current literature) in performance in either L1 or L2 reading (Bialystok, McBride-Chang, & Luk, 2005; Chen, Ku, Koyama, Anderson, & Li, 2008). Interestingly, this would be the case independent of which was the language of initial literacy learning (Geva & Wang, 2001; Hu, 2003; Mumtaz & Humphreys, 2001). The same representation and access questions arise in regard to the deployment of other nonlinguistic knowledge structures. For example, research on L2 reading comprehension (Morrison, 2004; Walter, 2004)

has largely directed its attention to what we could characterize as abilities that are clearly not language-specific and the extent to which these abilities can be called upon in the L1 and L2 (the “transfer” metaphor commonly applied to this type of interface as well). The influence of L1 orthographic knowledge on L2 reading should now be understood better: Within the framework of an analysis that conceives of components of reading ability, which component structures correspond to different kinds of knowledge and processing mechanisms?

The LTH addresses the relative weight that should be assigned to L2 linguistic competence, on the one hand, and to general reading ability and general information processing skills, on the other. The latter would have been acquired previously from L1 literacy or from some other source in the case of nonliterate L2 literacy learners. Perhaps, a better way to understand the LTH is that assuming other factors (relevant text-related background knowledge, IQ, etc.) to be constant, L2 grammatical competence and L2 lexical knowledge, up to a certain threshold, represent significant factors in reading performance. Related to this idea, Verhoeven’s (2000) “componential analysis” of L2 reading emphasized the “dual-task,” which places greater or lesser strains on all aspects of reading, with the possible exception of the lowest levels of decoding. Even here, the critical experiments may not have yet been carried out—for example, word recognition tasks that compare the performance of native speakers with that of L2 learners below a sufficiently low “language threshold.”²

In another componential analysis of L2 reading that sought to test the LTH, Leikin et al. (2005) sharpened the focus on the critical dimension of phonological processing abilities. Methodologically, the study stands out because it controlled for prior L1 literacy attainment. Investigators addressed a factor related to the idea of linguistic thresholds that might account for difficulties among unsuccessful readers: level of L2 (Hebrew) linguistic competence. Measures of linguistic competence in Hebrew correlated with L2 reading ability. L2 grammatical knowledge was predictive, in particular, of reading comprehension. In a separate analysis of the results from a series of phonological tasks, the authors underscored the important distinction, often left ambiguous in the research literature, between two separate categories of ability—what we could term “primary” and “secondary.” Assessment procedures and interpretation of results must distinguish between (a) core phonological competence and the “basic” phonological processing modules that deploy this competence in speech and auditory reception (“primary” ability) and (b) metalevel awareness of phonology and literacy-related processing skills (“secondary”). The investigators emphasized the need to attend to the distinction between linguistic and metalinguistic knowledge and their respective processing

mechanisms and interfaces. Before moving on to the comparison between alphabetic and nonalphabetic literacy, we could say that the emphasis in the LTH on the importance of the components of linguistic competence in reading is in line with the emphasis in the UPP on one of these components in particular, phonology.

Comparative Writing System Research

The second kind of cross-language comparison that was alluded to at the beginning of this article is the one that does not necessarily involve the study of bilingual readers. It is the alphabetic/nonalphabetic dimension that has attracted growing interest among researchers, for one reason: because it represents the maximum possible contrast among the world's modern languages and their corresponding orthographies. For now, we will restrict the discussion to the psycholinguistics of Chinese writing and literacy development.

Access to Phonology When Phonemes Are Not Represented in the Orthography

From a number of points of view, it would seem that the literacy development of children learning the morphosyllabic/logographic Chinese writing system could be taken as the most stringent test for the UPP. In fact, support exists for the view that nonalphabetic systems implement a direct visual-to-meaning connection that circumvents phonology, the “phonology bypass” or “direct access” hypothesis (Chen, 1996). A strong version of this proposal would be that the only necessary route from orthography (O) to semantics (S) in silent reading is the one that is not mediated by phonology (P); $O \rightarrow S$ is the dominant route. The strongest claim, a second position, would be that there is no $O \rightarrow P \rightarrow S$ route at all. Phonology might be activated, but as a nonessential byproduct, for the purpose, perhaps, of holding words in working memory while contextual information is processed. Taft and van Graan (1998) seemed to apply a version of this model to reading in all writing systems. A third position, known as the “parallel-access” hypothesis, favors a two-pathway model: one route directly from orthography to semantics and the other mediated by phonology (Xu, Pollatsek, & Potter, 1999). Simplification aside, these models, in addition to a number of subtle distinctions and inevitable qualifications, are currently being evaluated by investigators to determine what is precisely the role of phonology in reading Chinese. Componential analyses of reading ability, it will be proposed, might be especially useful in sorting out the key research questions. One possible avenue of analysis, alluded to

in the previous section, could attempt to differentiate between phonological competence and the interfaces and processing mechanisms associated with all speech and auditory reception, on the one hand, and metalevel knowledge and ability, on the other.

There is another way of thinking about these three hypotheses. If Chinese presents the critical test of the UPP, it also provides for a unique opportunity for garnering support for the O → S direct-access hypothesis (Chen, 1996), or at least a weaker version of it: accepting (provisionally) phonological activation in alphabetic reading while positing exceptionality for the processing of logographic orthographies. Assuming that this way of framing the discussion is properly conceived, what follows is a tentative proposal for why the question of phonological activation is important: Finding the direct-access hypothesis to be correct and finding that all variants of the UPP to be false, for Chinese, would contradict modular approaches to reading. Far from being a very convincing argument against direct access, it would stand as strong evidence against modularity, as was suggested earlier. This approach to the discussion may turn out to be unsatisfactory because research findings often place different emphases and weights on the factor of phonological activation, qualifying claims that at first seemed to represent a clear counterposition. However, for now, it serves as a way of getting one view of the bigger picture.

