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Research Article

ORTHOGRAPHIC REPRESENTATION AND PHONEMIC SEGMENTATION IN SKILLED READERS: A Cross-Language Comparison

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Abstract—*The long-lasting effect of reading experience in Hebrew and English on phonemic segmentation was examined in skilled readers. Hebrew and English orthographies differ in the way they represent phonological information. Whereas each phoneme in English is represented by a discrete letter, in unpointed Hebrew most of the vowel information is not conveyed by the print, and, therefore, a letter often corresponds to a CV utterance (i.e., a consonant plus a vowel). Adult native speakers of Hebrew or English, presented with words consisting of a consonant, a vowel, and then another consonant, were required to delete the first "sound" of each word and to pronounce the remaining utterance as fast as possible. Hebrew speakers deleted the initial CV segment instead of the initial consonant more often than English speakers, for both Hebrew and English words. Moreover, Hebrew speakers were significantly slower than English speakers in correctly deleting the initial phoneme, and faster in deleting the whole syllable. These results suggest that the manner in which orthography represents phonology not only affects phonological awareness during reading acquisition, but also has a long-lasting effect on skilled readers' intuitions concerning the phonological structure of their spoken language.*

Phonological awareness is the ability to recognize and manipulate internal phonemic constituents of spoken words. Previous research has provided ample evidence that this ability is necessary for reading acquisition and is related to skilled reading performance (for recent reviews, see Bentin, 1992; Goswami & Bryant, 1990). For example, reliable correlations were found between children's ability to manipulate subword units and the rate and efficiency of learning to read (Goswami & Bryant, 1990; Liberman, Shankweiler, Liberman, Fowler, & Fisher, 1977; Mann & Liberman, 1984; Treiman, 1985). In addition, phonological awareness in kindergarten was found to be a good predictor of reading success in the early school years (Bradley, 1989; Bradley & Bryant, 1983; Lundberg, Olofsson, & Wall, 1980; Mann, 1984; Stanovich, Cunningham, & Cramer, 1984).

A causal connection between phonological skills and reading acquisition has been supported by studies showing that intervention aimed at improving phonological skills facilitates reading acquisition (Ball & Blachman, 1988, 1991; Bentin & Leshem, 1993; Blachman, 1989; Bradley & Bryant, 1983; Lundberg, Frost, & Peterson, 1988). Other studies have shown, however, an inverse causal connection, that is, that exposure to literacy enhances phonological awareness (Bentin, Hammer, & Cahan, 1991; Morais, Bertelson, Cary, & Alegria, 1986). Together, these results suggest a strong bidirectional influence between reading acquisition and phonological awareness. Probably, the exposure to clearly defined orthographic segments triggers awareness of coarticulated phonemic segments, while at the same time this awareness fosters the acquisition of grapheme-to-phoneme correspondence rules. This interpretation is further supported by comparing the effects of different reading instruction methods on reading skills. Alegria, Pignot, and Morais (1982) reported that children who learned to read by analytic methods emphasizing letter-sound correspondences performed better on tests of phonemic segmentation than children who learned by holistic methods.

These results suggest that the manner in which the writing system represents the spoken language may influence phonological awareness. Support for this claim is gained from cross-linguistic studies. Mann (1986) compared phonological awareness of syllables and phonemes in Japanese and American first graders and found that Japanese children performed more poorly than American children on tests assessing awareness of phonemes but not of syllables. Mann argued that the Japanese children's performance was influenced by their reading experience with a syllabary orthography, whereas American children were affected by their reading experience with an alphabetic orthography. Her conclusions are supported by Read, Zhang, Nie, and Ding (1986), who showed that literate Chinese adults who learned to read the alphabetic (pinyin) orthographic system performed better in phonemic segmentation tests than literate Chinese adults who read only the logographic (kanji) system.

A possible conclusion from these studies is that the size of the phonological unit that the beginning reader becomes aware of is affected by the size of the speech segment into which orthographic units are mapped. In the present study, we investigated this hypothesis by comparing phonological sensitivity of skilled adult readers trained initially to read either Hebrew or English. We sought to examine the influence of different orthography-to-phonology mapping rules on the ability of mature readers to manipulate the various segments of spoken words.

