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Orthography, Phonology, Morphology, and Meaning: An Overview

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The area of research on printed word recognition has been one of the most active in the field of experimental psychology for well over a decade. This is in part because the behavior under scrutiny is seen as complex enough to be interesting but circumscribed enough to make discovery feasible. It contains many of the theoretical concepts that are part of the cognitive psychologist's standard investigative repertoire (form perception, attention, awareness, information, representation, neural networks, theoretical linguistics—to name a few) and an armamentarium of clever experimental techniques. However, notwithstanding the energetic research effort and despite the fact that there are many points of consensus, major controversies still exist. One central matter is the question of whether to view reading primarily as a linguistic activity or, alternatively, as a process that is subject to the same kinds of learning as other visually based, but nonlinguistic, information.

Our stance on this is that it is quite necessary to take spoken language into consideration when attempting to understand the psychological processes by which reading is accomplished. We need to do this for two kinds of reasons. First, it is well known that writing systems are designed primarily to represent spoken language and, therefore, it seems at least plausible that we should find the imprint of spoken language in the processes that lead from the recognition of the printed word to the comprehension of the phrase. Secondly, in the past two decades of research, there has been a wealth of data supporting this claim. However, the fact that these two statements are not unchallenged leads us to many of the issues that involve the contributors to this volume. Nevertheless, the motivation for the present volume derives from this putative relationship between language and reading; the book takes as its primary issue the question of the degree to which basic processes in reading reflect the structural characteristics of language such as phonology and morphology.

In Part 1. *Language and Orthography*, several chapters point out how the phonological and morphological structures of a language have, historically, often determined the kind of orthography that is adopted for a language. The variety that exists in spoken languages has given rise to a variety of orthographies. each orthography reflecting a unique relationship to its language's structural characteristics. A chapter by Mattingly begins Part 1. Mattingly points out the dependence of writing and reading on spoken language. He describes how constraints on human memory and perception together with the requirement that writing should be a productive system have shaped the kinds of orthographies that have been developed. Mattingly explores the idea that once a reader has learned a particular orthography the reader's intuitions (linguistic awareness) about his or her language are shaped by the particulars of that orthography. An issue is thereby raised: does the process by which reading is accomplished—the psychological process—also vary among languages. reflecting, in processing diversity, the orthographic diversity? To address this, we present research from a variety of different languages covering the spectrum of writing systems. Frost and Bentin's chapter presents evidence suggesting that a special kind of flexibility exists for the reading process: that the Hebrew reader can optimize his or her processing for the kind of information being presented by the printed word. Skilled Hebrew readers are able to take advantage of a particular characteristic of that orthography: morphologically related words in Hebrew are normally printed to include their common consonantal root but omit the vowel information that distinguishes the relatives when they are spoken. Readers can read words printed this way quite efficiently, determining what the specific form of the word is from the context. Nevertheless, despite this efficiency, when Hebrew readers read words in the extended Hebrew orthography (which includes all vowel information), they are flexible enough to adopt a different strategy—one that prefers to utilize the available vowel information.

Within the group of alphabetic orthographies there are large differences in the degree to which writing systems adhere to a strict alphabetic principle, i.e. the principle of an isomorphic relation between letter and phoneme. A question of interest is whether these differences in orthography are reflected in differences in the process of printed word recognition. How different is reading in Spanish, which conforms closely to the alphabetic principle. from reading in Hebrew, in whose orthography the spelling reflects the spoken form of the word only incompletely? A common proposal has been that the more closely an orthography conforms to the alphabetic principle. the more efficiently phonological representations will mediate between print and lexicon. A phonological representation is assumed to be assembled by the reader who makes use of the orthography's correspondences between subword spelling and sound. This proposal has been termed the orthographic depth hypothesis. It is explored in several chapters in this volume, but particularly in Part 1. in a paper by Besner and Smith and a paper by Katz and Frost. Besner and Smith point out the evidence (both rational and empirical) that a strong version of the orthographic depth hypothesis. in which phonology is deemed to be the *only* code for word recognition. is not viable. Katz and Frost agree with that point but suggest a weaker version of the hypothesis. which has experimental support. According to Katz and Frost's version of the orthographic depth hypothesis. full recovery of a printed word's phonological structure can involve both prelexical (i.e. assembled) phonology and

lexical (i.e., stored) phonology. Their main point is that the relative dependence on prelexical versus lexical sources for phonology is a function of the orthography's depth. For example, in Spanish, a shallow orthography, phonology should be more easily assembled because the letter-phoneme relation is fairly simple and consistent. Because assembled phonology is easily obtained, it should be, more often, the actual mechanism for obtaining a word's phonological representation than in a deeper orthography like English, in which letter-phoneme correspondences are more complex.

