

CHAPTER 11

Phonological Awareness, Reading, and Reading Acquisition: A Survey and Appraisal of Current Knowledge

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Phonetic production and perception are part of the natural endowment of the human race. As soon as infants can be tested, they show an ability to distinguish between phonetic categories (e.g., Kuhl, 1987; Kuhl & Meltzoff, 1982; Molfese, & Molfese, 1979) and very early in life they are able to use phonetic elements and a few rules of combination to form phonologic structures that represent words. Children's phonological perception ability is, in fact, admirable. Even though the several phonetic gestures that are included in a phonological structure are co-articulated and therefore their acoustic effects overlap, very young children are able to decipher the phonetic code and distinguish between words on the basis of single phonemes (Eimas, 1975; Eimas, Miller, & Jusczyk, 1987; Eimas, Sequeland, Jusczyk, & Vigorito, 1971; Morse, 1972). Moreover, the deciphering of the phonetic code requires very little attention and effort. These findings lead several investigators to propose that the perception of speech is accomplished by a precognitive process controlled by a distinct biological module which is specialized to recover the coarticulated gestures from the acoustic stream and provide the cognitive system with unequivocal phonological information (Lieberman & Mattingly, 1989; Mattingly & Liberman, 1990).

In contrast to their well developed phonological ability young children cannot reflect on or intentionally manipulate structural features of spoken language. Most four-to-five year-old children will not be able, for example, to tell what a word's first phoneme is, or how the word ends. Putting it differently, young children do not have the metalinguistic ability that would enable them to manipulate sub-word phonological elements (Bruce, 1964; for a recent review and an alternative perspective see Goswami & Bryant, 1990). This metalinguistic ability has been labeled *phonological awareness* (Lieberman, 1973; Mattingly, 1972). The study of phonological awareness is important because the last two decades of research have provided ample evidence for its intimate relationship with reading acquisition and skill. In the present chapter I examine the nature of phonological awareness, its acquisition and development, and its role in reading acquisition.

Forms and levels of phonological awareness

By definition, awareness should be an all-or-none aptitude. In support of this view, studies in our laboratory (Leshem, unpublished doctoral dissertation), as well as in others (Calfee, Chapman, & Venezky, 1972; Stanovitch, Cunningham, & Cramer, 1984) revealed that the distribution of children's performance on tests of phonemic segmentation is bimodal: on a particular test, individual scores were either very high or very low. Additional support to this view was provided by several authors who have shown that pre-school children as well as illiterate adults can learn initial consonant deletion within a single session if they are provided with corrective feedback (Content, Kolinsky, Morais, & Bertelson, 1986; Morais, Content, Bertelson, Cary, & Kolinsky, 1988). Other authors, however, postulated that the development of explicit representation of phonemic structures could well be gradual (Content et al., 1986). This view was based on results showing that children's performance on different tests of phonological awareness varied considerably (e.g., Stanovitch Cunningham, & Cramer, 1984). For example, preschool children are relatively successful in rhyme detection tasks (Bradley, & Bryant, 1983; Lenel & Cantor, 1981; Maclean, Bryant, & Bradley, 1987), can accurately count the number of syllables in words (Lieberman, Shankweiler, Fisher, & Carter, 1974), but they cannot isolate single phonemes (Lieberman, Shankweiler, Lieberman, Fowler, & Fisher, 1977; Rosner & Simon, 1971). The "all-or-none" view of awareness and the variability in performing different tests of phonological awareness can be reconciled by assuming that phonological awareness is a heterogeneous metalinguistic competence involving abilities that differ in developmental trends and origins. Indeed, several recent reports emphasized the heterogeneous nature of phonological awareness (Bertelson & de Gelder, 1989; Bertelson, de Gelder, Tfouni, & Morais, 1989). In order to understand what the different forms of phonological awareness might be, we should first survey the ways phonological awareness has been assessed.