The Hebrew writing system is characterized by several properties that make it interesting for comparison with other alphabetic orthographies, such as English orthography (e.g., Frost & Bentin, 1992). In Hebrew, letters represent mostly consonants, and most of the vowels are represented by diacritic marks (dots and dashes). Some vowels, however, are represented by letters (which have dual function and represent either a consonant or a vowel). There are two modes of writing Hebrew: pointed and unpointed. The pointed writing system contains all the diacritic marks and is used mainly for children's books, holy scripts, and poetry. The unpointed print uses the same letter characters as

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the pointed system (including the vowel letters) but omits the diacritic marks. The pointed system is taught in the early elementary grades. However, starting in the third grade, the vowel marks are gradually omitted from textbooks, and adult readers use the unpointed writing system almost exclusively. Hence, although Hebrew has an alphabetic orthography, its basic orthographic units usually represent more than single phonemes. Because the letters are mostly consonants onto which vowels are subsequently attached, these orthographic units usually correspond to consonant-plus-vowel (CV) utterances.

In the present study, we examined whether the size of the unit represented by the orthography affects the size of the segments that mature readers are aware of. Specifically, we hypothesized that reading in Hebrew, in which alphabetic units represent mostly CV segments, should foster awareness of spoken word segments of that size (CV). In contrast, reading in English, in which most letters are mapped into phonemic segments, should enhance awareness of single phonemes. We were interested in the intuition of adult readers concerning the phonemic structure of their spoken language, as well as in their ability to manipulate single phonemes.

Several studies have suggested that for skilled readers, orthographic and phonological representations interact so that orthographic knowledge affects the recognition of words in the auditory modality. It has been shown that lexical decisions to spoken words are facilitated if successive words share the same spelling (Jakimik, Cole, & Rudnicky, 1980). Similarly, using the naming task, Tanenhaus, Flanigan, and Seidenberg (1980) demonstrated a visual-auditory interference in a Stroop paradigm. However, although it seems evident that reading and listening could share one lexicon, allowing identical messages to be understood in the two modalities in the same way, it is possible that phonological awareness and the basic phonological skills of adult native speakers are independent of the special characteristics of their writing system.

If orthographic knowledge affects phonological skills, such as phonemic segmentation, then English and Hebrew speakers should differ, for example, in their ability to omit the first consonant of a spoken word and pronounce the remaining phonemes (a phoneme deletion task). Whereas this task should be fairly simple for readers of English, the reading experience of Hebrew readers would cause them to delete the initial CV units of Hebrew words. Moreover, even a correct deletion of the initial phoneme instead of the initial CV unit would involve greater cognitive effort for Hebrew readers and, consequently, would result in slower deletion latencies for Hebrew than for English speakers. In contrast, similar performance of the two subject groups would support a view that basic phonological skills of literate adults are not affected by their reading experience. A second aim of the present study was to examine the effect a first language may have on phonemic segmentation in a second language, that is, how Hebrew bilingual readers segment words in English, and vice versa.

METHOD

Subjects

Fifty-two subjects participated in the experiment for course credit or for payment. Twenty-six subjects were bilingual native speakers of Hebrew from The Hebrew University, and 26 subjects were bilingual speakers of English from a 1-year Hebrew program for overseas students.

Tests and Materials

Phonemic sensitivity was measured by a phoneme deletion test, a task that is commonly used to assess phonological awareness. There were two word lists, one containing English words and one containing Hebrew words. Each list contained 28 monosyllabic items consisting of a consonant, then a vowel, and a final consonant (CVC). Half of the items in each word list were words that have identical phonological structures in the two languages (but obviously differ in their surface phonetics). For example, English words such as *but* and *gun* are homophonic with Hebrew words that have the same phonemic sequences but have, naturally, different meanings (/bʌt/ meaning "daughter" and /gʌn/ meaning "garden"). However, whereas in English the vowel of each of these words is represented by an independent letter, in Hebrew the vowels are omitted in print (e.g., *bt* for /bʌt/, and *gn* for /gʌn/). Comparing performance on deletion tests for words that "sound the same" across languages may provide strong evidence concerning the influence of orthographic representation on phonemic awareness. The other half of the items in the lists were pairs of CVC Hebrew and English words that were matched on the first and second phonemes. The distribution of types of final consonants was similar across languages.