Even proponents of the orthographic depth hypothesis have not made claims that word recognition in Chinese is aided by phonological representations mediating between the grapheme and the lexical entry. Chinese seems to be a poor candidate for such a claim because the phonologic morpheme in a Chinese word is typically a less precise, less reliable cue for pronunciation than is an alphabetic spelling. Nevertheless, Hung, Tzeng, and Tzeng presents data suggesting that, even in Chinese, phonology plays a role in word recognition. If their claim continues to be supported, its import cannot be understated: Because a phonological representation in Chinese is so much less specific than an alphabetic prelexical phonological representation in determining a unique word, its use in spite of this ambiguity suggests that phonological representations may be even more pervasive in less phonologically opaque (i.e., syllabic, alphabetic) writing systems.

Seidenberg, while acknowledging that orthographic depth plays some role in word recognition, argues that we ought not to put too much emphasis on it: that reading processes for different orthographies are more alike than they are different. And he emphasizes the need to go beyond the question of whether or not the word recognition process employs assembled phonology or not: Seidenberg feels that we need to understand the nature of the flexibility that the reading process displays with regard to how it distributes its resources for word recognition: to the use of assembled phonology, on the one hand, and to the use of visual-orthographic representations, on the other. In order to understand this flexibility, we need to understand better the cognitive structures involved in reading and how their various limitations and constraints are played off against each other.

The two chapters by Grainger and by Johnson are not concerned with cross-orthography effects or with the question of phonologic involvement. Rather, they use a single orthography and focus on the role of the lexicon's neighborhoods of words in word perception. A neighborhood, in the internal lexicon, consists of a set of words that have, to one degree or another, spellings that are similar. Neighborhood theories view the identification of a particular printed word as a process of differentiating that word from the other words in its neighborhood. Thus, neighborhood theories take *similarity*, usually defined orthographically, as the important determiner of word recognition. Mutual facilitation and/or inhibition between the target word and its neighbors (based on the degree of their similarities) can affect the speed and success of identification. These two chapters, together, review the state of the art in neighborhood theory and also contribute new experimental results.

In Part 2, *Orthography and Phonology*, two major controversial issues are treated. The first continues the concern over the role of phonology in lexical access and focusses on experimental work on this topic: Under what conditions does the reader address the

lexicon by assembling a phonological representation from the orthographic form and under what conditions is the orthographic form itself used directly for access? How the lexicon is addressed is a matter of considerable importance because it is vital, in understanding the reading process, to know the nature of the internal representations generated in the information flow. Only then can we attempt to characterize the information theoretic structure of the reading process and to understand its division and allocation of processing resources. There is also a second issue, one of considerable practical importance. The problem of understanding how readers achieve word recognition bears directly on the question of the preferred method of teaching reading. Here an often bitter conflict has raged in the education community for decades. Although it is an oversimplification to say that there are only two opposing points of view, nevertheless, it is fair to say that any of the current approaches to the teaching of reading either emphasizes the importance of decoding skills for the beginning reader (and therefore emphasizes the importance of learning to produce phonological representations) or minimizes it (emphasizing, instead, the importance of visual-orthographic representations such as in "whole-word" reading). While the debate within experimental psychology has been more civil, it has not been less volatile, with evidence accumulating for both positions.

Liberman's chapter discusses the theoretical implications of something that should have been obvious but, unfortunately, has not been: that listening to speech is both easy and universal while reading is neither; reading is, in a real sense, unnatural. One implication of this is that a theoretical explanation of reading must be very different from a theoretical explanation of listening. As Liberman points out, theorists usually fail to make this contrast and theories of reading and theories of speech perception have both suffered as a consequence. Liberman stresses the dependence of the reading process on speech; he raises the often expressed idea that there is a link between a child's success in learning to read and the child's ability to analyze the phonological structure of his or her language— at least that particular phonology that the orthography maps on to. This understanding then allows the child to utilize the correspondence between letter and phoneme to decode the printed letter string: It allows recognition of that word as if it were in the child's own spoken lexicon. A deficiency in this ability should be particularly damaging for children who must learn an alphabetic orthography because the child must first understand that spoken words are composed of phonemes, a requirement that is difficult because it requires a cognitive awareness of phonological representations that are normally processed automatically, without awareness, in speech perception and production.