Because phonological awareness refers to the phonological structure of spoken words, phonological awareness tests require the ability to either detect, isolate, or manipulate sub-word phonological segments (or some combination of the above). Some tests require these aptitudes explicitly. These are, for example, phoneme isolation ("What is the first/last sound in desk?"; e.g., Bentin, Hammer, & Cahan, 1991; Wallach & Wallach, 1976), phoneme segmentation ("What sounds do you hear in the word hot?"; e.g., Fox & Routh, 1975; Williams, 1980), phoneme counting ("How many sounds do you hear in the word cake?"; Lieberman et al., 1974; Yopp, 1985), and specifying a deleted phoneme ("What sound do you hear in cat, that is missing from at?"; Bentin & Leshem, in press; Stanovich et al., 1984). In other tests, correct performance requires sensitivity to sub-word phonological segments, although awareness of those segments is not explicitly tested. Such tests are, for example, the detection and/or production of rhyme ("Does sun rhyme with run?"; e.g., Calfee et al., 1972; Maclean et al., 1987), word-to-word matching ("Do pen and pipe begin the same?"; e.g., Bentin et al., 1991; Wallach & Wallach, 1976), phoneme reversal ("Say on with the first sound last and the last sound first"; Alegria, Pignot, & Morais, 1982), and phoneme deletion ("What would be left if you took out the /t/ from told?"; e.g., Bruce, 1964; Rosner, 1975; Morais, Cary, Alegria, & Bertelson, 1979). Tests also differ in the size of the segment they refer to. Some tests require awareness of single phonemes while others require awareness of sub-syllabic segments

such as the word's onset or rime¹ (Kirtley, Bryant, Maclean, & Bradley, 1989; Treiman, 1985) or of syllabic segments (e.g., syllable counting; Liberman et al., 1974). Hence, phonological awareness was tested in many ways and, apparently, the observed level of "phonological awareness" was determined to some extent by the particular tests used.² The above survey suggests that tests of phonological awareness may differ along at least three dimensions: 1) operation required (detection, isolation, or manipulation of the phonological segment); 2) manner of testing awareness of phonological codes (indirect or explicit); and 3) size of the relevant phonological segment (syllabic, sub-syllabic, phonemic). Although the above dimensions are not entirely orthogonal (most detection tests, for example, are also indirect), a detailed examination of previous reports shows that the performance on different tests of phonological awareness varied systematically along all three dimensions.

Regardless of their size, detection of phonological segments was better than isolation, while the manipulation of segments was the poorest and latest accomplished task. For example, 29 out of 66 four-year-old children were able to detect the one word (out of three) which did not rhyme with the others, but only 8 were able to produce rhymes to target words (Maclean et al., 1987). Similarly, most studies revealed that children in kindergarten are usually very poor at isolating one phoneme of a word (Bentin et al., 1991; Lundeberg, Frost, & Petersen, 1988) or repeating an utterance after deleting one phoneme (e.g., Bruce, 1964; Rosner & Simon, 1971; Content et al., 1986), but they are more successful when they have to match words or detect oddity among words on the basis of only one phoneme (Content et al., 1986; Stanovich, Cunningham, & Crammer, 1984; Yopp, 1988). Children are more aware of syllabic and subsyllabic segments than they are of phonemic segments. For example, children start detecting rhymes and common phonemic clusters at the onset of a word much before they can match words on the basis of single phonemes (e.g., Bradley & Bryant, 1983; 1985). Similarly, preschool children are considerably more accurate in counting the syllables than the phonemes included in words (Cossu, Shankweiler, Liberman, Katz, & Tola, 1988; Liberman et al., 1974; Treiman & Baron, 1981), and the same is true for more sophisticated manipulations of syllables vs. phonemes such as segmentation (Fox & Routh, 1975; Lundberg et al., 1988) and reversal (Content, Morais, Alegria, & Bertelson, 1982; Mann, 1984). Finally, it appears that children's performance is better when phonological awareness is tested indirectly than in explicit tests. For example, counting the number of phonemes (particularly when tokens or wooden blocks are used) is more accurate than "spelling out" the sounds of a word (Yopp, 1988).