Beginning with the direct-access hypothesis, the wide disparity between Chinese and even the “deepest” alphabet regarding the reliability of phonological information in the orthography poses, by itself, the question of a phonology bypass. On this point, there should be a relatively broad agreement among supporters of all positions in the debate (for a possible dissenting view, see DeFrancis, 1989). It has been estimated that only about 23% of semantic-phonetic compounds that Chinese-speaking children are taught during initial literacy instruction are fully regular (42% are semiregular), semantic-phonetic compounds themselves counting for less than 75% of the characters that primary school age children typically learn in school (Shu, Chen, Anderson, Wu, & Xuan, 2002). In addition, a significant number of integrated characters, corresponding to free morphemes and semantic radicals of compound characters, give the reader a graphically distinctive categorical cue to meaning, some of them containing relatively transparent iconic features (e.g., the adpositions: 下 [below], 上 [above], 中 [middle/inside]). The shared semantic radical, 口 [mouth], in 吟 [chant], 吃 [eat], 吐 [vomit], and 可口 [palatable], provides the reader with semantic information, directly.³ The first two characters in the phonetic rendering of *Coca-Cola*, 可口可樂 [ke³-kou³-ke³-le⁴], correspond, opportunely, to “palatable.” Parenthetically, L2 learners of Chinese have been known to make

use of these visible and explicit links to meaning in the orthography (when they can) to help bootstrap themselves into a rudimentary interlanguage grammar (De Courcy, 2002, pp. 108–113, 126–127).

Chen (1996) summarized evidence that favors direct access: In studies of word recognition, the processing of characters and alphabetic words differs cognitively in important ways. In naming-aloud and lexical decision tasks, strategies appear to differ between Chinese characters and alphabetic words. Whereas naming is normally faster than lexical decision and the word frequency effect is greater for lexical decision, in reading alphabetic words, the opposite result is obtained with Chinese characters: Lexical decision is usually faster and frequency effects are greater in the naming task. In an experiment that required Chinese-English bilinguals and English monolinguals to identify mathematical logographs and corresponding words, logographs and characters were named equally fast by bilinguals, whereas word-naming was faster for the alphabetic-reading monolinguals. Interestingly, when the bilinguals attempted the task in their L2 (English), performance resembled that of the native-speaker monolinguals. Together with findings that show prelexical phonological activation to be weaker in Chinese than in English and other evidence indicating a lack of homophonic effects in semantic categorization, an important contrast between alphabetic and nonalphabetic processing appears to have been demonstrated (Chen, 1996, pp. 51–56). This contrast appears to suggest that the O → S route predominates.

For some versions of the direct-access hypothesis, what is called into question is not that phonological structures are automatically activated in silent reading. Even an early activation of phonology in Chinese word identification might be possible. Rather, the claim would be that mediation of phonology does not strongly constrain access to meaning. For example, studies have shown significant effects of phonology for only a minority of Chinese characters in which the pronunciation of the compound character is the same as the pronunciation of its phonetic component (Zhou & Marslen-Wilson, 1999). According to this view, the O → P → S (mediated) route

cannot be the predominant or default mechanism for linking orthographic form to lexical semantic representation. There is little doubt that phonology is activated early and obligatorily in reading Chinese characters . . . [and] that under specific circumstances phonological factors can drive semantic activation for skilled readers. It is, however, much more plausible to view phonological and orthographic factors as functioning in an interactive framework. (p. 598)

Zhou and Marslen-Wilson's (1999) position appears to be close to the two-pathway parallel-access view. According to Xu et al. (1999), a model in which orthography accesses phonological and semantic codes in parallel has the virtue of not assuming different processing mechanisms for Chinese and alphabetic systems. Findings that indicate a divergence between word reading processes in the two systems can be explained simply by the relative speed of the route in which phonology is more easily activated by an alphabet versus the route to meaning in Chinese in which the $O \rightarrow P \rightarrow S$ route would end up being slower than the direct $O \rightarrow S$ pathway. Here, again, the same phonology-semantics connections of speech comprehension come online automatically, and are not bypassed, strictly speaking. An interactive network for literacy would consist of three "nodes": one for orthography, one for phonology, and one for semantics. During reading, all three would be in continuous interaction (Xu et al., 1999, p. 853).

Lexical Entries in a Mental Lexicon

As we can now well appreciate, adjudicating among the various claims regarding the role of phonology in Chinese reading will depend on what comes to be considered as the central distinguishing feature(s) of each competing hypothesis. However, which features are in competition is not entirely obvious either; see Guo, Peng, and Liu (2005), Tsai, Lee, Tzeng, Hung, and Yen (2004), Tzeng, Zhong, Hung, and Lee (1995), and Zhou and Marslen-Wilson (2000) for discussions and relevant research findings. At this point, perhaps, only the confrontation between the strongest version of direct-access (Taft & van Graan, 1998) and models roughly convergent with the UPP will allow for a first approximation of a definitive test. This being a good place to begin, Packard (2000) seemed to dispense with the notion of "routes" ($O \rightarrow S$, $O \rightarrow P \rightarrow S$), suggesting rather an alternative based on a model of the mental lexicon with each lexical entry composed of substructures. The lexical entry is a "relation" among phonology, syntactic form class and subcategory, morphology, semantics, and so forth, interfaced with an orthographic representation for literate speakers. In the end, these may not be the actual substructures; but the basic idea would be the same for explaining how Chinese characters activate phonology and meaning.

A brief overview of Packard's (2000) model of how characters access the mental lexicon will help frame our concluding assessment of the UPP. The model assumes that Chinese orthography is completely dependent on the natural speech lexicon. The linguistic subsystems that are accessed in reading are the same ones that all speakers of the language possess, including nonliterate.

It would be less plausible that literacy development recreates a parallel, duplicate competence for processing written language. What literate speakers of Chinese are typically able to count on is a more advanced explicit awareness of morphemes and words, which might help them with certain analytic tasks and in reading itself, especially in the case of difficult texts. However, the development of this metalinguistic knowledge remains separate from, and leaves intact, the core components of native-speaker linguistic competence, including all interface modules. For example, in bilinguals, script differences (e.g., in English-Japanese bilinguals) apparently do not block cross-language influences that are typically expected in “same-script” bilinguals (English-Spanish) (Hoshino & Kroll, 2008).

