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Strategies for Visual Word Recognition and Orthographical Depth: A Multilingual Comparison

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We investigated the psychological reality of the concept of orthographical depth and its influence on visual word recognition by examining naming performance in Hebrew, English, and Serbo-Croatian. We ran three sets of experiments in which we used native speakers and identical experimental methods in each language. Experiment 1 revealed that the lexical status of the stimulus (high-frequency words, low-frequency words, and nonwords) significantly affected naming in Hebrew (the deepest of the three orthographies). This effect was only moderate in English and nonsignificant in Serbo-Croatian (the shallowest of the three orthographies). Moreover, only in Hebrew did lexical status have similar effects on naming and lexical decision performance. Experiment 2 revealed that semantic priming effects in naming were larger in Hebrew than in English and completely absent in Serbo-Croatian. Experiment 3 revealed that a large proportion of nonlexical tokens (nonwords) in the stimulus list affects naming words in Hebrew and in English, but not in Serbo-Croatian. These results were interpreted as strong support for the orthographical depth hypothesis and suggest, in general, that in shallow orthographies phonology is generated directly from print, whereas in deep orthographies phonology is derived from the internal lexicon.

Recognition of a word presented in the visual modality is ultimately based upon a match between a printed string of letters and a lexical representation. This match can be mediated by two types of codes: one that is based on some abstract representation of the orthography and one that refers to phonemic information represented by the graphemic structure. There is some agreement that both code types are automatically activated during the process of word recognition and act in parallel (but asynchronously) to mediate lexical access (but see Humphreys & Evett, 1985, for a critical review). The relative use of the orthographic and phonemic codes is determined by factors such as the subject's reading ability, the complexity of the stimuli, and task demands. For example, orthographic codes gain priority when the subjects are fluent readers, when the stimuli are very familiar or phonemically irregular, and when the task em-

phasizes the graphemic aspects of the printed words. In contrast, phonological codes are used relatively more by inexperienced readers, when the stimuli are more complex, and when the phonemic aspects of the material are emphasized by the task (for a review, see McCusker, Hillinger, & Bias, 1981).

The data on which these suggestions have been based were provided primarily by studies conducted in English. Research outside of the English language suggested that in addition to these three factors, a bias toward one or the other code type may be tied to the depth of the language's orthography (Lukatela, Popadic, Ognjenovic, & Turvey, 1980). Alphabetic orthographies can be classified according to the complexity of their letter to sound correspondences. In a *shallow orthography*, the phonemic and the orthographic codes are isomorphic; the phonemes of the spoken word are represented by the graphemes in a direct and unequivocal manner. In contrast, in a *deep orthography*, the relation of spelling to sound is more opaque. The same letter may represent different phonemes in different contexts; moreover, different letters may represent the same phoneme. Comparison of the English and Serbo-Croatian orthographies exemplifies this distinction. The Serbo-Croatian writing system directly represents the phonology of the word; each grapheme unequivocally represents a single phoneme, and each phoneme is represented by only one grapheme. Therefore, it is considered shallower than the English spelling system, which simultaneously represents both the phonology and morphology and where these representations are mixed inconsistently from word to word (Gleitman & Rozin, 1977). Consequently, genera-

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tion of phonemic codes from print should be easier in Serbo-Croatian than in English. Several studies revealed that, indeed, lexical access in English is mediated by both orthographic and phonemic codes, whereas native readers of Serbo-Croatian are biased toward using phonemic codes in word recognition (Feldman, 1980; Feldman & Turvey, 1983; Lukatela, Popadic, et al. 1980).

The influence of orthographical depth on word recognition has been suggested in several studies that compared lexical decision and naming performance. It has been argued that in a shallow orthography the extensive use of grapheme-to-phoneme translation¹ for word recognition might efficiently provide the articulatory codes used for pronunciation and, therefore, would minimize involvement of the lexicon in naming printed words. On the other hand, if the grapheme-to-phoneme translation is complex, the translation may be excessively costly in terms of time, and naming may be mediated by a lexical representation of the word. In this case, lexical access would have been achieved by means of an orthographic code, which then affords the word's stored pronunciation. Consequently, lexical processes in naming printed words should be more conspicuous in English than in Serbo-Croatian. Katz and Feldman (1983) compared pronunciation and lexical decision in English and Serbo-Croatian. In both languages, naming was faster than lexical decision, but the difference was smaller in English. Furthermore, semantic priming facilitated lexical decision but not pronunciation performance in Serbo-Croatian, whereas in English, semantic priming was effective in both tasks. These results are in perfect accordance with the English language's putatively greater dependence on the lexicon for pronunciation.

The influence of orthographical depth on word recognition processes was apparently confirmed by the comparisons between English and Serbo-Croatian, but this conclusion is not without criticism. Orthographical depth is not the only dimension along which these two languages differ. English and Serbo-Croatian have different grammatical structures and possibly different lexical organizations (Lukatela, Gligorijevic, Kostic, & Turvey, 1980). Because it is not known how those other factors may affect word recognition in English and Serbo-Croatian, attribution of differences in performance only to orthographical depth might be incorrect. Moreover, the effects of orthographical depth on printed word processing is not unanimously accepted. Recently, the claim has been made that the manner in which an orthography encodes phonology has little effect on skilled word recognition (Seidenberg & Vidanovic, 1985).

One way to test the validity and psychological reality of the concept of orthographical depth is to find a third language that, although different from either of the other two in many aspects, would represent a third point along the continuum of orthographical depth. Assuming that orthographical depth is indeed the relevant factor and that there is no other relevant dimension on which the three languages may be aligned along a continuum, the effects found in a two-language comparison should be found to extend in a systematic manner to the three-language comparison. An appropriate ordering of the three languages on a given measure would corroborate the psychological reality of the orthographical depth factor more strongly because the predicted ordering would then be one out of six possibilities of or-

der (for the three languages), instead of only one out of two possibilities (for the two languages).

The Hebrew language provides a natural third point on the continuum of orthographic depth. In Hebrew, consonantal information is represented by letters, whereas vowels are mainly conveyed by small diacritical marks added to the consonants. These vowel marks, however, are omitted from regular reading material such as literature (except poetry), newspapers, advertisements, street signs, and so on. Although the full writing system (consonants and vowel marks) is taught in the first two grades of elementary school, the adult reader is exposed almost exclusively to unvowelized print. Therefore, the Hebrew orthography is an extreme example of ambiguity. Because several words may share an identical consonant structure, many consonant strings can be pronounced in several ways, each producing a different legal Hebrew word. This is in complete contrast to Serbo-Croatian and is essentially different from English as well. (English has only a few heterophonic homographs: *bow*, *wind*, *read*, etc. An English reader can get some feeling for the adult Hebrew orthography by imagining an English orthography in which the vowels are omitted: The string *bittr* would stand for *batter*, *better*, *bitter*, and *butter* and, of course, a large number of nonwords, e.g., *bottir*.) Clearly, in such an orthography, the full phonemic code of the word is less transparent than it is in either English or Serbo-Croatian and represents the third and deepest point along the continuum of orthographical depth.