The considerable variation in pre-schoolers' performance on different tests of phonological awareness was mentioned and discussed by several authors. However, most of these authors were concerned primarily with the selection of the tests that were most reliable and best correlated with reading skills (e.g., Golnikoff, 1978; Lewkowicz, 1980; Torneous, 1984). Other authors simply partitioned the different tests into coherent groups

¹The "onset" and the "rime" are, respectively the consonant (or consonants) that precede the vowel, and the rest of the syllable (Halle & Vergnaud, 1980; MacKay, 1972). I will elaborate on these segments and their relationship to phonological awareness later in the text.

²An additional test that was often used is blending, i.e. the ability to form a word by synthesizing syllables or phonemes uttered by the experimenter (e.g., Fox & Routh, 1975; Lundberg, Frost, & Petersen, 1988). I think, however, that although this test requires the manipulation of phonological units, it does not require explicit deciphering of the phonological code, and therefore it examines a skill that is basically different from phonological awareness.

(e.g., Content et al., 1986) or established a hierarchy of tests according to relative difficulty (e.g., Roberts, 1975; Stanovich et al., 1984). Only a few authors used this variation to analyze the nature and components of phonological awareness. A notable exception is the factor analysis that was recently performed by Yopp (1988) on the results of kindergarten children in ten tests of phonological awareness. The factor analysis revealed that only two factors accounted for most of the variance. Tests of phonemic segmentation, sound isolation, and phoneme counting had high loadings on Factor 1 and low loadings on Factor 2. Tests requiring the deletion of phonological segments and tests of word matching on the basis of single phonemes had moderate to high loadings on Factor 2 and low loadings on Factor 1. Because the tests that loaded Factor 2 required more steps to completion and placed a greater burden on short-term memory than the tests that loaded Factor 1, Yopp suggested that Factor 2 reflects a *Compound Phonemic Awareness* whereas Factor 1 reflects a *Simple Phonemic Awareness*. Hence, Yopp explained the variation in performance along the "operation" dimension by assuming that different levels of operation vary in the number of steps required for test completion. A stepwise regression analysis of reading scores on phonological awareness showed that both factors were good predictors of reading ability. This, however, is not surprising, since it turns out that simple phonemic awareness is in fact included in compound phonemic ability. Therefore, although the description of the two factors might help explain the variability of phonological awareness measures, it adds very little to the explanation of the relationship between phonological awareness and reading.

One of the most reliable sources of variation in phonological awareness performance is the size of the test-relevant segment. Most studies of phonological awareness showed that most preschool children can segment words into syllables but cannot manipulate or isolate single phonemes (Bruce, 1964; Calfee, 1977; Calfee, Lindamood, & Lindamood, 1973; Fox & Routh, 1975; Hakes, 1980; Liberman et al., 1974; Lundberg et al., 1988; Rosner & Simon, 1981; Treiman & Baron, 1981; Zhurova, 1963). Other studies found that four-year-old children can detect rhymes and can match words on the basis of common subsyllabic segments (e.g., Bradley & Bryant, 1985; Kirtley et al. 1989) but are unable to match words on the basis of single phonemes (Maclean et al., 1987). A possible explanation of the difference between children's ability to detect, count, and manipulate syllables or sub-syllabic clusters and their performance with single phonemes is to assume, as Content et al., (1986) did, that phonological awareness is a gradually developing ability, or that there are "levels" of phonological awareness (e.g., Goswami & Bryant, 1990). However, it is also possible that there is a qualitative distinction between the awareness of single phonemes and the awareness of multi-phonemic structures which accounts for the observed difference in performance with the two types of segment. In other words, it is possible that awareness and manipulation of single phonemes and detection and sensitivity to syllabic or intrasyllabic structures are qualitatively different forms of phonological awareness rather than two levels along a continuum of one ability. I will try to defend this qualitative distinction.