Recall the distinction made by Liberman (1999) in the first section between primary linguistic knowledge and secondary, literacy-related, metalevel knowledge. Following this logic, the grammatical subsystems of the lexical entry are tightly interlinked, the input of a linguistic form (orthographic in this case) triggering the “retrieval” of its core linguistic substructures, rapidly and automatically in skilled reading. In speech perception, access is triggered by sound, which can only activate the substructures of the lexical entry by way of phonology. In reading, on the other hand, lexical entries could be activated by triggering another substructure “first”; and as Packard (2000) pointed out, in Chinese this might even be more likely under certain word identification task conditions. Here, again, we have an indication that modular approaches (such as those of Liberman and Packard) lend support to the UPP and are not consistent with strong versions of direct access (i.e., phonology bypass).

Consistent with this view, studies of dyslexia, dysgraphia, and aphasia have shown that the lexical substructures and the corresponding linguistic subsystems and interfaces with which they are linked can suffer selective impairment. In the case of dyslexia, different networks of processing mechanism can be affected, yielding a diverse array of impairments, not a single undifferentiated category of reading impairment (Chung et al., 2008). Additionally, as would be expected, different patterns of disability are associated with alphabetic and nonalphabetic dyslexic reading (Ho, Chan, Lee, Tsang, & Luan, 2004). Studies have revealed opposite and complementary patterns of selective impairment: fluent speech accompanied by disabled oral reading (a defective orthography-phonology link) and disrupted access to meaning in speech with spared oral reading (suggesting an intact orthography-phonology pathway and a disrupted access to semantics) (Law, Wong, & Chiu, 2005; Weekes, Yin, Su, & Chen, 2006). With phonology and semantics being dissociable, nothing in principle then should exclude the possibility of an initial activation of

either one under experimental conditions of single character or single word identification.

In unimpaired readers, however, the interfaces among the linguistic sub-components of the lexical entry must be dedicated, fast, and obligatory in their activation, revealing properties of highly encapsulated modular processing; their deployment is mandatory. These interconnections within the natural lexical entry have evolved, hypothetically, as part of the specialized language faculty and would be highly resistant to being reconfigured in any fundamental way. Crucially, the connection to orthography (established through learning and extended practice) is not predetermined in this way. Therefore, a “direct” initial access to a word’s meaning, demonstrable in experimental tasks, cannot be effected independently of the phonological structures of spoken language in the sense of bypassing them; in this sense, “recoding” is a “virtual reflex” (Packard, 2000, pp. 304–309). In actual reading of continuous text, if any cognitive domain is susceptible to disengagement, it would be a higher order level of conceptual structure related to interpretation and sentence/text comprehension, a phenomenon that metacognitively aware readers are quite familiar with (the reverse, not coincidentally, of the well-known tip-of-the-tongue state). Under normal receptive language processing, given a fragmentary structure in a particular format, the interface modules work rapidly to construct a fully specified structure (Jackendoff, 2002, p. 198), presumably in word identification just as in syntax. The lexicon as a whole, according to this view, is a substantive part of the language processor’s network of interface components:

A word, by virtue of having features in each of the components of grammar, serves as part of the linkage between the multiple structures . . . The proper way to regard [the lexical item] is as a small-scale three way interface rule. It lists a small chunk of phonology, a small chunk of syntax, and a small chunk of semantics, and it shows how to line these chunks up when they appear in parallel phonological, syntactic, and conceptual structures. (p. 131)

Characters and Words in Context

One could perhaps question experimental methods that are restricted to studying individual word (and nonword) identification on the grounds that they lack ecological validity (Goodman, 2005). However, this would be an unfair criticism that confounds important methodological considerations of data collection and the complementary but different requirements of reliability and interpretation (validity). For example, if consistent results demonstrate significant differences between the processing of individual words in Chinese and a

given alphabetic orthography, the results stand as reported and invite a theoretically grounded explanation, speculation, and methodological critique. Competing accounts of the data inform subsequent experimental and nonexperimental lines of inquiry; and if one chooses to dismiss a given method of inquiry, it is necessary to explain why it cannot yield *any* interpretable finding, under *any* circumstance.

At the same time, studies of reading that require subjects to decode connected text should complement single-character/word-in-isolation studies in all respects. Lin and Akamatsu (1997) appeared to suggest this approach in their observations of the research on eye movement patterns and other aspects of reading continuous text; see Frenck-Mestre (2005) for a discussion. As expected, comparative eye movement studies reveal noteworthy differences between Chinese and English. In reading “Chinese in context,” nevertheless, phonological representations are activated and play an important role, even if we assume, for argument’s sake, that activation is “postlexical.” In this case, it is proposed that we should assume that the same processing mechanisms are brought online in Chinese and English. What appears to follow is the conclusion that text processing in all languages and across all writing systems cannot bypass phonological recoding for the purpose of syntactic and semantic integration in linguistic working memory. However, this conclusion should not be taken as contradicting the evidence from numerous studies “that skilled readers of different orthographies [adapt] their processing strategies to meet the different cognitive demands posed by different orthographies” (Lin & Akamatsu, 1997, p. 378).

In their study of the development of early reading ability comparing performance in the Taiwanese Mandarin alphabet, Zhuyin fuhao, and logographic Chinese, Hu and Catts (1998) commented on the role of phonological working memory. In particular, the issue comes up in decoding less familiar words in context. Because Chinese orthography does not indicate word boundaries, phonological patterns need to be maintained in working memory until word boundaries are identified. Less skilled beginning readers, it has been proposed, have difficulty in segmenting effectively between juxtaposed characters, distinguishing in online processing of text between free and bound characters, and parsing grammatical constituents correctly that contain two-character and multicharacter compound words. In this way, phonology is activated and plays an important role in decoding.

Independent of the mixed results from single-character/word-in-isolation studies on whether phonology is “prelexical” or “postlexical,” in the reading of connected text, what is the effect of an ongoing and overriding engagement

of phonological working memory? If the above observations are correct, can we even plausibly pose the possibility of a direct access to meaning without phonological mediation in word identification *in text processing*? These two questions are indirectly suggested in the discussion of methodological problems in single-character/word-in-isolation studies. Chen (1996) contrasted two kinds of approach: (a) Tasks are presented to the subject in which a character's name is required or can be helpful and (b) situations in which the meaning of a character is to be consulted for a correct response with phonological information unnecessary, as in the semantic-decision task. In approach a, if no effect of phonological interference is in evidence, then one explanation is that phonological activation does not occur routinely or necessarily as a part of character recognition (Chen, 1996, p. 53). However, in reference specifically to the second scenario, if in context the phonological component of linguistic working memory comes online mandatorily (even if access to phonology on the first character of a text passage could be "postlexical") direct, unmediated access to meaning may be impossible. Entirely speculative, this possibility may be worth exploring in future investigations. However, again, in relation to approach b, if significant differences between Chinese and English, for example, continue to be evidenced, this finding requires further serious discussion, even if it turns out that "no effect of phonological interference" is only found in single-character/word-in-isolation tasks.