Previous studies have already suggested that in Hebrew, orthographic codes play a more important role in the process of word recognition than do phonemic codes, especially in comparison with the roles played in other languages. For example, Bentin, Bargai, and Katz (1984) found that rejection of nonwords in a lexical decision task is slower if they are orthographically similar than if they are phonemically similar to real words. Moreover, addition of the missing phonemic information (vowel marks) did not facilitate lexical decision, and sometimes even delayed it (Bentin & Frost, in press; Koriati, 1984). In none of these studies, however, was controlled comparison between languages made; therefore, the relative importance of phonemic and orthographic codes in different languages was not directly examined. We sought to fill this gap; we hoped to improve the validity of the interlanguage comparison (a) by using identical methodology and apparatus for all three languages and (b) by studying all three in their native environments to ensure that the language on which a subject was tested was, in fact, the actual language environment of the subject. Thus, we hoped to provide clearer evidence for or against the notion that the directness with which an orthography represents the phonology of its language determines the relative use of orthographic versus phonological codes in the perception of printed words.

General Method

Because we conducted this study in three different countries, we took special care to standardize procedures, materials, and

¹ Throughout this article we use the term *grapheme-to-phoneme translation* with the understanding that the process often involves units larger than single letters.

apparatus. The same experimenter ran identical experiments in Israel, Yugoslavia, and the United States.

All stimuli in each language were two-syllable nouns that had a stop consonant as their first letter. Native speakers constructed the word data base in each language, but, wherever possible, literal translations were used. Homographs and homophones were not used. In Hebrew, all stimuli were undotted (i.e., without vowel marks) but could be pronounced as only one real word. Because there are no reliable sources of standard objective word frequency in Hebrew and in Serbo-Croatian, we devised a procedure for estimating subjective frequencies. Recently, subjective and standard objective word frequencies were found to be highly correlated (Gordon, 1985). The same procedure of frequency estimation was used in all three languages: Two hundred words that conformed to the above criteria were printed on two pages (in Hebrew, without the vowel marks). Fifty undergraduates were asked to rate each word on a 5-point scale ranging from *least frequent* (1) to *most frequent* (5). We calculated estimated frequency for each word by averaging the ratings across all 50 judges. On the basis of these ratings, groups of high- and of low-frequency words were selected.

Experiment 1

This experiment was designed to assess the effect of lexical factors on naming of words and of nonwords across Serbo-Croatian, English, and Hebrew and to relate naming to lexical decision performance in the three languages. This technique was used in order to assess the hypothesis that the deeper the orthography is, the more the reader will depend on lexical information for naming.

Previous studies in English suggested that naming and lexical decision performance are significantly correlated; this correlation was interpreted as evidence that naming in English is usually lexically mediated (Forster & Chambers, 1973; see also Forster, 1979; Theios & Muise, 1977; West & Stanovich, 1982). More recently, Katz and Feldman (1983) used the same technique to assess the extent of lexical mediation for naming in Serbo-Croatian and to compare it with that in English. In that study, they also used semantic priming as a manipulation that was assumed to affect only lexically mediated processes. Semantic priming effects were found for lexical decision in both languages, but for naming, only in English. Moreover, in English, but not in Serbo-Croatian, they found significant lexical decision-naming correlations, regardless of the semantic relation between target words and previously presented primes. On the basis of these results, the authors concluded that naming is less mediated by lexical information in the orthographically shallow Serbo-Croatian; naming in that language was apparently dependent on prelexical phonological coding. However, attributing the differences between the two languages specifically to orthographic depth is problematic because they differ in other ways as well (as was discussed earlier).

Assessment and interpretation of the effects that orthographical depth might have on word recognition is further complicated by two recent studies. Hudson and Bergman (1985) revealed that if only words are to be named (in a blocked condition), lexical involvement (as reflected by word frequency

effects) may be found even in Dutch, which has a shallow orthography. In addition, phonological manipulations had a similar effect on naming words in the deep Chinese logography and in the English alphabetic orthography. In both languages, only very infrequent words were affected (Seidenberg, 1985).

This study addresses these controversies; we attempted to assess the validity of the orthographical depth hypothesis (a) by using a three-language comparison and (b) by using the lexical decision results for each language only as a reference point against which its naming results could be interpreted. Thus in Experiment 1 we investigated how factors that are generally agreed to involve lexical processing affect naming in each language; we considered the effects of the same factors on lexical decision only as a point of reference.

The most obvious lexical factor is the difference between words and nonwords. Although some authors suggested that nonwords might be pronounced by referring to related lexical entries for words (Glushko, 1979), only a few would argue that nonwords are represented in the lexicon. Therefore, one can reasonably assume that pronunciation of nonwords is mediated by a process of grapheme-to-phoneme translation, and lexical involvement is minimal. However, if the grapheme-to-phoneme translation is the route chosen for naming both words and nonwords, then the lexical status of the stimulus should have only a small effect on performance. On the other hand, if the lexical route is the strategy usually chosen for naming words, then naming nonwords should be delayed by the lack of a lexical entry.

A similar argument can be made about the effects of word frequency. Word frequency should affect performance more for processes that depend on lexical search than for processes that do not involve lexical mediation. Although the frequency of the word may confound prelexical and lexical factors, there is little doubt that both levels influence lexical access. To the extent that naming depends primarily on prelexical (i.e., phonologic) information, word frequency should affect word pronunciation less.

Assuming that orthographical depth indeed affects word recognition, we predicted that (a) lexical factors would influence naming in Hebrew more than in English and in English more than in Serbo-Croatian, and (b) because naming and lexical decision would share more commonality in deep than in shallow orthographies, the influence of lexical factors on the two tasks should be more similar in Hebrew than in English and more in English than in Serbo-Croatian.

Method

Subjects. The subjects were undergraduates who participated as part of the requirements of courses in psychology. There were 48 students from the Hebrew University in Jerusalem, Israel, 48 from the University of Connecticut, and 48 from the University of Belgrade in Yugoslavia. They were all native speakers of Hebrew, English, and Serbo-Croatian, respectively. Different sets of 24 subjects in each language were employed in the naming and in the lexical decision tasks.