As a consequence of the process of coarticulation that characterizes speech production, the sound frequency patterns forming acoustic segments in speech reflect the combined contribution of several complex gestures, each intended to produce a different phone. Moreover, because a phone can be coarticulated with different phonetic contexts, there can be no direct correspondence in segmentation between the acoustic signal and the phonetic message it conveys. Therefore, speech perception cannot be based on a simple

translation from a set of auditory representations to a set of perceptual phonetic categories. Consequently, awareness of each of the phonemes conveyed by one acoustic segment probably follows a more basic and automatic process of phonetic deciphering. This is probably why, although phonetic distinctions in speech are easy and natural, awareness of phonetic categories appears much later in ontogenetic development and probably requires more than simple cognitive maturation. This awareness requires the ability to break up the coarticulated phonological segments and isolate their individual phonemic constituents.

The above analysis implies that segmentation should be relatively easy when the required phonological units correspond to perceived acoustic segments but difficult when the disentangling of coarticulated phones is required. Coarticulated phonological units usually include a highly resonant nucleus (a vowel) flanked by one or several consonants, together forming a syllable. Therefore, syllabic segmentation can be based on simple auditory perception and might not reflect genuine phonological awareness. This view also suggests that the isolation of stop consonants should be significantly more difficult than the isolation of steady-state vowels because the former have no independent acoustic existence—they are always coarticulated. The latter hypothesis, however, is only partly supported by empirical evidence. Previous studies of initial phoneme isolation (Bentin & Leshem, in press) and initial phoneme deletion (Content et al., 1982; Content et al., 1986) suggested that the performance of pre-school children was better with vowels than with consonants; that order of difficulty was reversed, however, when the last (rather than the first) phoneme had to be isolated: Final consonants were easier to isolate than final vowels (Bentin & Leshem, in press). A similar pattern was found when performance with stop consonants was compared to performance with fricatives (Content et al., 1986).

In contrast to the commonly reported failure of pre-literate children to isolate and manipulate single phonemes which are perceived in coarticulated form, most studies demonstrate that children are considerably more successful in detecting and producing rhymes. The sensitivity to rhymes might be taken as evidence for a second form of phonological awareness because it also requires the breaking of coarticulated phonetic clusters. For example, the recognition that the monosyllabic words "beg" and "leg" rhyme involves breaking them into b-eg and l-eg segments, and recognizing that the end segments of each syllable sound alike. Because the same children cannot usually tell that /b/ is the first and /g/ is the last phone in "beg," it is conceivable that rhyme detection and phonemic segmentation require different phonological skills. The most outstanding attempt to explain this difference was made by Peter Bryant, Lynette Bradley and their collaborators at Oxford.

The basic idea advocated by the Oxford group is that there are linguistically valid segments intermediate between single phonemes and syllables. These segments were labeled *onset* and *rime*. The onset is the consonant or string of consonants that precedes the vowel in a syllable, and the rime is the rest of the syllable. For example the onset of the monosyllabic word "black" is /b/ and its rime is /ack/. Note, that although the onset and the rime are phonologically defined units, the validity of this distinction was based either on observing the nature of errors in speech (MacKay, 1972), or on linguistic constraints on sequences of phonemes (Halle & Vergnaud, 1980). Hence, the validity of this phonological categorization is not based on phonetic considerations and is very different from the distinction between phonetic categories that was discussed above. Nevertheless, awareness of this intrasyllabic segmentation and the ability to manipulate

these segments require, as mentioned above, breaking the coarticulated unit of perception, and they may therefore be considered a form of phonological awareness.