Phonology as a Constituent of Word Identification

The UPP was characterized as a "constituency hypothesis" by Guo et al. (2005). A more complete summary of how the UPP should or might apply to Chinese now merits our attention. Perfetti (2003) began by pointing out the incomplete and thus misleading conception of the character as morphemic. Rather, "morphosyllabic" better captures its orthographic-linguistic properties: "corresponding not to an abstract formless piece of meaning, but usually to a spoken Chinese syllable that is also a morpheme" (p. 7). On this point, a morphosyllabic writing system is not exceptional; it also realizes a mapping between orthography and linguistic patterns of a language. Far from a quibble about terminology, this assumption about how a "true writing system" functions (DeFrancis, 1996) points us toward an important ongoing discussion in cognitive science: Assuming that the semantic domains of conceptual structure (Jackendoff's term, 2002) are autonomous from the linguistic structures (morphology, syntax, phonology), how do meaning and language, now defined narrowly, interface in language use (such as in reading)? The more fundamental debate revolves around the proposals of both meaning-linguistic structure

differentiation and the distinction between knowledge of language and language use (Newmeyer, 1998), both of which also have been widely challenged.

Assuming for now that, in silent reading, the activation of phonology occurs in both alphabetic and nonalphabetic systems, it would be incorrect to claim no difference in the execution of the decoding processing mechanism. As we could see from the brief review of the research evidence in the previous section, on this point there seems to be wide agreement. As Perfetti (2003) described it, an alphabetic system allows activation to occur sublexically based on letter recognition, building up rapidly; and word identification does not have to wait for complete processing of all lower level units. In silent reading of Chinese, in contrast, activation of phonology awaits a threshold level of character recognition (see Note 3). Summing up, we can consider the following contrast: alphabetic-cascade style and logographic/morphosyllabic-threshold style. Thus, the basic idea of phonology being a constituent of word identification is that the moment of orthographic recognition is the moment of access to phonology, constituting together with the lexical entry's semantic features a "three-constituent word identity" (Perfetti, 1999, p. 177). This would stand in contrast to phonology as a byproduct of identification, "postlexically." In English, the graphemes that trigger phonological processing correspond to phonemes; in Chinese, they correspond to spoken syllables that happen also to be morphemes (Perfetti & Liu, 2005, p. 195).

The intention in all of the preceding discussion is not to argue that the UPP has already garnered decisive support as the best theory for Chinese literacy (if we recall, this is the most demanding test) but rather that it is broadly compatible with modular approaches to the study of language ability. If it turned out to be substantively correct, then this would favor, according to the argument, at least some versions of the modularity thesis. Another way to appreciate the argument might be to ask: Why, typically, do strong top-down holistic theories of reading tend to favor models in which semantic/pragmatic context and background knowledge penetrate decoding extensively and why do they tend to minimize the importance of bottom-up mechanisms, in regard to the development of phonological/orthographic skills in particular? Also strongly antimodular, they appear to coalesce around a kind of "direct-access" model, implying a direct interface (or degrees of "directness" depending on how strongly holistic one's position is) between orthography and semantics. Antithetical (to holism) modular models of reading, that, for example, are "subskill-oriented," pedagogically, appear to be strongly bottom-up. This is because, following the assumptions of the modularity approach, certain components of language processing in

reading are engaged in a mandatory way, not subject to bypass or deflection by “central” top-down influences.

A pivotal concept in understanding these differences is that of *mental representation*—that actual neurological structures subserve competencies and processors. What does it mean when we refer to cognitive components of reading, for example, in discussing the research on feedback influences (from higher levels) on lower level representations? How is it that in some cases the “feedback loops” are effective, in some cases less so, and in others, ineffective because feedforward (relatively encapsulated) processes predominate (Perfetti, 1999, p. 171)? Along with the conception of the lexicon as a mental representation of a special kind (a part of the domain of interfaces), are these components intrinsic and constitutive of a “permanent” language faculty or should they be considered more like emergent patterns of activation (not “permanent”)? The following concluding section on developmental aspects of Chinese literacy might provide another point of view on the role of phonology in reading.

Conclusion: Literacy-Related Skills and Awareness

To wrap up this review of the research we turn our attention to a practical issue: that of phonological *skills* (and explicit knowledge about phonology) in *learning* how to read. One could accept the phonology-as-constituent-of-word-identification hypothesis (the UPP) and be neutral regarding the role that phonological awareness plays in literacy learning, or take one position or another. The componential approach that we have been considering as an overall analytic framework might help to explain why. To start with, the difference between the two questions is mainly one between a representation problem and a learnability problem. The distinction between explicit knowledge/metalinguistic awareness and implicit competence (question 1 on the list of the four modularity-related research questions from the first section) also allows us to separate the two issues: meta-level abilities associated with phonology are not relevant, or not very much, in evaluating the claims of the UPP. Evidence either for or against the claim can be drawn from the study of the activation of the encapsulated phonological module and performance in a “closed” subsystem. In contrast, the study of the role of phonological awareness in literacy learning focuses on the development of metalinguistic knowledge in a domain that is “open” and subject to deliberate reflection. Fortunately, unlike the contention among the different claims regarding phonological mediation in word identification, the lines are drawn much more clearly on the issue of how explicit knowledge develops. We can outline them concisely as follows.