Stimuli and apparatus. An identical list of 48 words and 48 nonwords was used for lexical decision and for naming. All stimuli were three to seven letters long. Because in Hebrew the vowels were omitted, the average number of letters per word was smaller than in either English or Serbo-Croatian, which did not differ from each other. However, the

range of phonemes per word was similar in the three languages (four to six phonemes), and the means did not differ significantly. The word stimuli were composed of 24 high-frequency and 24 low-frequency words selected from those that were rated above 4.0 or below 2.0, respectively. The mean ratings of the high-frequency groups were 4.42, 4.40, and 4.30, and those of the low-frequency groups were 1.72, 1.71, and 1.68, in Hebrew, English, and Serbo-Croatian, respectively. Each nonword was produced by replacing one letter of a real word. All letters were normal characters generated by a computer on the center of a cathode-ray tube (CRT) screen. On the average, a stimulus subtended a visual angle of approximately 2.5°.

Subjects communicated lexical decisions by pressing either a "Yes" or a "No" button. The dominant hand was always used for the "Yes" (i.e., word) responses and the other hand for the "No" (i.e., nonword) responses. In the naming task, subjects' verbal responses were recorded by a Mura-DX 118 microphone connected to a voice key. Reaction times were measured in milliseconds from stimulus onset.

Procedure. Subjects were randomly assigned to either the lexical decision or the naming task. They were tested individually in a semidarkened room. The instructions were to respond as fast and as accurately as possible by pressing one button (in the lexical decision task) or by pronouncing the word (in the naming task). After the instructions, 15 practice trials were presented. A trial began with the presentation of a stimulus that was removed by the subject's response. After the practice trials, the 96 test trials were presented in one block at a 3-s intertrial interval. In the naming task, incorrect pronunciations were recorded by the experimenter and were considered errors.

Results

Each subject's distribution of reaction times (RTs) was normalized by excluding RTs that were above or below two standard deviations from the subject's own mean. The percentage of outliers was similar across all word conditions, less than 2.5%. This procedure was followed for all subsequent experiments reported in this article. In an analysis of variance (ANOVA), we assessed the effects of language (Hebrew, English, Serbo-Croatian), task (lexical decision, naming), and stimulus group (high-frequency words, low-frequency words, nonwords). The mean reaction times for conditions are presented in Figure 1.

All main effects and two-way interactions were significant; however, the most important result was the three-way interaction that was significant both for the stimulus analysis, $F(4, 207) = 9.07$, $MS_e = 1482$, and for the subject analysis, $F(4, 276) = 6.30$, $MS_e = 2051$, with $F'_{\min}(4, 46) = 3.72$, $p < .02$. This interaction demonstrates that each task was affected differently by the stimulus group manipulation in each language. In the naming task, the reaction time difference between nonwords and high-frequency words systematically decreased from 157 ms in Hebrew to 101 ms in English and to 56 ms in Serbo-Croatian. In contrast, in the lexical decision task, these differences were similar across languages (217 ms, 192 ms, and 198 ms for Hebrew, English, and Serbo-Croatian, respectively).

The influence of the language on naming was more conspicuous when we compared words and nonwords than when we compared high- and low-frequency words. We tested this observation by analyzing separately those two effects on naming. First, a Frequency \times Language ANOVA (with the exclusion of nonwords) revealed that Hebrew words were named signifi-

cantly more slowly than English and Serbo-Croatian words, and there was no difference between the latter two, $F(2, 69) = 21.24$, $MS_e = 14314$. High-frequency words were named faster than low-frequency words, $F(1, 69) = 137.99$, $MS_e = 478$; however, the interaction between word frequency and language was not significant, $F(2, 69) = 1.57$, $MS_e = 478$. The effect of lexicality was assessed by a second ANOVA that compared nonword performance with the mean of high- and low-frequency words. Both main effects were significant, $F(2, 69) = 26.36$, $MS_e = 19548$ for language, and $F(1, 69) = 159.16$, $MS_e = 1566$ for stimulus type. More important, the interaction between the stimulus type words/nonwords and language was significant, $F(2, 69) = 20.0$, $MS_e = 1566$, suggesting that lexicality influenced naming differently in each language.

A second important result is the Task \times Language interaction. Across stimulus groups, naming was 149 ms faster than lexical decision in Serbo-Croatian and 88 ms faster in English but 17 ms slower in Hebrew. However, the difference between naming and lexical decision in Hebrew was significant only for the high-frequency words.

In Table 1 we present the mean percentage of errors in each condition. Because the number of errors was small, their distribution did not permit a three-factor analysis. However, some trends were observed. The pattern of stimulus group effects on lexical decision was similar across languages. In contrast, in the naming task the pattern of the effects was different in each language. This difference is most conspicuous when high- and low-frequency words are compared. In Hebrew the difference between the number of low- and high-frequency words that were pronounced incorrectly is practically the same as the difference between the number of incorrect lexical decisions made with low- and with high-frequency words. In English this difference is considerably reduced in the naming task relative to the lexical decision task, whereas in Serbo-Croatian an equal percentage of errors was found with high- and low-frequency words.

Discussion

The results of this experiment substantiated the hypothesis that the deeper the orthography is, the more lexical mediation occurs. In Hebrew, naming was affected by lexicality and word frequency, variables that are believed to affect processing in the lexicon. In accordance with the orthographical depth hypothesis, the effects of these factors were smaller in English and even smaller in Serbo-Croatian. Furthermore, similarity—or the lack of similarity—between tasks in their sensitivity to word frequency and lexicality was revealing. In Hebrew, naming and lexical decision performance were similarly affected by the lexical nature of the stimulus, and, except for the high-frequency words, the reaction times in the two tasks were practically identical. In contrast, in Serbo-Croatian, which represents the other end of the orthographical depth continuum, lexical factors had only a slight influence on naming even though their effect on lexical decision was almost as strong as in Hebrew. In English, as might be expected by its place on the continuum (deeper than Serbo-Croatian but more shallow than Hebrew), lexical factors affected both lexical decision and naming.