Words that rhyme share, by definition, the same rime. Therefore, the reliable demonstrations that four-year-old children can detect and produce rhymes proves that they are aware of the rimes of syllables. Are they also similarly aware of the onsets? That evidence is less compelling. Kirtley et al. (1989) attempted to demonstrate such an awareness, however most of their evidence is based on negative findings and their interpretations are speculative. In their study they used oddity tasks with different word sets. First they replicated the finding that it is easier to find an "odd" word among four when the commonality is based on the initial consonant than on the final consonant. Their interpretation of this phenomenon was that the initial consonant formed the whole onset of the word whereas the final consonant was only a part of the rime. However, in order for this interpretation to hold unequivocally they would have had to show that when the initial consonant was only a part of the onset (such as the /s/ in "string") its detection should be more difficult. Unfortunately such a comparison has not been attempted. Moreover, our own observations (Leshem, unpublished doctoral dissertation) suggest that the opposite is true. Our five-year-old subjects were more successful in isolating the initial consonant in words that began with a CCV string than in words that began with a CV string.

In a second experiment Kirtley et al. (1989) used different oddity combinations aimed at distinguishing between situations in which the odd word could be detected on the basis of a full intrasyllabic segment or required the breaking of such segments. In all the conditions the results supported the prediction that it is easier to detect oddity on the basis of intact intrasyllabic structures. However, the same results could be interpreted solely on the basis of special sensitivity to the rime, without making any assumptions about the onset. Moreover, as in the first experiment, no multi-phonemic segments were used, and so the "onset" was always confounded with a single initial phoneme. Nevertheless, it should be stressed that the authors' interpretation is not counter-intuitive and may be right. At this time, however, all we can say is that there is strong evidence for a particular sensitivity to the rime of syllables which may have been induced by extensive experience with rhymes. Moreover, this form of sensitivity was shown only in detection tasks. To the best of my knowledge, awareness of onset and rimes has never been shown in tests of segmentation or isolation. Hence, it is possible that children who are able to detect rhymes and correctly select the odd word in an oddity tests are sensitive to sub-syllabic units but still unable to point out the phonological segment on which their decision is based. Consequently, it is possible that sensitivity to sub-syllabic segments, either as suggested by the Oxford group or limited to rimes only, reflects a qualitatively different form of phonological awareness than sensitivity to single phonemes. Later in this chapter I discuss the relevance of both forms of phonological awareness to reading.

In conclusion, this section shows that there are, in fact, only two forms of phonological awareness: One which is demonstrated by the ability to isolate segments and manipulate single phonemes, and one demonstrated by sensitivity to the rime and perhaps to the onset of syllables. The first requires explicit knowledge about the phonemic segment and, therefore I will label it "phonemic awareness"; the second is reflected indirectly in the detection of oddity and commonality between words on the basis of subsyllabic segments. I will label this second form "early phonological awareness." Other tests vary along different dimensions but do not reflect any separate ability.

Factors influencing the development of phonological awareness

Clearly, phonological awareness is not an innate aptitude; it is probably triggered by some experience. Therefore, the questions of "how" and "when" this skill appears have frequently been raised and have been the subject of much controversy. Some authors claimed that phonological awareness is triggered, or at least considerably enhanced, by exposure to the alphabet (e.g., Bertelson et al., 1985; Bertelson & de Gelder, 1990). Others proposed that phonological awareness develops a long time before children learn to read, through experiences which at the time have nothing to do with reading (e.g., Bryant & Bradley, 1985). As we will see, however, these are not mutually exclusive theories, because each of the proponents is actually talking about of a different form of phonological awareness.