There are different viewpoints on the importance of phonological awareness skills in child literacy learning. However, there is one result around which some measure of agreement exists. It appears that learners decompose compound characters and that they make use of and are sensitive to different degrees of partial information found in the phonetic component. There may be a stage in reading development in which an analytic stance toward the phonetic component of compound characters facilitates children's mastery of the orthography (Shu, 2003; Tzeng, 2002). It has also been suggested that Chinese dyslexic readers have difficulty applying phonological processing strategies and that direct teaching of script-sound regularities improves reading performance in these cases (Ho & Ma, 1999). All of this might be true even if it turns out that phonological awareness and phonological processing skills, overall, play a role in Chinese literacy that is significantly different from that in alphabetic systems (Ko & Tzeng, 2000). Morphological awareness, for example, might play a much more prominent role in literacy learning (Li, Anderson, Nagy, & Zhang, 2002; Shu, McBride-Chang, Wu, & Liu, 2006).

One interpretation of this finding is that the development of this kind of phonological awareness gets its boost mainly from literacy learning itself or that there is a complex reciprocal relationship *subsequent* to initial experience with literacy and literacy-related language use in general. This argument has been well developed in the research literature on alphabetic literacy learning over the years; see Castles and Coltheart (2004) and Ziegler and Goswami (2005) for a comprehensive review. Long ago, Perfetti (1992) observed that: "Downgrading phonological awareness from causal status to reciprocal status does not diminish its importance for reading. Indeed, it allows it to be seen as a central component of reading instead of as a prerequisite" (p. 166).

Among researchers who question the hypothesis that phonological awareness, per se, predicts successful literacy learning, we might be able to discern two approaches: (a) that the hypothesis should be disfavored in general and (b) that it can be discarded in the case of nonalphabetic literacy learning (in regard to Chinese, we should assume that the consideration of the factor of phonological awareness is restricted to the syllable level, not to phonemic awareness). For now, we will set aside the first approach and consider the possibility that in Chinese the relationship between reading development and phonological awareness is secondary or even marginal. This was the conclusion of Tan, Spinks, Eden, Perfetti, and Siok (2005) in a study that attempted to analyze the "component skills" that are relevant to the complex ability of character recognition. Recalling that children must grapple with "system-level" complications (both linguistic and orthographic) in Chinese that make mapping between

characters and linguistic and meaning structures significantly more complex than in any alphabetic system, the first assumption might be that the learning task is unlikely to be supported by phonological awareness in a major way. The authors proposed that the formation of an “integrated reading circuit that links orthography, meaning, and pronunciation” (Tan et al., p. 8781) occurs at the visual-orthographic level, facilitating children’s awareness of the character’s internal structure. This “orthographic awareness” appears to depend on the establishment of long-term motor memories of characters through extensive practice in copying and writing. Naming speed and measures of accuracy in copying characters were found to be strongly related to reading ability; the relationship with measures of phonological awareness (oddity test and syllable deletion) was minor. Addressing the developmental/learning issue, these findings confirm the results of a number of other studies, suggesting an important difference on this point between alphabetic and nonalphabetic literacy development (Taylor, 2002).

A number of studies make a strong case for an alternative view. Starting from the idea that children might implicitly “analyze” patterns in the internal structure of characters and make use of both the phonetic in fully regular compounds and partial information elsewhere, researchers have proposed a greater role for awareness of phonology (at the syllable level, not to forget). Evidence from studies of the regularity effect (more accuracy in reading regular characters), analysis of reading errors (overgeneralization), and pseudocharacter naming (positively correlated with reading achievement) suggests the development of a “phonetic principle.” This aspect of phonological awareness helps children store compound characters more systematically and facilitates the learning of new characters (Chen, Shu, Wu, & Anderson, 2003), for example, by using an “analogy strategy,” decoding unfamiliar characters with recourse to knowledge of the same phonetic of a familiar character (He, Wang, & Anderson, 2005).

Although findings on the relationship between phonological processing, phonological awareness and Chinese reading remain mixed, the number of studies that have found a positive correlation, contrary to Tan et al. (2005), for example, is noteworthy and future work in this important domain of literacy learning will need to reconcile the differences. Memory tasks involving sets of nonwords, sound categorization (which word out of a group is different; Hu & Catts, 1998) and syllable deletion (Chow, McBride-Chang, & Burgess, 2005; McBride-Chang & Ho, 2000) have been shown to be significant predictors of reading ability in young children. Consistent with other biliteracy studies, the Chow et al. study found that performance on syllable detection in L1 (Cantonese) also predicted L2 reading (in English). Siok and Fletcher (2001) found

that onset-rime awareness was positively related to reading ability at the higher grades (visual skills at the lower grades), but *phonemic* awareness, as we would predict, was not. As was noted earlier, there is a general recognition of the reciprocity between literacy learning and phonological awareness. However, as a component of early reading development (even if it cannot be shown to be a prerequisite), the participation of phonological awareness and the importance of phonological processing are not minor or secondary for the above-mentioned researchers who appear to have drawn different conclusions than the ones in the Tan et al. (2005) study. In other words, the importance of phonological awareness and phonological processing is not specific to alphabetic literacy learning (Chan & Siegel, 2001). In conclusion, the most promising first step toward reconciling the different positions might be to systematically confront the opposing findings from research on the development of reading ability, including phonological awareness (a learnability problem) among studies that all assume one version or another of the UPP (mainly a representation problem).

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Notes

- 1 Strong views of modularity tend to disfavor extensive intermodular or cross-domain interaction (Fodor, 1998). Weaker versions allow for a conception of modules (knowledge structures and processing mechanisms) as “encapsulated” to a lesser extent (Francis, 2008; Marcus, 2006) and for cognitive components to show degrees of “domain-specificity” or “domain-general.” Thus, for the latter, the degree of interactivity among domains is more of an open question, yet to be determined by empirical research. What weaker versions would reject is that interactivity is unconstrained and that mental architecture is entirely homogenous and holistically structured, the key distinction then being between *interaction* (among components/modules) and noncomponential *integration* (no domain-specific cognitive structures). Jackendoff (2002) discussed at length the different versions of modularity in regard to these dimensions.
- 2 The LTH and the “dual-task of L2 literacy” concept are at odds with proposals that minimize the factor of linguistic knowledge in learning how to read in an L2. Poorly designed studies aside, it seems that much of the counterevidence is based on evaluations of L2 reading ability in which subjects’ L2 grammatical competence has already advanced beyond the required threshold for the specific text material or assessment task under consideration. In many studies, subjects’ level of L2 grammatical competence is simply left unspecified. More controlled studies, in the coming years, should begin to converge on what has been taken as a working assumption by most researchers in the field: Even though we should recognize the