The lexicality effect (the difference between nonwords and

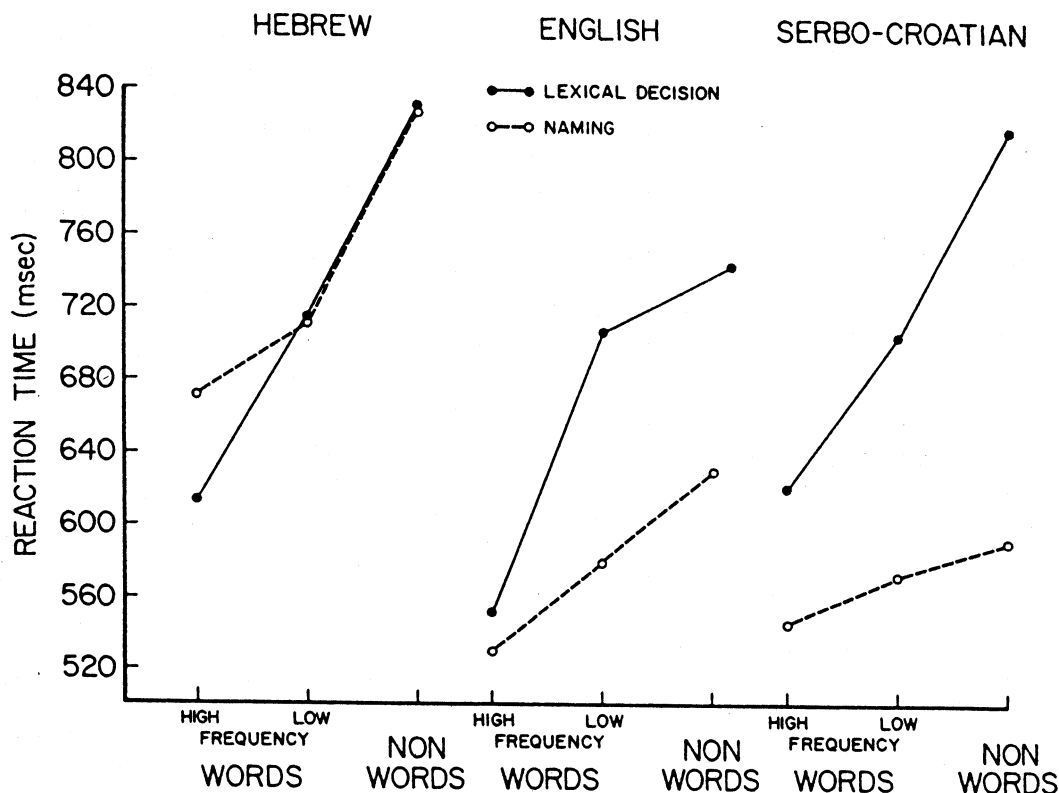


Figure 1. Average response time to high-frequency words, low-frequency words and nonwords in the naming task (dashed line) and in the lexical decision task (solid line) in Hebrew, English, and Serbo-Croatian.

the mean of high- and low-frequency words) discriminated between languages more than the word frequency effect. In fact, in agreement with the results of Seidenberg and Vidanovic (1985), word frequency (high vs. low) did not have a significantly different effect on naming English and Serbo-Croatian words. However, when we additionally considered nonwords, we saw a slightly sharper difference between Serbo-Croatian and English, and when we extended our view to Hebrew, that difference became very marked indeed. If only Serbo-Croatian and English had been studied and only word frequency effects had been considered, the results may have led to the incorrect conclusion that orthographical depth has no influence on word recognition (see also Frederiksen & Kroll, 1976).

Further analysis supports this view. A common finding in English and Serbo-Croatian is that naming is faster than lexical decision (cf. Forster & Chambers, 1973; Frederiksen & Kroll, 1976; Katz & Feldman, 1983); this finding was replicated in our study. In contrast, there is no such ordering for Hebrew; indeed, the opposite appears to be true, at least for high-frequency words. Apparently, in Hebrew, naming cannot be accomplished before lexical decision. This result is consistent with the suggestion that naming in Hebrew is lexically mediated, and replicates previous observations (Bentin et al., 1984, Bentin & Frost, in press). Presumably, naming depends on lexical information in Hebrew because the print provides only partial phonemic information.

With regard to the other languages, the comparison of English and Serbo-Croatian reveals that the difference between lexical decision and naming is smaller for English. This greater similarity between the two tasks for English suggests that naming in English shares more of its processing with lexical decision than is true for Serbo-Croatian. Nevertheless, the relation between naming and lexical decision time is similar in Serbo-Croatian and English for low-frequency words, whereas the difference is most conspicuous for high-frequency words: Naming was 86 ms faster in Serbo-Croatian and 22 ms faster in English than was lexical decision, whereas in Hebrew the effect was reversed and naming was 43 ms slower than lexical decision. This pattern partially supports the hypothesis that there is a tendency to recognize high-frequency words on a graphemic basis

Table 1
Percentage of Errors in the Naming and in the Lexical Decision Tasks in Hebrew, English, and Serbo-Croatian

Language	Lexical decision			Naming		
	Hfreq	Lfreq	Non-words	Hfreq	Lfreq	Non-words
Hebrew	1.0	8.2	3.1	0.3	7.3	7.5
English	0.1	12.5	5.0	0.2	2.5	2.6
Serbo-Croatian	0.5	7.8	3.7	0.3	0.5	5.0

Note. Hfreq = high frequency; Lfreq = low frequency.

(Seidenberg, 1985). However, the results of this experiment suggest the qualification that the use of graphemic/orthographical codes depends in addition on the orthography being read. In a very shallow orthography, even recognition of high-frequency words may be mediated by a process of grapheme-to-phoneme translation.

Experiment 2

In Experiment 1 we assessed the extent of lexical mediation for naming by manipulating the lexical status of the stimulus (high or low frequency, word or nonword). Although suggestive, these manipulations cannot be unequivocally interpreted as influencing lexical processing, and Experiment 2 offers converging evidence. High-frequency words, low-frequency words, and nonwords differ not only on lexical dimensions but also on orthographic familiarity, a factor that might influence prelexical processes of word recognition (cf. Mason, 1975). Furthermore, recent evidence suggests that lexical access is not the only process that is influenced by word frequency in pronunciation tasks; postlexical processes are also affected (Balota & Chumbley, 1985). Therefore, the link between orthographical depth and the degree of lexical information used in naming needs to be subjected to further evaluation. We designed Experiment 2 to assess lexical involvement in naming Hebrew, English, and Serbo-Croatian words by using the semantic priming technique.

Since Meyer and Schvaneveldt's (1971) report, numerous studies have shown that words are recognized faster if they are presented simultaneously with or immediately after a semantic associate than if they are paired to an unrelated word. In most of these studies the researchers used a lexical decision task. Results of several studies, however, suggested that semantic priming might also be effective in naming (Meyer, Schvaneveldt, & Ruddy, 1975; Becker & Killion, 1977). In comparison to lexical decision, semantic priming effects in naming are usually smaller and can be obtained only with strongly associated word pairs (Forster, 1981; Lupker, 1984). One possible interpretation of the weaker effect of semantic priming on naming than on lexical decision is that in English the use of lexical information for naming may be limited to only a subset of words (such as the exception words), whereas others are named by means of at least some phonological coding directly from print. This interpretation is consistent with the orthographical depth hypothesis; it implies that the size of the semantic priming effect on naming should correlate positively with orthographical depth.

Several authors have suggested that the magnitude of semantic priming can be influenced by the "depth" at which words are analyzed (Henik, Friedrich, & Kellogg, 1983; Smith, Theodor, & Franklin, 1983). In an analogous way, the rationale of Experiment 2 was based on the assumption that semantic information used to prime a target word in the lexicon should facilitate pronunciation of the target only if in the naming process one is able to use the lexically activated information. More generally, one would expect the effect of semantic priming to be greater for an orthography that putatively depends most strongly on lexical information for pronunciation (e.g., Hebrew) and smallest for the orthography that depends least on

lexical mediation (e.g., Serbo-Croatian). The effect on English should be intermediate in relation to the others.