In addition to this between-language comparison, the study included a within-language comparison of performance for two types of words within the Hebrew orthography. Fourteen of the 28 Hebrew stimuli were words that are written with a vowel letter (i.e., the vowel is explicitly represented in print, as in the word *kir,* meaning "wall," in which the vowel /i/ is represented by the Hebrew letter *i*). The other 14 words were words in which the vowels are not represented in print (such as *bt* or *gn*). Comparing phonemic deletion performance, within a single language, for words that have the same internal phonological structure (CVC) but differ in their orthographic representation may provide further insight into the influence of orthographic representations on phonemic segmentation.

Procedure and Apparatus

Each subject was tested individually. Half of the subjects in each native language group heard the English words first and the Hebrew words second. The other half heard the Hebrew words first and the English second. Subjects were told that they were about to hear some words in Hebrew (or in English) and were instructed to delete the first "sound" of each word and say as fast as possible "what is left of it." The first "sound" was not specified by the experimenter, and no feedback was given to the subjects following their responses. This procedure allowed intuitive judgments about the size of the phonemic segments that subjects deleted. Reaction time (RT) was measured from the onset of the experimenter's uttered stimulus (in each trial) to the onset of the subject's response using a voice key. The voice key was attached to an electronic counter-timer, and

Table 1. *Reaction time (in milliseconds) and percentage of correct responses for deletion of the first phoneme in Hebrew and English words*

Measure of performance	Native Hebrew speakers: Presented first	Native Hebrew speakers: Presented second	Native English speakers: Presented first	Native English speakers: Presented second
	Hebrew words			
Reaction time	1,149 (41)	904 (34)	736 (11)	678 (9)
Percentage correct	63 (2.3)	76 (1.3)	92 (0.7)	100 (0.0)
	English words			
Reaction time	933 (25)	1,040 (25)	742 (18)	664 (14)
Percentage correct	79 (1.4)	74 (0.9)	100 (0.0)	92 (0.0)

Note. Numbers in parentheses are standard errors of the means. Reaction times are for correct trials only.

RTs were logged manually by the experimenter along with the subject's responses.

RESULTS

Correct response was considered to be a VC utterance reflecting deletion of the initial consonant only (e.g., /ʌt/ following the word *but*). Errors consisted mainly of omitting the CV segment, thereby producing the final consonant. For each word in each language, the percentage of correct responses and the mean RT were calculated separately for Hebrew and English native speakers. These data were further categorized by the order of presentation (i.e., whether the subject was presented with Hebrew followed by English words or vice versa). The RT analysis was based on correct trials only (see Table 1).

These data were analyzed by three-factor analysis of variance (ANOVA) in an item analysis.[1] The effect of the language of the stimulus was averaged within subject groups, and the effects of the native language of the subjects and the order of presentation were assessed within items. The analysis of the accuracy data showed that the percentage of correct responses was higher for English words (86.25%) than for Hebrew words (82.75%), $F(1, 54) = 16.53$, $MS_e = 43.2$, $p < .001$; that native English speakers were more accurate than native Hebrew speakers (97.5% and 73.2%, respectively), $F(1, 54) = 678.7$, $MS_e = 42.9$, $p < .001$; and that the percentage of correct responses was higher for the second test (85.5%) than for the first test (83.5%), $F(1, 54) = 8.82$, $MS_e = 26.9$, $p < .005$. Both the effect of native language of the subject and the effect of the order of presentation interacted with the effect of the stimulus language, $F(1, 54) = 14.19$, $MS_e = 42.9$, $p < .001$, and $F(1, 54) = 155.6$, $MS_e = 26.9$, $p < .001$, respectively. Finally, a significant interaction of order of presentation and native language of the subject suggested that the order of presentation affected the performance of native Hebrew speakers more than that of native English speakers, $F(1, 54) = 5.82$, $MS_e = 30.7$, $p < .025$. The three-way interaction was not significant, $F(1, 54) < 1.0$. Because of insufficient variation in the accuracy scores of the native English speakers (i.e., many subjects having zero errors), the nature of the interaction could not be reliably investigated any further in this group. For native Hebrew speakers, a two-way ANOVA showed that the order of presentation influenced performance with Hebrew and English words, but in opposite directions, $F(1, 54) = 44.8$, $MS_e = 54.5$, $p < .001$. For the Hebrew words, accuracy was lower when they were presented first than when they were presented second, $t(55) = 2.058$, $p < .05$; for the English words, the accuracy was not significantly different regardless of whether they were presented before or after the Hebrew words, $t(55) = 0.244$.