If children who are unable to learn to read easily have a problem in the phonological domain, might this problem be expressed in other ways as well? Shankweiler and Lundquist's chapter widens the focus of discussion to include spelling ability. Their argument is that spelling ability is largely a function of linguistic skills which are indexed by phonological awareness, the ability to analyze a spoken word into its phonologic components. Although it has been claimed by others that spelling ability reflects visual-orthographic memory, the authors make the argument that the underlying psychological structure for spelling has, at the least, a strong phonological component. The chapter by Bentin also deals with phonological awareness, showing that this ability is responsible for much of the variation in reading ability observed among children. His chapter discusses

the causes of phonological awareness. Bentin's data demonstrate that maturation and instruction in reading both affect the development of children's phonological awareness. Thus, he shows us that learning to read is not only influenced by phonological awareness but, as learning occurs, it furthers the growth of phonological awareness.

Three chapters each make the strong claim that phonology plays an obligatory part in the word recognition process. Each uses a different experimental methodology, which furthers the generality of the claim. Carello, Turvey, and Lukatela marshal the arguments and evidence that printed word recognition, as observed in the lexical decision task, inevitably (although not exclusively) involves assembling a phonological representation: that word recognition relies mainly on the information provided via the alphabetic principle. Their evidence comes largely from experiments in the shallow Serbo-Croatian orthography, in which there is a strong correspondence between grapheme and phoneme. Perfetti, Zhang, and Berent present English data that buttress the claim that there is obligatory assembled phonology in lexical access. Their procedure involves the injection of printed phonological information into the processing stream shortly after the tachistoscopic presentation of the target word: the target is masked by a pseudoword that is either phonologically similar to the target or not. Because the time from target onset to mask onset can be quite brief in their experiments (e.g., 25 to 65 ms), the effects of phonological similarity seem to be attributable to an early phase of processing. The authors argue further that phonological processes play a role throughout the entire reading process—not just in word recognition but in comprehension as well. Finally, they compare reading in English and Chinese and suggest that the similarity between the two orthographies with regard to the role of phonology is greater than their differences. Further support for the position that phonology is an inherent part of the word recognition process appears in the paper by Van Orden, Stone, Garlington, Markson, Pinnt, Simonfy, and Brichetto. Their experimental paradigms include sentence verification, lexical decision, categorization, and proofreading: a mix of techniques that all provide converging evidence. Their paper discusses the notion of covariant learning in which the relation between orthography and phonology is expressed as a statistical relation instead of as a collection of rule based correspondences between letter and phoneme. Covariant structural relations fit more naturally into neural network formulations of the word recognition process, the class of models preferred by the authors. Finally, both this chapter and the chapter by Carello, Turvey, and Lukatela make the point that, in the debate between phonological versus visual-orthographic representations, there has been little effort given to collecting positive evidence in favor of the visual-orthographic hypothesis. Rather, the emphasis has been on showing that phonology does (or does not) have an effect on word recognition. In cases in which there was no evidence of phonological effects, it has often been assumed that the alternative hypothesis—visual-orthographic coding—was proven by default. Thus, decisions have been made based on failures to reject the null hypothesis, a notoriously poor strategy.

Paap, Noel, and Johansen lay out the theory and data for dual route theories of printed word pronunciation. The dual routes are the pathways carrying the phonological and orthographic information used for pronouncing printed words. Although the chapter is oriented toward the response of naming printed words, the authors also discuss dual route theory for tasks in which a silent response is made (e.g., a semantic decision about the

target word). They describe their chapter as a tutorial for the newcomer but its clarity will serve the advanced researcher as well by dispelling many non-issues (the authors call them "red herrings") that have cluttered discussion in this area. Several other chapters (e.g., those cited in the previous paragraph) also suggest that lexical access depends on dual codes, i.e., dual representations. If one argues for dual codes, there arises the question of what it is that determines whether the visual-orthographic or phonologic code is used in a particular instance of word recognition. In standard dual route theory, the factors that are said to affect the lexical access code are stable and fixed—word frequency, spelling regularity, and perhaps, characteristics of the orthography (e.g., orthographic depth). However, others suggest that subject strategies may play an additional role in determining which code is used: these strategies are affected by more variable characteristics of the reading context. For example, Colombo and Tabossi demonstrate that subjects are capable of making fine adjustments to their strategy for naming words in Italian. Naming (pronouncing a word aloud as fast as possible) is a task that requires subjects to take into account the word's syllable stress. Colombo and Tabossi's show that subjects' response times are affected by the kinds of word stress that the experimenters build into their lists of stimulus words. Subjects could be induced to use either a sublexical (i.e., assembled) or a lexical strategy, assigning stress one way or the other in agreement with the list bias. It will be of major interest if it turns out that the reader has exquisite control of such presumably low-level components of the reading process. The issue of strategic use necessarily raises questions about the allocation of attentional resources to the various components of the reading process: both where and how attention is distributed. These are likely to be questions researchers will be increasingly concerned with, as the chapters of Paap, et al., Seidenberg, and Van Orden et al. suggest. Finally, although Colombo and Tabossi's data show there is flexibility in subjects' coding strategies, an implication of their experiments is that subjects will not choose to use a phonological strategy under normal circumstances in reading. This poses a challenge to those who argue for the ubiquity of phonological coding: to show that the evidence in favor of phonology is not an artifact of particular experimental paradigms but can be generalized to normal reading.