There is ample evidence that learning to read affects phonological awareness skills. For example, using consonant addition and deletion tasks, Read, Zhang, Nie, and Ding (1986) found well-developed phonological awareness in Chinese subjects who learned to read a recently developed Chinese alphabetic system (Pinyin) but not among subjects who read only the logographic system (Kanji). The mean percentage of correct performance was 83% in the former group but only 21% in the later. Along the same lines, Mann (1986) reported that first-graders in Japan who learned how to read a syllabary (Kana) were good at manipulating syllables but significantly inferior to American first-graders in manipulating phonemes. Equivalent results were found with Belgian children in the first grade; those who learned to read according to the "analytic" (segmental) method performed better on tests of phonemic segmentation than those who learned to read by the "global" (holistic) method (Alegria, Pignot, & Morais 1982). However, the strongest support for the view that in the absence of reading acquisition phonemic segmentation skills do not develop spontaneously is provided by a series of studies by Morais and his colleagues showing that illiterate adults perform very poorly on tests of phoneme deletion, although they may manipulate phonology at syllabic and word levels (Morais et al. 1979, 1986, 1987). Similar results were also found with semi-literate adults (Read & Ruyter, 1985) and with the reading disabled (Bryne & Ledez, 1983). The ability of the illiterate subjects to manipulate multi-phonemic units as opposed to single phonemes is congruent with findings in preschool children.

As reviewed in the previous section, there is no doubt that some three-year-old children and most four-year-old children recognize and play with rhymes (e.g., Chukovsky, 1963). Formal testing has shown that when either detection through oddity or the production of rhyme and alliteration was involved, many three- and four-year-old children could make judgments about the component sounds (particularly rimes) in words that they heard or uttered (Maclean et al., 1987). The significant ability of pre-literate children to detect rhymes as well as to perform above chance in oddity tests based on sensitivity to subsyllabic segments (Bradley & Bryant, 1985; Kirtley et al., 1989) lead to the conclusion that phonological awareness exist before reading acquisition (Maclean et al., 1987). Note, however, that the apparent disagreement between the two views stems from a different definition of phonological awareness. Those who found signs of phonological awareness in three and four-year-old children refer primarily to what we called the early form of phonological awareness—the one which focuses on subsyllabic segments and is tested indirectly. In contrast, the defenders of the alternative view, (i.e., that phonological awareness is triggered by the exposure to the alphabetic principle), refer to phonemic awareness—the one reflected in the ability to explicitly manipulate single phonemes

deciphered from the coarticulated unit. This fact was recently recognized by both parties (Bertelson et al., 1989; Goswami & Bryant, 1990).

Having resolved the above controversy, we are still left with several important questions. What are the factors that affect the development of the two forms of phonological awareness? Is the early form a precursor of the later form? Does the early form develop spontaneously or is it the result of explicit or implicit instruction? Is exposure to the alphabetic principle the only factor influencing the development of phonemic awareness? Can the development of phonemic awareness be accelerated and achieved prior to exposure to the alphabetic principle? The available literature may provide answers to some of these questions.

The impressive studies reported by Bradley and Bryant (1985) prove beyond any reasonable doubt that explicit training with sound categorization improves performance on oddity tests based on rime and onset. In other words, the early form of phonological awareness can be significantly improved in kindergarten by explicit training. This, however, does not prove that this metaphonological ability cannot occur spontaneously. A direct answer to this question requires a rigid control of children's pre-test experience with rhymes. Obviously, it is practically impossible to control children's experience in life, and so we are forced to address this question only indirectly. For example, in a longitudinal study by Maclean et al. (1987), young children's performance on different tests of rhyme and alliteration detection as well as their knowledge of nursery rhymes, was related to their socio-economical background and their parents' education. Although it is a rough estimate, it would not be completely wrong to assume that children of middle-class highly educated parents had more opportunities to be exposed to nursery poems and other forms of rhymes than children coming of lower-class poorly educated parents. Therefore, a significant difference between the performance of the two groups might indicate that experience with rhymes is a critical trigger of the early phonological awareness. The results of this comparison suggested that at the earliest age tested (3 years old) children coming from the "privileged" homes were more successful in the detection of alliteration than the other children, but there were no differences in the detection of rhymes, and both groups were equally knowledgeable about nursery rhymes. Moreover, even the small difference did not last. There was no sign of influence of family background after the initial tests. On the basis of these results, and considering that illiterate adults who showed no phonemic awareness were nevertheless sensitive to rhyme judgments and vowel deletion (e.g., Bertelson et al., 1989), we may safely conclude that the early phonological awareness, which does not require awareness of single phonemes, can be easily triggered without explicit instruction and may develop independently of reading acquisition.