Previous interlanguage comparisons of semantic priming effects on naming contrasted only English and Serbo-Croatian, and the results were contradictory. Katz and Feldman (1983) reported that in English, semantic priming equally facilitated lexical decision and naming performance, whereas in Serbo-Croatian, naming was not facilitated at all. Seidenberg and Vidanovic (1985), however, recently reported different results: Naming printed words was equally facilitated by semantic priming in both English and Serbo-Croatian. A major methodological difference between the studies of Katz and Feldman (1983) and of Seidenberg and Vidanovic (1985) is the selection of subjects. Whereas the former study was conducted in Yugoslavia where the subjects were undergraduate students, the subjects in Seidenberg and Vidanovic's study were mainly less well-educated Yugoslavian workers in Montreal, Canada. A second difference concerned the kind of relation between prime and target. For Katz and Feldman, this was a superset-subset relation (e.g., music-jazz), whereas for Seidenberg and Vidanovic, an associative relation was used. Nevertheless, in both studies, the same stimuli produced semantic facilitation in a lexical decision task. Thus, although the different results may reflect methodological differences between the two studies, Seidenberg and Vidanovic's report raises doubts about the generality of the orthographical depth effect.

In this experiment, we hoped that the careful matching of methodology and stimuli in all three languages would allow an unequivocal cross-language comparison. If there is an orthographical depth effect on word recognition, semantically related primes should facilitate naming performance in Hebrew more than in English and in English more than in Serbo-Croatian.

Method

Subjects. The subjects were undergraduates studying in Jerusalem, in Storrs, Connecticut, and in Belgrade, Yugoslavia, who participated in the experiment as part of the requirements of their respective courses in psychology. There were 48 native speakers of each language.

Stimuli and design. The critical stimuli were 32 target words, none of which had been used in Experiment 1. The mean word frequency rating was approximately the same for the three languages: 3.32, 3.24, and 3.20 for Hebrew, English, and Serbo-Croatian, respectively. Each target word was paired with a semantically related prime. A target and a prime were different examples of one semantic category (e.g., lion-tiger; rifle-cannon). Semantic categories were used only once. Whenever possible, straightforward translations from language to language were made; otherwise, two other examples from the same category were usually selected. In addition to the critical targets, 16 words (mean frequencies of 3.30, 3.31, and 3.30 for Hebrew, English, and Serbo-Croatian, respectively) were paired with nonwords. The 48 stimulus pairs were compiled into two stimulus lists. In each list, only 16 of the 32 critical targets were presented in conjunction with their related primes. The remaining 16 primes were redistributed between the other 16 targets such that no obvious semantic relation could be found between a prime and a target. Targets presented with semantically related primes in one list were unrelated in the other list and vice versa. The nonword pairs were the same in both lists.

Half of the subjects were randomly assigned to each list. Each subject was presented with 16 semantically related word pairs, 16 semantically

Table 2
Naming Time (in Milliseconds) and Standard Error of the Mean (SEM) for Semantically Primed and Unprimed Words in Hebrew, English, and Serbo-Croatian

Condition	Hebrew		English		Serbo-Croatian	
	ms	SEM	ms	SEM	ms	SEM
Unprimed	619	15.3	499	11.4	565	15.7
Primed	598	17.3	483	10.6	565	17.9
Facilitation	21		16		0	

unrelated word pairs, and 16 nonword-word pairs; each critical target was semantically related to its prime for 24 subjects and unrelated for the other 24.

Procedure. An experimental session consisted of 15 practice trials, followed by one block of 48 test trials. Each trial contained three events: a warning signal and two consecutive test stimuli, the prime and the target. Subjects were instructed to make a lexical decision for the prime (by pressing a "Yes" or a "No" button as in Experiment 1) and to read the subsequent target aloud as soon as they could. The interstimulus interval between the warning stimulus and the prime was 1000 ms. The exposure of the prime was terminated by subject's manual response. The target's onset was 500 ms from the prime offset, and it was removed from the screen by the subject's vocal response. The intertrial interval was 3 s.

All stimuli were presented at the center of a CRT screen. The apparatus and the physical characteristics of the stimuli were identical to those in Experiment 1.

Results

In Table 2 we present the average reaction times for semantically primed and unprimed conditions in each language. In Hebrew, the target words were named 21 ms faster when they were semantically related to the prime. In English, the priming effect was reduced to 16 ms, and in Serbo-Croatian it was nonexistent.

These data were analyzed by a Language (Hebrew, English, Serbo-Croatian) \times Semantic Relationship (related, unrelated) mixed-model ANOVA with repeated measures. Both main effects were significant for both the stimulus and the subject analysis; however, the most important result was the interaction between the two factors. This interaction was significant for the subject analysis, $F(2, 141) = 4.54$, $MS_e = 645$, $p < .013$, but not for the stimulus analysis, $F(2, 93) = 2.40$, $MS_e = 731$, $p < .097$, probably because the priming effects in Hebrew and English were not significantly different. Nevertheless, planned t tests revealed that the priming effect was significant in Hebrew, $t(47) = 3.94$, $p < .0001$ for the subjects analysis and $t(31) = 4.1$, $p < .0001$ for the stimulus analysis, and in English, $t(47) = 6.88$, $p < .0001$ for the subjects analysis and $t(31) = 2.08$, $p < .046$ for the stimulus analysis. In contrast, for Serbo-Croatian, the differences in naming time in the related and unrelated conditions were insignificant.

We gained some additional insight by comparing (a) words that were preceded by nonwords with (b) words that were pre-

ceded by unrelated words. In Hebrew, words that were preceded by nonwords were named significantly more slowly (650 ms) than words that were preceded by unrelated words (619 ms). A small difference, but in the same direction, was found for English (509 ms and 499 ms, respectively) but not for Serbo-Croatian (564 ms and 565 ms). A Language \times Stimulus Group mixed-model ANOVA and a Tukey post hoc analysis revealed that the interaction was significant, $F(2, 141) = 14.79$, $MS_e = 526$, $p < .0001$, and that the stimulus group effect was significant only in Hebrew.

Discussion

The results of Experiment 2 revealed that semantic priming had the strongest priming effect in Hebrew, a slightly smaller effect in English, and no effect in Serbo-Croatian. This pattern replicates Katz and Feldman's (1983) suggestion that naming in Serbo-Croatian is not strongly influenced by lexical processes. Most important, the results of this study corroborate the hypothesis that the Serbo-Croatian, English, and Hebrew orthographies are on different points of a dimension that influences the amount of lexical involvement in naming. The reasonable conclusion is that orthographical depth is this dimension.