Orthographies convey not only phonologic but also morphologic information. In fact (we must sometimes remind ourselves), phonological and orthographic information are simply vehicles for the activation of morphological information. Part 3. *Orthography and Lexical Structure,* is concerned, in part, with the representation of morphological information in lexicon. Morphological information includes those parts of a word that convey (1) syntactic inflection (e.g., number, case, gender, tense, mood, etc.) or (2) derivational relations (e.g., nominalizations of adjectives, formation of diminutives, etc.) as well as (3) word roots.

Morphological relatives are different words that have a common root. For example, WALK/WALKED/WALKING all have the same root but different inflectional morphemes and WEIGH/WEIGHT/WEIGHTY are derivationally related. Are relations between morphological relatives represented in the lexicon by connections that are specifically morphological? There is considerable evidence of connections between words

in the same morphological family. However, much of this evidence may be confounded by one or more artifacts. As Feldman and Andjelkovic point out, it is quite difficult to demonstrate pure morphological relations among words experimentally. One major experimental design problem is the requirement to separate the effects of the strictly morphological relationships between words from their formal similarity (i.e., related words tend to sound and look alike). Subjects may respond similarly to two words for either of those two reasons, producing the appearance of a morphological effect but not the reality. Additionally, morphological relatives will nearly always have a semantic communality, and experimental effects may be found that are attributable to this factor, further obscuring the observation of purely morphological relationships between words. Feldman and Andjelkovic address much of their chapter to the solution of these problems.

What is the organization in lexicon of words that are morphological relatives? Despite the evidence that some such organization does exist, the details of morphological organization are far from clear. After briefly discussing the various models of morphological representation, Burani and Laudanna go on to focus on the specific question of how derivational relatives are organized. Beauvillain and Segui are also concerned with the organization of morphological relatives. In addition, they discuss the forms that the lexical representations of derived words may take. Does a derived word's lexical entry consist of distinct components, viz., a root and one or more derivational morphemes? Or, instead, is the word stored "intact," as a whole unit? This question is relevant to the third question they confront: What is the process by which derived words are recognized? If words are stored as a set of morphological components, then a printed target word must first be decomposed into its components (root and derivational morpheme) before recognition can occur. If not, then each relative must be accessed as a whole word, without specific reference to its morphological characteristics. De Groot's chapter also deals with relations between words in the lexicon. Here, the lexicon of interest is the bilingual lexicon. The relation between words in the two languages involves their semantic communality. Given the problem she has set herself, de Groot's focus is not on the lexical level itself and its orthographic, phonologic, and morphologic information but, rather, on conceptual memory. Evidence from several semantic memory paradigms are used. De Groot's work is informative beyond the question of the bilingual lexicon because it raises questions about the nature of the representation of meaning itself.

Although much attention is paid to questions of representation in printed word recognition (i.e., the kinds of codes that occur in the information flow from print to lexicon), there has been relatively little concern about other aspects of the process. In spite of the fact that our primary tool for investigating word recognition is the lexical decision task, our knowledge of the mechanism by which lexical access is achieved is still uncertain. Forster's chapter redresses some of this imbalance with an organized discussion of the classes of models that are capable of accounting for the lexical search process: how the target word is selected from among the tens of thousands of words in the lexicon. His paper describes and evaluates the various models on rational grounds of efficiency and plausibility and in terms of their adequacy for explaining the major phenomena of word recognition: the word frequency effect, the repetition effect, neighborhood effects, etc. The chapter will certainly form the nucleus for a revitalized discussion on lexical search models.

This book presented a unique opportunity to bring together leading researchers who address the question of printed word recognition from a linguistic perspective. The chapters reveal the interactive nature of their work in this field: a measure of this closeness can be found in the high degree of mutual citations. From the mix of tutorial articles, critical articles, data papers, and theory papers, comes a portrait of the field; this includes not only a picture of current theory and data but a view of the directions in which this vigorous research area is moving.