effects of a number of interacting external social factors, there exists for *preliterate monolingual L1-speaking child learners*, in addition to preliterate L2-beginners, a Fundamental L1-L2 Literacy Difference, a position that we have argued in favor of from our work on L2 and bilingual literacy in central and northern Mexico (Francis & Paciotto, 2004; Hamel & Francis, 2006). See the section on “Language of instruction” (D. J. Francis, Lecaux, & August, 2006), in the *Report of the National Literacy Panel on Language-Minority Children and Youth* and related sections that are consistent with the LTH and the Fundamental L1-L2 Literacy Difference, and Guglielmi (2008) and Restrepo and Gray (2007) for findings that support the facilitative effect of L1 literacy-related proficiency on L2 literacy attainment.

- 3 Compound characters are composed of two subcomponents (or radicals), each one usually an independent integrated character by itself. Usually they consist of a semantic radical, which often provides a categorical clue for meaning, and a phonetic radical (or phonetic), which can give or suggest pronunciation (see examples for “chant,” “eat,” and “vomit”—semantic radical on the left, phonetic on the right). Phonetics can also be “bound,” not appearing as independent characters. Some compound characters, on the other hand, combine two semantic components to suggest a new meaning. Integrated characters are not composed of separate phonetic and semantic components. They consist of stroke patterns that form an integrated unit that is inseparable. In the examples given, “below,” “above,” and “middle” are independent integrated characters. The great majority of compound characters are irregular or semiregular, neither radical providing a completely reliable clue for meaning or pronunciation. Perhaps the feature of the Chinese writing system that distinguishes it most from alphabetic systems is that there are no component parts of a character that encode individual phonemes. Also taking into account the overall inconsistency of the phonetic radical, the correct pronunciation of characters requires identification of the entire character, unlike in alphabetic writing where a reader can reliably “sound out” unknown words and provide a more or less correct pronunciation for them (Chen et al., 2003; Perfetti, Liu, & Tan, 2005; Weekes et al. 2006; Xu et al., 1999).

References

- Bialystok, E., McBride-Chang, C., & Luk, G. (2005). Bilingualism, language proficiency, and learning to read in two writing systems. *Journal of Educational Psychology, 97*, 580–590.
- Castles, A., & Coltheart, M. (2004). Is there a causal link from phonological awareness to success in learning to read? *Cognition, 93*, 77–111.
- Chan, C. K. K., & Siegel, L. (2001). Phonological processing in reading Chinese among normally achieving and poor readers. *Journal of Experimental Child Psychology, 80*, 23–43.

- Chen, H.-C. (1996). Chinese reading and comprehension: A cognitive psychology perspective. In M. Bond (Ed.), *The handbook of Chinese psychology* (pp. 43–62). Oxford: Oxford University Press.
- Chen, X., Ku, Y.-M., Koyama, E., Anderson, R., & Li, W. (2008). Development of phonological awareness in bilingual Chinese children. *Journal of Psycholinguistic Research, 37*, 405–418.
- Chen, X., Shu, H., Wu, N., & Anderson, R. (2003). Stages in learning to pronounce Chinese characters. *Psychology in the Schools, 40*, 115–124.
- Cheung, H., & Lin, A. M. Y. (2005). Differentiating between automatic and strategic control processes: Toward a model of cognitive mobilization in bilingual reading. *Psychologia, 48*, 39–53.
- Chow, B. W.-Y., McBride-Chang, C., & Burgess, S. (2005). Phonological processing skills and early reading abilities in Hong Kong Chinese kindergartners learning to read English as a second language. *Journal of Educational Psychology, 97*, 81–87.
- Chung, K. H., McBride-Chang, C., Wong, S. W. L., Cheung, H., Penney, T. B., & Ho, C. S.-H. (2008). The role of visual and auditory temporal processing for Chinese children with developmental dyslexia. *Annals of Dyslexia, 58*, 15–35.
- Coltheart, M. (1999). Modularity and cognition. *Trends in Cognitive Science, 3*, 115–120.
- Coltheart, M., Rastle, K., Conrad, K., Langdon, R., & Ziegler, J. (2001). DRC: A dual route cascaded model of visual word recognition and reading aloud. *Psychological Review, 108*, 204–256.
- Cummins, J. (2000). *Language, power and pedagogy: Bilingual children in the crossfire*. Clevedon, UK: Multilingual Matters.
- De Courcy, M. (2002). *Learners' experiences of immersion education: Case studies in French and Chinese*. Clevedon, UK: Multilingual Matters.
- DeFrancis, J. (1989). *Visible speech: The diverse oneness of writing systems*. Honolulu: University of Hawaii Press.
- DeFrancis, J. (1996). How efficient is the Chinese writing system? *Visible Language, 30*, 6–44.
- Fodor, J. (1998). *In critical condition: Polemical essays on cognitive science and the philosophy of mind*. Cambridge, MA: MIT Press.
- Francis, D. J., Lesaux, N., & August, D. (2006). Language of instruction. In D. August & T. Shanahan (Eds.), *Developing literacy in second-language learners: Report of the National Literacy Panel on Language-Minority Children and Youth* (pp. 365–413). Mahwah, NJ: Erlbaum.
- Francis, N. (2004). The components of bilingual proficiency. *International Journal of Bilingualism, 8*, 167–190.
- Francis, N. (2008). Modularity in bilingualism as an opportunity for cross-discipline discussion. In J. Cummins & H. Hornberger (Eds.), *Encyclopedia of language and education, Volume 5* (pp. 105–116). New York: Springer.