The analysis of RTs showed that, overall, responses were equally fast for English (845 ms) and Hebrew (867 ms) words, $F(1, 54) = 0.965$. However, native English speakers were much faster to respond (705 ms) than native Hebrew speakers (1,006 ms), $F(1, 54) = 338.63$, $MS_e = 15{,}055$, $p < .001$, regardless of the language of the materials. Overall, responses were slower in the first test (890 ms) than in the second test (821 ms), $F(1, 54) = 22.93$, $MS_e = 11{,}429$, $p < .001$. But order of testing interacted with the stimulus language, $F(1, 54) = 33.64$, $MS_e = 11{,}429$, $p < .001$. Furthermore, a significant three-way interaction suggested that the interaction between the effect of stimulus language and the effect of the order of presentation was different for native Hebrew and native English speakers, $F(1, 54) = 43.36$, $MS_e = 11{,}064$, $p < .001$.

To clarify the source of the three-way interaction, we conducted two-way ANOVAs for Hebrew and English speakers separately. These analyses revealed that order of presentation and stimulus language interacted for native Hebrew speakers ($F[1, 54] = 44.3$, $MS_e = 19{,}452$, $p < .001$), but not for the native English speakers ($F[1, 54] < 1.0$). Hebrew speakers responded to Hebrew words more slowly when they were presented first than when they were presented following the En-

1. A subject analysis could not be carried out because the factors of order of presentation and stimulus language were not independent across subjects (subjects who were presented with Hebrew stimuli first were necessarily presented with English stimuli second, and vice versa). Therefore, the variance in each level of order of presentation is not independently distributed for stimulus language and speakers' language, across subjects.

glish materials, $t(55) = 1.955$, $p < .06$. In contrast, they responded faster to English words when they were tested first than when they followed the Hebrew words, $t(55) = 6.5$, $p < .001$.

Table 2 presents subjects' performance with the subset of stimuli that were phonologically identical in Hebrew and English. The pattern of results for this subset of words is very similar to the pattern found for the entire set. That is, native Hebrew and English speakers differed in their performance in segmenting words that are pronounced similarly in the two languages.

Finally, we compared performance for Hebrew words in which the vowel is represented in print only by dots and words in which the vowel is represented by a letter (Table 3). ANOVA showed that the effect of word type on performance differed for Hebrew and English native speakers. For Hebrew speakers, the percentage of correct deletions of initial phonemes in CVC words was higher when the vowel was represented in print by a letter than when it was represented only by points, and RTs to the correctly segmented words were faster if the vowel was represented by a letter than if it was not. In contrast, for English speakers, the percentage of correct deletions was not influenced by the word type, and RTs for words with vowel letters were even slower than RTs for words without vowel letters. The interaction of word type by subjects' native language was significant for both accuracy and speed of responses, $F(1, 26) = 18.18$, $MS_e = 18.9$, $p < .001$, and $F(1, 26) = 4.48$, $MS_e = 8{,}732$, $p < .05$, respectively.

Before drawing firm conclusions from these results, we had to examine whether the poorer performance of Hebrew than of English speakers stemmed from simple group differences in verbal skills,which are related to differences in academic background. For example, Treiman, Fowler, Gross, Berch, and Weatherston (in press) have shown that performance in the phoneme deletion task is correlated with university selectivity. To address this methodological issue, native Hebrew and English speakers were tested in a syllable deletion task. With an identical method and apparatus, 24 Hebrew and 24 English speakers were presented with 24 Hebrew and English bisyllabic words and were explicitly required to omit their initial syllables instead of their initial "sounds." The results are presented in Table 4.