In contrast to their sensitivity to syllabic and sub-syllabic phonological segments, evidence from studies with illiterates suggests that the ability to isolate and manipulate single phonemes that are coarticulated in speech (i.e., phonemic awareness) does not develop spontaneously (Morais et al., 1979; Morais, Bertelson, Cary, & Alegria, 1986). These authors proposed that learning to read an alphabetic orthography provides most children (and adults) with the opportunity to develop full phonemic awareness. In contrast to speech, where individual phonemes are coarticulated, in writing the phonemes are represented by clearly defined orthographic segments, the letters. Assuming that children learn about these letter-sound correspondence when they learn to read, it seems likely that during the acquisition of reading skills they become explicitly aware that words are

formed of the sounds which the letters represent. Indeed, most studies revealed a significant gap between the phonemic segmentation skills of first-graders and of kindergarten children. For example, Liberman et al. (1974) found that none of the pre-kindergartners and only 17% of the kindergartners tested were able to parse words into phonemes, while 70% of the first-graders tested succeeded in doing so.

A caveat about interpreting developmental studies of phonological awareness, and particularly the striking improvement in phonemic segmentation ability during the first grade, is that all such studies share the serious problem of the possible confounding of differences in the extent or method of reading acquisition with other age-related variables that may have influenced phonological awareness (e.g., the amounts of informal linguistic experience and general cognitive development). In addition, the comparison of illiterate and ex-illiterate adults may be compromised, for example, because the choice to join a literacy program in adulthood was probably not arbitrary. Therefore, before definite claims about a causal relationship between reading acquisition and the emergence of phonemic awareness could be made, it was still necessary to isolate the effect of reading acquisition on the appearance and development of awareness of individual phonemic segments.

Owing to the impossibility of experimenting with elementary school attendance, previous attempts to control for general age-related effects on phonological awareness were based on comparisons between the youngest and the oldest children within one grade level (Bowey & Francis, 1991), or between the oldest children in the kindergarten and the youngest children in the first grade (Bowey & Francis, 1991; Morrison, 1988). Although suggestive, this approach suffers from a serious shortcoming of selection, because the cutoff date for school admission is never strictly imposed. Moreover, the exceptions are not random: Intellectually advanced children who are slightly younger than the official school age are often admitted, while children who are somewhat older than the cutoff point but insufficiently developed may be held back an additional year (Cahan & Davis, 1987; Cahan & Cohen, 1989). This creates a situation of "missing" children in each grade, particularly among children at the extreme ages. Such selective misplacement usually leads to overestimation of the schooling effect (Cahan & Cohen, 1989).

In a recent study Bentin, Hammer, & Cahan (1991) proposed a solution to this problem. Rather than comparing empirically obtained data from children at the extreme ages in each grade, the authors predicted these data on the basis of the best fitting regression of test scores on chronological age, across the entire legal age range in each grade, with the exclusion of the selection-tainted birth dates near the cutoff point. The separate effects of schooling and one year of age were estimated by means of a regression discontinuity design (Cook & Campbell, 1979) involving the regressions of phonemic segmentation scores on chronological age. The effect of age was reflected by the slope of the within-grade regressions, whereas the effect of schooling was reflected in the discontinuity between the two regression lines. The results of this analysis are presented in Figure 1.

As evident in Figure 1, the percentage of correct responses on the phonemic segmentation battery was higher in school children (76%, $SD=14\%$) than in the kindergarten group (35%, $SD=23\%$) ($t(674)=29.12, p<.0001$). However, this difference reflected the combined effects of age and schooling. The comparison of the independent schooling and age effects revealed that, although both effects were statistically significant, the effect of schooling (reading acquisition) was four times as large as the effect of one year of chronological maturation.