- Francis, N., & Paciotto, C. (2004). Bilingüismo y diglosia en la Sierra Tarahumara: Fundamentos de la evaluación del lenguaje. *Pueblos Indígenas y Educación*, 55, 57–82.
- French-Mestre, C. (2005). Eye-movement recording as a tool for studying syntactic processing in a second language: A review of methodologies and experimental findings. *Second Language Research*, 21, 175–198.
- Genesee, F. (2002). Portrait of the bilingual child. In V. Cook (Ed.), *Portraits of the L2 user* (pp. 170–196). Clevedon, UK: Multilingual Matters.
- Geva, E., & Wang, M. (2001). The development of basic reading skills in children: A cross-language perspective. *Annual Review of Applied Linguistics*, 21, 182–204.
- Goodman, K. (2005). Making sense of written language: A lifelong journey. *Journal of Literacy Research*, 37, 1–24.
- Grabe, W., & Stoller, F. (2002). *Teaching and researching reading*. London: Longman.
- Guglielmi, R. (2008). Native language proficiency, English literacy, academic achievement, and occupational attainment in limited-English-proficiency students: A latent growth modeling perspective. *Journal of Educational Psychology*, 100, 322–342.
- Guo, Y., Peng, D., & Liu, Y. (2005). The role of phonological activation in the visual semantic retrieval of Chinese characters. *Cognition*, 98, B21–B34.
- Hamel, R. E., & Francis, N. (2006). The teaching of Spanish as a second language in an indigenous bilingual intercultural curriculum. *Language, Culture and Curriculum*, 19, 171–188.
- He, Y., Wang, Q., & Anderson R. C. (2005). Chinese children's use of subcharacter information about pronunciation. *Journal of Educational Psychology*, 97, 572–579.
- Ho, C. S.-H., Chan, D. W.-O., Lee, S.-H., Tsang, S.-M., & Luan, V. H. (2004). Cognitive profiling and preliminary subtyping in Chinese developmental dyslexia. *Cognition*, 91, 43–75.
- Ho, C. S.-H., & Ma, N.-L. (1999). Training in phonological strategies improves Chinese dyslexic children's character reading skills. *Journal of Research in Reading*, 22, 131–142.
- Hoshino, N., & Kroll, J. (2008). Cognate effects in picture naming: Does cross-language activation survive a change of script? *Cognition*, 106, 501–511.
- Hu, C.-F. (2003). Phonological memory, phonological awareness, and foreign language word learning. *Language Learning*, 53, 429–462.
- Hu, C.-F. (2004). The development of phonological representations among Chinese-speaking children. *Taiwan Journal of Linguistics*, 2, 103–130.
- Hu, C.-F., & Catts, H. W. (1998). The role phonological processing in early reading ability: What we can learn from Chinese. *Scientific Studies of Reading*, 2, 55–79.
- Jackendoff, R. (2002). *Foundations of language: Brain, meaning, grammar, evolution*. Oxford: Oxford University Press.

- Ko, H., & Tzeng, O. J. L. (2000). Learning to read Chinese: The role of phonological awareness in a phonetically opaque script. *Studies in the Linguistic Sciences*, 30, 119–132.
- Kovelman, I., Baker, S., & Petitto, L. A. (2008). Age of bilingual language exposure as a new window into bilingual reading development. *Bilingualism: Language and Cognition*, 11, 203–223.
- Law, S.-P., Wong, W., & Chiu, K. M.-Y. (2005). Preserved reading aloud with semantic deficits: Evidence for a non-semantic lexical route for reading Chinese. *Neurocase*, 11, 167–175.
- Leiken, M., Share, D., & Schwartz, M. (2005). Difficulties in L2 Hebrew reading in Russian-speaking second graders. *Reading and Writing*, 18, 455–472.
- Li, W., Anderson, R. C., Nagy, W., & Zhang, H. (2002). Facets of metalinguistic awareness that contribute to Chinese literacy. In W. Li, J. S. Gaffney, & J. L. Packard (Eds.), *Chinese children's reading acquisition: Theoretical and pedagogical issues* (pp. 87–106). Boston: Kluwer.
- Liberman, A. (1999). The reading researcher and the reading teacher need the right theory of speech. *Scientific Studies of Reading*, 3, 95–111.
- Lin, A. M.-Y., & Akamatsu, N. (1997). The learnability and psychological processing of reading in Chinese and reading in English. In H.-C. Chen (Ed.), *Cognitive processing of Chinese and related Asian languages* (pp. 369–387). Hong Kong: The Chinese University Press.
- Marcus, G. (2006). Cognitive architecture and descent with modification. *Cognition*, 101, 443–465.
- McBride-Chang, C., & Ho, C. S.-H. (2000). Developmental issues in Chinese children's character acquisition. *Journal of Educational Psychology*, 92, 50–55.
- Morais, J., & Kolinsky, R. (2001). The literate mind and the universal human mind. In E. Dupoux (Ed.), *Language, brain, and cognitive development: Essays in honor of Jacques Mehler* (pp. 463–480). Cambridge, MA: MIT Press.
- Morrison, L. (2004). Comprehension monitoring in first and second language reading. *Canadian Modern Language Review*, 61, 77–106.
- Mumtaz, S., & Humphreys, G. W. (2001). The effects of bilingualism on learning to read English: Evidence from the contrast between Urdu-English bilingual and English monolingual children. *Journal of Research in Reading*, 24, 113–134.
- Newmeyer, F. (1998). *Language form and language function*. Cambridge, MA: MIT Press.
- Norris, D. (1990). Connectionism: A case for modularity. In D. Balota, G. Flores d'Arcais, & K. Rayner (Eds.), *Comprehension processes in reading* (pp. 331–343). Hillsdale, NJ: Erlbaum.
- Ong, W. J. (1982). *Orality and literacy: The technologizing of the word*. London: Methuen & Co.
- Packard, J. (2000). *The morphology of Chinese: A linguistic and cognitive approach*. Cambridge: Cambridge University Press.