In contrast to the results for the deletion of initial phonemes. Hebrew speakers were overall faster than English speakers in deleting the initial syllable for both Hebrew and English materials, $F_1(1, 46) = 141$, $MS_e = 1{,}551$, $p < .001$. There was no significant difference in RT between omitting the first syllable of Hebrew and English words, $F_1(1, 46) = 2.0$, $MS_e = 10{,}120$, $p < .15$. The interaction between speakers and material was significant: Native Hebrew speakers were faster in deleting the first syllable of Hebrew than of English words, whereas language did not affect the native English speakers, $F_1(1, 46) = 10.7$, $MS_e = 1{,}551$, $p < .002$. The small percentage of errors did not allow a reliable statistical analysis. Nonetheless, it is evident that in contrast to the results for the phoneme deletion task, Hebrew speakers were not less accurate than English speakers in syllable deletion. In fact, most errors were made by English speakers for English words, and consisted of omitting the initial phoneme rather than the first syllable.

DISCUSSION

The results of the present study indicate that the phonological sensitivity of fluent readers and their ability to manipulate phonemic segments may be influenced by the way phonological information is represented by the orthography. When asked to remove the first sound of English and Hebrew words composed of CVC trigrams, native Hebrew speakers tended to remove the initial CV combinations rather than the initial consonants more often than native English speakers. Two findings reveal that this difference reflects not merely different understandings of the deletion test (e.g., confusing the removal of the first "sound" with the removal of the first letter) but a genuine cognitive difference in manipulating phonemes. First, native Hebrew speakers made more errors in both languages, suggesting that they did not just omit the first letter and produce the remaining utterance. Second, and more important, they were overall much slower than native English speakers in correctly

Table 2. *Reaction time (in milliseconds) and percentage of correct responses for deletion of the first phoneme in phonologically identical Hebrew and English words*

Measure of performance	Native Hebrew speakers: Presented first	Native Hebrew speakers: Presented second	Native English speakers: Presented first	Native English speakers: Presented second
	Hebrew words			
Reaction time	1,272 (55)	875 (28)	730 (17)	668 (12)
Percentage correct	37 (3.7)	76 (2.6)	92 (0.8)	100 (0.0)
	English words			
Reaction time	942 (33)	1,100 (32)	769 (23)	684 (16)
Percentage correct	76 (2.2)	73 (1.0)	100 (0.0)	92 (0.0)

Note. Numbers in parentheses are standard errors of the means. Reaction times are for correct trials only.

Table 3. *Reaction time (in milliseconds) and percentage of correct responses for deletion of the first phoneme in Hebrew words that do and do not include printed vowels*

Measure of performance	Native Hebrew speakers	Native English speakers
	Words with vowels	
Reaction time	985 (45)	715 (11)
Percentage correct	84 (1.0)	96 (0.5)
	Words without vowels	
Reaction time	1,074 (34)	699 (12)
Percentage correct	65 (2.0)	96 (0.4)

Note. Numbers in parentheses are standard errors of the means. Reaction times are for correct trials only.

deleting only the initial phoneme for both Hebrew and English materials. This outcome suggests a genuinely greater difficulty in detaching single phonemes in the phoneme deletion task. The results from the syllable deletion task strongly reinforce this conclusion. When it was not the initial phoneme that had to be detached, but the initial syllable, Hebrew readers performed significantly better than English readers.

Within-language-group comparisons revealed a marked difference in the way Hebrew and English speakers were affected by the language of the presented stimulus. Whereas English speakers performed almost identically with Hebrew and English materials, Hebrew speakers tended to isolate CV segments more often with Hebrew than with English words, even when the words had identical phonemic sequences in the two languages. Hebrew speakers also differed from English speakers in their susceptibility to the order of material presentation. The RT analyses suggest that the order of presentation reflects mostly a practice effect for English speakers, who were faster in the second test block than in the first, regardless of the stimulus language. In contrast, performance of Hebrew speakers depended heavily on the language of their initial test session. An initial exposure to English materials had a beneficial effect on Hebrew speakers' subsequent performance with Hebrew words; RTs to Hebrew words were 245 ms faster if the first testing session was conducted in English. A similar pattern was revealed in the accuracy scores. However, an opposite effect was found with English materials: An initial exposure to Hebrew words hindered performance in the subsequent presentation of English words. Thus, Hebrew speakers were some 100 ms slower to detach the first phoneme of English words if they were first tested with Hebrew materials.