The discrepancy between our findings in Serbo-Croatian and the findings reported by Seidenberg and Vidanovic (1985) is puzzling. One possible explanation is that the discrepancy was caused by differences in the stimuli or subjects. Seidenberg and Vidanovic's subjects were native Serbo-Croatian speakers, but they were residents in Montreal. They reportedly spoke little French or English and, therefore, the environment in which they were tested had presumably little if any influence on their performance. Even if that was the case, there was a second difference to consider. Seidenberg and Vidanovic's subjects were less educated than our subjects, who were university students. This difference in the level of education might have decreased the subjective word frequency of the stimuli for these subjects. Insofar as the size of the semantic priming facilitation is larger for low- than for high-frequency words (Becker, 1979), the difference in the subjective frequency of the stimuli in our study and Seidenberg and Vidanovic's results might explain the difference of the results. Nevertheless, their results could suggest that in Serbo-Croatian, as in other languages, lexical involvement in naming can be manipulated.

In Hebrew, words that followed nonwords were named significantly more slowly than words that followed words. As discussed in Experiment 1, the only way one can pronounce a nonword is by some process that includes grapheme-to-phoneme translation. Thus, naming words after processing nonwords might have been slowed down by a change from a naming strategy that involves grapheme-to-phoneme translation (for nonwords) to one that is primarily lexically mediated (for words). In Serbo-Croatian, for which we assumed that the same strategy (grapheme-to-phoneme translation) is in effect for naming both words and nonwords, the lexicality of a stimulus has no effect on naming the subsequent stimulus. Therefore, results showing a difference between the naming times for words preceded by nonwords and for words preceded by unrelated words might

also be determined by orthographic depth. In Experiment 3 we examined this assumption.

Experiment 3

In Experiment 2 we observed that in Hebrew, words that followed nonwords were named more slowly than words that followed words, whereas in Serbo-Croatian this factor had no effect whatsoever on naming time. It is possible that this effect is characteristic of only deep orthographies because only in deep orthographies does switching from naming nonwords to naming words involve a strategic change of the naming mechanism. In shallow orthographies the same mechanism (grapheme-to-phoneme translation) is presumably used for naming both words and nonwords; therefore, naming them in alternation is without cost. In Experiment 3 we attempted to examine this hypothesis by using a technique that discouraged subjects from giving priority to a lexical strategy for naming strings of consonants.

Previous studies in English revealed that word recognition strategies (at least in lexical decision tasks) can be influenced by task demand characteristics and/or by the nature of the stimuli. For example, Glanzer and Ehrenreich (1979) reported that lexical decisions for high-frequency words are faster if the list includes only high-frequency words than if high- and low-frequency words are mixed in the list. More relevant to our study are findings suggesting that the use of phonemic encoding of printed words is discouraged if the stimulus list includes a large proportion of homophones (Hawkins, Reicher, Rogers, & Peterson, 1976), whereas the use of visual codes in word recognition is discouraged by backward masking the stimuli (Spoehr, 1978).

We attempted to influence naming strategies by manipulating the proportion of nonwords in the stimulus list. In previous studies, frequency effects in naming were more conspicuous when the list contained only words than when words and nonwords were intermixed (Frederiksen & Kroll, 1976; Hudson & Bergman, 1985). One possible interpretation of these results is that naming is less likely to involve lexical mediation when there are many extralexical tokens in the stimulus list. A high proportion of nonwords in the list may have discouraged the subject from using lexical mediation because this route was inefficient most of the time. Consequently, if the grapheme-to-phoneme translation is the natural naming strategy in a shallow orthography and the lexical route is usually used in a deep orthography, a high proportion of nonwords should impair word-naming performance, increasing the percentage of errors and RTs in the latter but not in the former orthography.

Method

Subjects. The subjects were 48 undergraduates from the Hebrew University, 48 from the University of Connecticut, and 48 from the University of Belgrade. None of the subjects in this experiment had participated in Experiments 1 or 2, but they were part of the same population of students.

Stimuli and design. Two lists of 160 stimuli each were assembled in Hebrew, in English, and in Serbo-Croatian. The list in which 80% of stimuli were nonwords (80%-NW) consisted of 128 nonwords and 32 words, and the list in which 20% of stimuli were nonwords (20%-NW)

Table 3
Naming Time (in Milliseconds), Standard Error of the Mean (SEM), and Percentage of Errors in the 80%-NW and 20%-NW Lists in Hebrew, English, and Serbo-Croatian

List	Hebrew	English	Serbo-Croatian
80%-NW			
ms	557	565	578
SEM (%)	15.3	8.0	15.3
Error (%)	12.6	5.0	0.0
20%-NW			
ms	627	501	558
SEM (%)	14.3	8.5	11.0
Error (%)	4.1	2.7	0.6

Note. NW = nonword.

consisted of 128 words and 32 nonwords. The target stimuli were 20 words (identical between the lists) that were the last words in the list, dispersed without disrupting the nonword/word ratio in either of the two lists. Both high- and low-frequency words were included among the targets; the mean frequency ratings were 2.97, 2.95, and 2.94 in Hebrew, English, and Serbo-Croatian, respectively.

Subjects in each language group were randomly assigned to the two lists, half to each list. The apparatus and experimental conditions were identical to those in Experiment 2.

Procedure. The procedure was similar to that used in the previous experiments. Subjects were instructed to name as fast and as accurately as possible words and nonwords that were presented on the screen. In Hebrew, the stimuli were presented without the vowel marks, and the subjects were told to assign to the nonwords any vowel combination that they preferred. All 160 stimuli were presented in one uninterrupted block. During performance, the experimenter recorded errors verbatim for subsequent qualitative analysis.

Results

The numbers of mispronounced targets in each list were compared in each language separately. In Hebrew, the number of errors in the 80%-NW list was significantly higher than in the 20%-NW list $t(46) = 5.44, p < .0001$. The same tendency was found in English; however, the difference between the two conditions was marginally significant, $t(46) = 1.90, p < .063$. In Serbo-Croatian there were no errors in the 80%-NW list and only a nonsignificant number of errors in the 20%-NW list (see Table 3).

We analyzed the average naming time to the 20 target words in each list by ANOVA on subjects and stimuli. The interaction between the language and the list factors was significant for both the subject analysis, $F(2, 138) = 14.087, MS_e = 4019$, and the stimulus analysis, $F(2, 57) = 130.10, MS_e = 351; F_{\min}(2, 58) = 12.66, p < .001$. In Serbo-Croatian, the target words were named slightly faster in the 20%-NW list than in the 80%-NW list; however, Tukey-A post hoc comparison revealed that the difference between the two lists was not significant ($p < .05$). In English and Hebrew, Tukey-A comparisons revealed that the differences in RTs between the two lists were significant ($p < .01$), but in different directions. In English the target words were named 61 ms faster in the 20%-NW list than in the 80%-NW

list. In contrast, in Hebrew, words were named 72 ms faster in the 80%-NW list than in the 20%-NW list.