- Paradis, M. (2004). *A neurolinguistic theory of bilingualism*. Amsterdam: Benjamins.
- Perfetti, C. (1992). The representation problem in reading acquisition. In P. Gough, L. Ehri, & R. Treiman (Eds.), *Reading acquisition* (pp. 145–174). Mahwah, NJ: Erlbaum.
- Perfetti, C. (1999). Comprehending written language: A blueprint of the reader. In C. Brown & P. Hagoort (Eds.), *The neurolinguistics of language* (pp. 167–208). Oxford: Oxford University Press.
- Perfetti, C. (2003). The Universal Grammar of reading. *Scientific Studies of Reading*, 7, 3–24.
- Perfetti, C., & Dunlap, S. (2008). Learning to read: General principles and writing system variations. In K. Koda & A. M. Zehler (Eds.), *Learning to read across languages: Cross-linguistic relationships in first and second language literacy development* (pp. 13–38). New York: Routledge.
- Perfetti, C., & Liu, Y. (2005). Orthography to phonology and meaning: Comparisons across and within systems. *Reading and Writing*, 18, 193–210.
- Perfetti, C., Liu, Y., & Tan, L. H. (2005). The lexical constituency model: Some implications of research on Chinese for general theories of reading. *Psychological Review*, 112, 43–59.
- Pesetsky, D. (1996). *Linguistics and learning to read*. Unpublished manuscript. Retrieved May 5, 2009, from <http://web.mit.edu/linguistics/www/pesetsky/NCTE1996essay.pdf>
- Petitto, L.A. (2007). Cortical images of early language and phonetic development using near infrared spectroscopy. In K. Fischer & A. Battro (Eds.), *The educated brain* (pp. 213–232). Cambridge: Cambridge University Press.
- Pinker, S. (1999). *Words and rules: The ingredients of language*. New York: Harper Collins.
- Plaut, D. C., McClelland, J. L., Seidenberg, M. S., & Patterson, K. (1996). Understanding normal and impaired word reading: Computational principles in quasi-regular domains. *Psychological Review*, 103, 56–115.
- Rayner, K., Foorman, B., Perfetti, C., Pesetsky, D., & Seidenberg, M. (2001). How psychological science informs the teaching of reading. *Psychological Science in the Public Interest*, 2, 31–74.
- Restrepo, M. A., & Gray, S. (2007). Optimizing literacy in English language learners. *Seminars in Speech & Language*, 28, 25–34.
- Seidenberg, M. S. (2005). Connectionist models of word reading. *Current Directions in Psychological Science*, 14, 238–242.
- Shatil, E., & Share, D. L. (2003). Cognitive antecedents of early reading ability: A test of the modularity hypothesis. *Journal of Experimental Child Psychology*, 86, 1–31.
- Shu, H. (2003). Chinese writing system and learning to read. *International Journal of Psychology*, 38, 274–284.
- Shu, H., Chen, X., Anderson, R.C., Wu, N., & Xuan, Y. (2002). Properties of school Chinese: implications for learning to read. *Child Development*, 74, 27–47.

- Shu, H., McBride-Chang, C., Wu, S., & Liu, H. (2006). Understanding Chinese developmental dyslexia: Morphological awareness as a core cognitive construct. *Journal of Educational Psychology, 98*, 122–133.
- Siok, W. T., & Fletcher, P. (2001). The role of phonological awareness and visual-orthographic skills in Chinese reading acquisition. *Developmental Psychology, 37*, 886–899.
- Stanovich, K. (2000). *Progress in understanding reading: Scientific foundations and new frontiers*. New York: Guilford.
- Stanovich, K. (2003). Understanding the styles of science in the study of reading. *Scientific Studies of Reading, 7*, 105–126.
- Stanovich, K., & Stanovich, P. (1999). How research might inform the debate about early reading acquisition. In J. Oakhill & R. Beard (Eds.), *Reading development and the teaching of reading: A psychological perspective* (pp. 12–41). Oxford: Blackwell.
- Taft, M., & van Graan, F. (1998). Lack of phonological mediation in a semantic categorization task. *Journal of Memory and Language, 38*, 203–224.
- Tan, L. H., Spinks, J., Eden, G., Perfetti, C., & Siok, W. T. (2005). Reading depends on writing, in Chinese. *Proceedings of the National Academy of Sciences, 102*, 8781–8785.
- Taylor, I. (2002). Phonological awareness in Chinese reading. In W. Li, J. S. Gaffney, & J. L. Packard (Eds.), *Chinese children's reading acquisition: Theoretical and pedagogical issues* (pp. 39–58). Boston: Kluwer.
- Tsai, J. L., Lee, C. Y., Tzeng, O., Hung, D. L., & Yen, N. S. (2004). Use of phonological codes for Chinese characters: Evidence from processing of parafoveal preview when reading sentences. *Brain and Language, 91*, 235–244.
- Tzeng, O. J. L. (2002). Current issues in learning to read Chinese. In W. Li, J. S. Gaffney, & J. L. Packard (Eds.), *Chinese children's reading acquisition: Theoretical and pedagogical issues* (pp. 3–16). Boston: Kluwer.
- Tzeng, O. J. L., Zhong, H. L., Hung, D. L., & Lee, W. L. (1995). Learning to be a conspirator: A tale of becoming a good Chinese reader. In B. de Gelder & J. Morais (Eds.), *Speech and reading: A comparative approach* (pp. 227–246). East Sussex, UK: Taylor & Francis.
- Verhoeven, L. (2000). Components of early second language reading and spelling. *Scientific Studies of Reading, 4*, 313–330.
- Walter, C. (2004). Transfer of reading comprehension skills to L2 is linked to mental representations of text and to L2 working memory. *Applied Linguistics, 25*, 315–339.
- Wang, M., Koda, K., & Perfetti, C. (2003). Alphabetic and nonalphabetic L1 effects in English word identification: A comparison of Korean and Chinese English L2 learners. *Cognition, 86*, 129–149.
- Weekes, B. S., Yin, W., Su, I. F., & Chen, M. J. (2006). The cognitive neuropsychology of reading and writing Chinese. *Language and Linguistics, 7*, 595–617.

- Xu, Y., Pollatsek, A., & Potter, M. C. (1999). The activation of phonology during silent word reading. *Journal of Experimental Psychology*, *25*, 838–857.
- Zhou, X., & Marslen-Wilson, W. (1999). Phonology, orthography, and semantic activation in reading Chinese. *Journal of Memory and Language*, *41*, 579–606.
- Zhou, X., & Marslen-Wilson, W. (2000). The relative time course of semantic and phonological activation in reading Chinese. *Journal of Experimental Psychology*, *26*, 1245–1265.
- Ziegler, J. C., & Goswami, U. (2005). Reading acquisition, developmental dyslexia, and skilled reading across languages: A psycholinguistic grain size theory. *Psychological Bulletin*, *131*, 3–29.