Table 4. *Reaction time (in milliseconds) and percentage of correct responses for deletion of the first syllable in Hebrew and English words*

Measure of performance	Native Hebrew speakers	Native English speakers
	Hebrew words	
Reaction time	790 (15.9)	912 (15.5)
Percentage correct	98.5	97.8
	English words	
Reaction time	846 (15.9)	915 (14.7)
Percentage correct	97	94

Note. Numbers in parentheses are standard errors of the means. Reaction times are for correct trials only.

This result provides some insight concerning the cognitive procedures used by the subjects in the phoneme deletion task. When asked to delete the first sound of the word, subjects probably invoked the word's orthographic representation and based their decision, in part, on the deletion of the first letter. Thus, because in all of the English words that we employed the second letter was a vowel, Hebrew subjects probably correctly realized that what should be deleted was the initial consonant and generalized this strategy to the Hebrew words as well. An opposite effect occurred when Hebrew words were presented first; in this case, the previous exposure to Hebrew materials was detrimental to segmenting the English words correctly. This interpretation is supported by the performance with Hebrew words that contain vowel letters. Hebrew speakers deleted the first phoneme of these words more often and much faster than for words that do not include a vowel letter. This within-language effect reflects a strategy of invoking an orthographic representation in the phoneme deletion task.

The results, however, cannot be explained only by invoking an orthographic representation in the task. First, performance of English speakers was similar across sessions and across stimuli, and did not reflect a fine-tuning to the different orthographic structures of the spoken word in the two languages. More important, regardless of the order of presentation and the materials to be segmented, Hebrew speakers were always slower than English speakers in the phoneme deletion task, even when they performed the task correctly. Therefore, we suggest that the different trends observed in the two groups' abilities to delete the first consonants of words represent a cognitive difference in manipulating phonemes. This cognitive difference is probably influenced by the basic phonemic awareness developed early in life and modulated by the nature of the grapheme-to-phoneme rules specific to a language's orthography. This view is consistent with the results obtained in the syllable deletion test. Because the Hebrew unpointed graphemes often represent syllables, Hebrew speakers performed better than English speakers in this test, in sharp contrast to their performance in phoneme deletion.

The results of the present study may clarify the mechanism by which reading acquisition fosters the development of phonological skills and the ability to segment words into their phonemic constituents during the early school years. In contrast to speech, in which phonemes are coarticulated and cannot be easily disentangled from one another, in writing the phonemes are represented by discrete units—the letters. When children are aware of the fact that words are composed of smaller meaningless units (i.e., have basic phonological awareness), exposure to an alphabet may help in determining the size of these units. In an alphabetic orthography, letters are mapped onto single phonemes, and therefore exposure to the alphabetic principle may help children realize that the smallest phonological unit is the phoneme. A writing system in which letters represent single phonemes has apparently long-lasting effects that extend to adult readers as well as children. When the native English speakers in our study were asked to delete the first sound in words, they isolated the initial sound most of the time, in English as in Hebrew. They did this because in English letters always represent single phonemes. In Hebrew, in contrast, although letters denote mainly single consonants, these consonants are combined and pronounced with the following vowels because the orthographic symbols that denote vowels are usually absent. Therefore, the basic subword phonological unit induced by exposure to Hebrew letters may take the form of a CV phonological unit. This may have caused the enhanced tendency of the native Hebrew speakers in the present study to isolate CV units in the deletion task both in Hebrew and in English.

In summary, our results support the claim that the way in which orthography represents phonology affects phonological awareness (Mann, 1986; Read et al., 1986). However, the present study suggests that this effect is not restricted to the phase of reading acquisition. Rather, it has a long-lasting influence on skilled readers' intuition concerning the phonological structure of their spoken language, and even on their basic phonological skills.

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REFERENCES

Alegria, J., Pignot, E., & Morais, J. (1982). Phonetic analysis of speech and memory codes in beginning readers. *Memory & Cognition, 10*, 451–456.

Ball, E., & Blachman, B. (1988). Phoneme segmentation training: Effect on reading readiness. *Annals of Dyslexia, 38*, 208–225.

Ball, E., & Blachman, B. (1991). Does phoneme awareness in kindergarten make a difference in early word recognition and developmental spelling? *Reading Research Quarterly, 26*, 49–66.