Discussion

Changing the proportion of nonwords in the stimulus list had a different influence on naming performance in each language. Consider first the error data. In Hebrew, the 80%-NW list yielded 8.5% more errors on the 20 target words than did the 20%-NW list. In English, the difference was in the same direction but smaller (2.3%). In Serbo-Croatian there were practically no errors. This systematic pattern is congruent with the hypothesis of orthographical depth. If naming words in Hebrew is normally mediated by the internal lexicon, subjects must change this strategy for naming nonwords (which have no lexical representation). When the stimulus list contains a high proportion of nonwords, the nonlexical naming strategy is the more efficient one. One consequence of this strategy is that many strings that would have made a word if given the appropriate vowelization were in fact assigned with incorrect vowels when the nonlexical naming strategy was used. Thus, the subject pronounced these as a nonword instead of a word. Indeed, in Hebrew, all erroneously read target words were pronounced as nonwords. We hypothesized that in Serbo-Croatian, in contrast to Hebrew, naming does not strongly involve the lexicon. Therefore, there is no obvious reason why different strategies should be used for naming words and nonwords. All stimuli can be named via the same mechanism that is based on grapheme-to-phoneme translation. Consequently, the proportion of nonwords in the list should have little influence on word-naming performance, as indeed was revealed in this experiment. English, more than the other two languages, combines both lexical and nonlexical routes for naming (cf. Coltheart, 1980). It is conceivable that the nonlexical strategy is used for nonwords and for a subset of words (e.g., low-frequency, phonemically regular words), whereas the lexical strategy is used for naming other words. Consequently, the reinforcement of a nonlexical strategy by the high proportion of nonwords in the list influenced reading of only a part of the words, which explains why the effect was smaller than in Hebrew.

Observations of the nature of the errors in Hebrew and in English provided further support of the hypothesis. If a nonlexical strategy is applied to name words that are usually named via the lexicon, the errors should primarily consist on naming words as nonwords. On the other hand, lexical substitution should be more prevalent when the lexicon is involved in naming. Indeed, in English, the nature of the errors found in the 80%-NW list was as in Hebrew, primarily reading words as nonwords. In contrast, in the 20%-NW list, the errors were mainly substitutions of words by other words (for example, *degree* instead of *decree*).

The influence of the proportion of nonwords in the list on naming time was less systematic. Although the results in Serbo-Croatian and English appear straightforward, those for Hebrew are not. In Serbo-Croatian, naming time in the two nonword conditions was similar, thereby supporting the hypothesis that word-naming strategy was not influenced by the proportion of nonwords in the list. In English, words were named significantly

more slowly in the 80%-NW condition than in the 20%-NW condition. Because the increase in naming time was followed by an increase in the percentage of errors, it is clear that naming performance was interfered with when the stimulus list contained a high percentage of nonwords. Although other interpretations might be possible, the explanation provided by the orthographical depth hypothesis is simple and straightforward. Grapheme-to-phoneme translation in English, in contrast to Serbo-Croatian, is constrained not only by phonemic rules, but also by morphophonemic factors (Chomsky & Halle, 1968). Therefore, in absence of lexical information, the grapheme-to-phoneme translation is sometimes a complex and painful process. No wonder it takes more time to complete.

The interpretation of the naming data in Hebrew is less straightforward. According to the simple rationale just elaborated, we should have observed a delay in naming words in the 80%-NW condition, which should have been even larger than in English. In contrast, naming the word targets in this condition was significantly *faster* than in the 20%-NW condition. There is, however, one interpretation that, although admittedly post hoc, can account for these results. This explanation is based on the insight that in contrast to English, Hebrew phonology has very few constraints on naming nonwords; the subject is free to choose almost any arbitrary set of vowels in order to make the consonantal structure pronounceable. Therefore, when the list contains both words and nonwords, the limiting factor operating on naming time is determined by some (as yet unspecified) competition between lexical search and grapheme-to-phoneme translation for consonants coupled with arbitrary addition of vowels. Before applying a nonlexical strategy, the subject must make sure, to some degree of certainty, that the presented consonant string is not a word. Therefore, naming is slow not only for words but also for nonwords. However, when the subject does not expect words, as in the 80%-NW list, he or she may be more inclined to change strategy and to use an idiosyncratic arbitrary selection of vowels for both words and nonwords. This change should result in different speed-accuracy trade-off strategies in the 20%-NW and the 80%-NW lists. In the latter list subjects might have been inclined to spend less time analyzing the stimulus in reference to lexical information. In many cases the fast analysis was sufficient to generate a correct response, but in some cases incorrect (nonword) responses were made. In the 20%-NW list, because subjects expected words to appear, they referred to the lexicon to find the correct pronunciation of the stimulus. This procedure increased naming time but decreased the probability that a word would be read as a nonword.

This interpretation is certainly not the only one possible, but it is supported by several observations. Recall that the average naming time was calculated on the basis of all 20 targets; that is, both errors and correct responses were included. Comparison of the naming time in the 80%-NW list revealed that the same words were read more slowly by the subjects who named them correctly (559 ms) than by the subjects who read them as nonwords (531 ms). Therefore, some portion of the difference between the naming time in the two lists can be explained by the errors that may have been read without lexical mediation. However, even considering only correctly read words, the

difference in naming time between the two lists remains considerably big (561 ms in 80%-NW vs. 625 ms in the 20%-NW list). Therefore, naming difference between the two lists should be accounted for by a factor that affects naming of all stimuli in the list, words and nonwords. As previously mentioned, a change in the speed-accuracy trade-off strategy is a reasonable explanation. There is additional evidence in support of our interpretation. If naming strategy was changed in the way we suggest, then naming nonwords should have been accelerated also when words are not expected. We verified this hypothesis by comparing (a) naming time to the 32 nonwords presented in List 20%-NW with (b) naming time to the same nonwords presented in List 80%-NW. In congruence with our prediction, naming the same nonwords was faster if words were not highly expected than if they were (635 ms vs. 505 ms, respectively).

In conclusion, we suggest that the error data is in complete agreement with the orthographical depth hypothesis, and the RT data can be reasonably explained without a necessity to change it. Therefore, we consider the results of Experiment 3 as additional support to the validity of the orthographical depth concept.

General Discussion

This study was designed to test the psychological validity of the orthographical depth hypothesis. According to this hypothesis, lexical word recognition in a shallow orthography is mediated primarily by phonemic cues generated prelexically by grapheme-to-phoneme translation. In contrast, lexical access for word recognition in a deep orthography relies strongly on orthographic cues, whereas phonology is derived from the internal lexicon. One implication of this hypothesis is that in a shallow orthography, the normal strategy for naming is to generate the major phonological information needed for word pronunciation prelexically by means of grapheme-to-phoneme translation. In contrast, in a deep orthography, such prelexical information for naming is either absent or too complex to be used efficiently. Therefore, pronunciation is based on information stored in the lexicon.