Bentin, S. (1992). Phonological awareness, reading, and reading acquisition: A survey and appraisal of current knowledge. In R. Frost & L. Katz (Eds.), *Orthography, phonology, morphology, and meaning* (pp. 67–84). Amsterdam: Elsevier, North-Holland.

Bentin, S., Hammer, R., & Cahan, S. (1991). The effects of aging and first year schooling on the development of phonological awareness. *Psychological Science 2*, 271–274.

Bentin, S., & Leshem, H. (1993). On the interaction of phonologic awareness and reading acquisition: It's a two-way street. *Annals of Dyslexia, 43*, 125–148.

Blachman, B. (1989). Phonologic awareness and word recognition: Assessment and intervention. In A.G. Kamhi & H.W. Catts (Eds.), *Reading disabilities: A developmental language perspective* (pp. 133–158). Boston: College Hill Press.

Bradley, L. (1989). Predicting learning disabilities. In J.J. Dumont & H. Nakken (Eds.), *Learning disabilities: Cognitive, social and remedial aspects* (pp. 1–17). Amsterdam: Swets & Zeitlinger.

Bradley, L., & Bryant, P. (1983). Categorizing sounds and learning to read: A causal connection. *Nature, 301*, 419–421.

Frost, R., & Bentin, S. (1992). Reading consonants and guessing vowels: Visual word recognition in Hebrew orthography. In R. Frost & L. Katz (Eds.), *Orthography, phonology, morphology,and meaning* (pp. 27–44). Amsterdam: Elsevier, North-Holland.

Goswami, U., & Bryant, P. (1990). *Phonologic skills and learning to read.* East Sussex, England: Erlbaum.

Jakimik, J., Cole, R.A., & Rudnicky, A.I. (1980, May). *The influence of spelling on speech perception.* Paper presented at the annual meeting of the Psychonomic Society, St. Louis, MO.

Liberman, I.Y., Shankweiler, D., Liberman, A.M., Fowler, C., & Fisher, F.W. (1977). Phonetic segmentation and recoding in the beginning reader. In A.S. Reber & D.L. Scarborough (Eds.), *Towards a psychology of reading* (pp. 207–226). Hillsdale, NJ: Erlbaum.

Lundberg, I., Frost, J., & Peterson, O.P. (1988). Effects of an extensive program for stimulating phonological awareness in preschool children. *Reading Research Quarterly, 23*, 263–284.

Lundberg, I., Olofsson, A., & Wall, S. (1980). Reading and spelling skills in the first school years predicted from phonemic awareness skills in kindergarten. *Scandinavian Journal of Psychology, 21*, 159–173.

Mann, V.A. (1984). Longitudinal prediction and prevention of early reading difficulty. *Annals of Dyslexia, 34*, 117–136.

Mann, V.A. (1986). Phonological awareness: The role of reading experience. *Cognition, 24*, 65–92.

Mann, V.A., & Liberman, I.Y. (1984). Phonologic awareness and verbal short term memory. *Journal of Learning Disabilities, 17*, 592–598.

Morais, J., Bertelson, P., Cary, L., & Alegria, J. (1986). Literacy training and speech segmentation. *Cognition, 24*, 45–64.

Read, C.A., Zhang, Y., Nie, H., & Ding, B. (1986). The ability to manipulate speech sounds depends on knowing the alphabetic reading. *Cognition, 24*, 31–44.

Stanovich, K.E., Cunningham, A., & Cramer, B. (1984). Assessing phonological awareness in kindergarten children: Issues of task comparability. *Journal of Experimental Child Psychology, 3*, 175–190.

Tanenhaus, M.K., Flanigan, H.P., & Seidenberg, M.S. (1980). Orthographic and phonological activation in auditory and visual word recognition. *Memory & Cognition, 8*, 513–520.

Treiman, R. (1985). Onsets and rimes as units of spoken syllables: Evidence from children. *Journal of Experimental Child Psychology, 39*, 161–181.

Treiman, R., Fowler, C.A., Gross, J., Berch, D., & Weatherston, S. (in press). Syllable structure or word structure: Evidence for onset and rime with dysyllabic and trisyllabic stimuli. *Journal of Memory and Language.*

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