We tested the hypothesis by investigating naming performance in Hebrew, English, and Serbo-Croatian. These languages represent deep, average, and shallow points, respectively, on the orthographical depth continuum. Our rationale was to examine the effects on naming performance of factors that were assumed to influence lexical processing; comparisons were made among the three languages (i.e., as a function of orthographical depth). Thus we were primarily interested in the interactions of effects of the lexical manipulations with the language factor, rather than in main effects that could reflect a multitude of factors.

In Experiment 1, we showed that the lexical status of the stimulus (i.e., being a high-frequency word, a low-frequency word, or a nonword) affected the speed of naming in Hebrew more than in English and in English more than in Serbo-Croatian. Furthermore, only in Hebrew were the effects on naming very similar to the effects on lexical decision. In Experiment 2, the results suggested that semantic priming (a factor that presumably operates on the lexicon) facilitates naming in Hebrew and

has a smaller effect in English, whereas in Serbo-Croatian it has no effect at all. Finally, in Experiment 3, the results indicated that presenting a large proportion of nonlexical items (nonwords) in a stimulus list encouraged the use of a nonlexical strategy that in Hebrew speeded naming at the expense of treating many words as nonwords. This manipulation had a similar but smaller effect on the reader of English, whereas in Serbo-Croatian the proportion of nonwords in the list had no effect on naming. We interpreted this to mean that Hebrew readers normally use an orthographic code to access the lexicon for naming but may abandon it when it becomes intractable (as when he or she must name many nonwords, which have no lexical representation). In each experiment there were six different permutations possible for ordering the three languages in terms of a given effect, but only one order was predicted in the orthographical depth hypothesis. Of most importance was that in all three experiments, different lexical factors affected naming systematically in perfect agreement with the order predicted in the orthographical depth hypothesis. Therefore, we suggest that the concept of orthographical depth is psychologically real and that it influences word recognition. We will elaborate some of the implications of this conclusion and incorporate it into current thinking on the process of word recognition.

Many reports suggest that the reader of English uses both orthographic and phonemic cues in word recognition (see the review by McCusker et al., 1981). Even when performance requires the generation of phonological codes for output, as in naming, grapheme-to-phoneme translation is not the only available route (Coltheart, 1980; Forster & Chambers, 1973; Frederiksen & Kroll, 1976). Is this strategic flexibility limited to orthographies located, like English, in the middle of the orthographical depth continuum? The results of this study suggest that this is probably not the case. The change in strategies observed in Experiment 3 suggests that the nonlexical route, although not accurate, can predominate even in Hebrew when it appears to be more efficient. Note, however, that there is no evidence in our data to imply that words were named correctly without previous lexical access. The extent of using the lexical route in Serbo-Croatian has not been tested. However, results of other studies support this possibility (Seidenberg, 1985; Seidenberg & Vidanovic, 1985). Considering the converging evidence, it seems plausible that both orthographic and phonological information are available prelexically in all languages and probably interact during the process of word recognition. Therefore, the relevant question should be not what are the codes used in each specific situation but what is the nature of this interaction and how might orthographical depth influence it.

One attempt to disclose the nature of the interaction between orthographic and phonemic codes in word recognition is the version of McClelland and Rumelhart's (1981) parallel interactive model suggested by Seidenberg (1985) and Seidenberg, Waters, and Barnes (1984). Their version of the model emphasizes the relative time course of the phonological and orthographical code activation, suggesting that prelexical generation of the two code types is mandatory and that because the phonological code depends on prior orthographic analysis, it usually lags behind. Consequently, they suggest that orthographic information accu-

ulates faster than phonemic information, and for many (perhaps most) words, lexical access occurs before a recognizable prelexical phonological code is generated. Recognition on the basis of an orthographic code, however, automatically provides the lexical representation of the phonological code, which can then be used in overt naming. We adopt this model as a working hypothesis but suggest some extensions to explain how orthographical depth may affect naming strategies. Most authors have so far emphasized the importance of the time course of the orthographical code for word recognition, implicitly assuming that it is coding speed that determines whether word naming is based on nonlexical processes or is mediated by the lexicon. However, this implicit assumption may be incorrect. Instead, one could plausibly assume that the time lag between generation of the graphemic and the phonemic codes may begin with the prior onset of the orthographic analysis but then is increased or decreased by the time course of orthographical code generation and by the time course of the phonological code. Our results suggest that the time course of phonological code generation is affected mainly by the simplicity of the rules governing the spelling-sound correspondence. Thus it is possible that at the extreme shallow end of the orthographic depth continuum, a sufficient portion of the phonological code can accumulate before the orthographic analysis can help word recognition.

The time it takes to extract graphemic information that is sufficient for lexical access is determined primarily by the familiarity of the stimulus (Balota & Chumbley, 1984; Mason, 1975). It is possible, however, that prelexical generation of phonemic codes is performed in a parallel interactive process, which is analogous to the process of orthographical code generation (see also Seidenberg et al., 1984). In this case nodes would consist of phonemic rather than graphemic features, but their activation would be governed by the same rules as proposed by McClelland and Rumelhart (1981). This hypothesis implies that stimulus familiarity should affect the time course of the phonemic code generation much in the same way as it affects the generation of the orthographic code, and probably for the same reasons. Thus, familiarity of the stimulus should not change the relation between the time course of the two code types. However, in addition to familiarity, prelexical generation of phonemic codes is also affected by orthographical depth. In a shallow orthography, the process might be based on idiosyncratic application of grapheme-to-phoneme translation rules. Such a process might get very fast access to the word's phonology and, in parallel, provide the articulatory mechanism with the necessary phonological information. In contrast, in a deeper orthography, simple grapheme-to-phoneme translation is difficult and may frequently lead to incorrect responses. Therefore, generation of the phonemic code is more complex, is frequently dependent on units larger than the single grapheme, and is therefore slower. In extreme cases, such as unvoiced Hebrew, a full phonemic code cannot be generated before information about the whole word has accumulated and some lexical decisions about its meaning are made. Therefore, we suggest that the major factor that determines the origin of the phonetic codes in naming is not the speed of orthographical code generation, but rather the ease of the generation of the phonemic codes.

In this study we concentrated on naming performance. Nevertheless, we suggest that orthographical depth affects lexical access in a similar way. Indeed, in Experiment 1, we observed that the lexical status of the stimulus had a similar pattern of influence on lexical decision performance in each language. However, we agree with Balota and Chumbley (1985) that the lexical decision task is probably not a very good way to examine this hypothesis. A better approach would be to examine, in each language, how factors that are related to the phonology and the orthography influence word recognition performance in semantic tasks. To this end, we believe that our data strongly support the validity of the orthographic depth factor in word recognition.

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