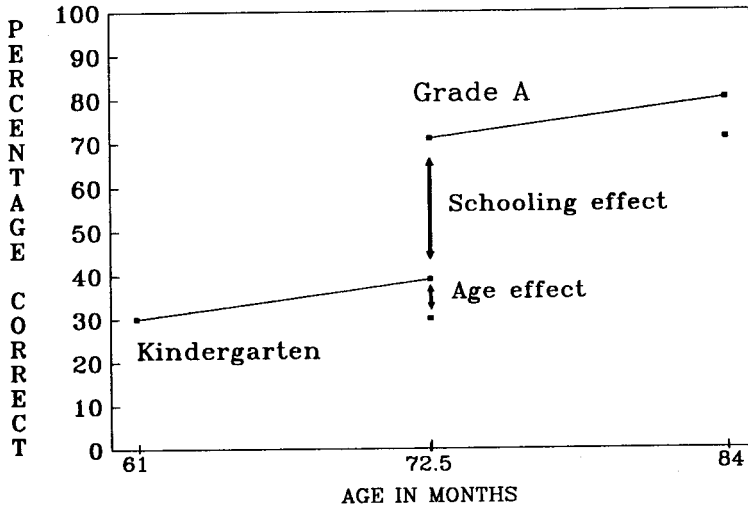


Figure 1. Schooling and age effects on the development of phonological awareness in kindergarten and Grade A children.

The results of the Bentin et al. (1991) study pointed to schooling (learning to read) as a major factor affecting the development of phonological awareness. This is not to say, however, that exposure to an alphabetic orthography is the only way to trigger phonemic awareness. There is ample evidence for the efficiency of tuition in metaphonological skills outside the context of reading acquisition (e.g., Lundberg et al., 1988). Significant improvement in phonemic segmentation skills were obtained using different training methods such as the use of visual aids to represent phonemes (Elkonin, 1973; Lindamood & Lindamood, 1969), the designing of speech-correction games played with puppets that impersonated human speakers (Content et al., 1982), simply using corrective information during testing in successive blocks (Content et al., 1986), and designing speech-sound oriented group games (Olofsson & Lundberg, 1983). In all these studies, however, the experimental groups were selected from a normal population of children. Moreover, in many of the previous studies the control groups were not trained for other language abilities (but see Ball & Blachman, 1991). Therefore, the specific effect of training in phonological awareness may have been confounded with the positive effects that training in general linguistic skills may have on reading acquisition and might have been limited to linguistically well-developed children. In a recent study we rectified these problems, finding that training in segmentation skills significantly improved phonemic segmentation ability in five-year-old children who were initially at the lower end of the distribution of scores on a battery of phonemic segmentation tests (Bentin & Leshem, in press). Moreover, in that study we found that children who had been trained in phonemic segmentation were able to apply their newly acquired metaphonological skills in other tests of phonological awareness.

In conclusion, the presently available evidence suggests that early phonological awareness, i.e., the ability to detect and produce rhymes and the sensitivity to subsyllabic segments, develops differently from phonemic awareness (i.e., the ability to isolate and manipulate individual phonemes in speech). The former appears to emerge almost automatically and instantaneously in the great majority of children when they are first exposed to nursery rhymes or other forms of phonological word games and develops independently of reading instruction. The latter, on the other hand, is triggered in most children when they come to understand the alphabetic principle during the acquisition of reading in an alphabetic orthography. However, phonemic awareness can be also be triggered and full phonemic awareness can be developed in pre-readers by explicit training of phonemic segmentation skills. There is no direct evidence for interdependence between the two forms of phonological awareness. It is conceivable, however, that well-developed awareness of rhymes and subsyllabic segments is necessary for a smooth acquisition of phonemic awareness during reading instruction. In other words, it is possible that a well-developed early phonological awareness is a prerequisite for the emergence of phonemic awareness without explicit instruction. Indirect evidence for this hypothesis is reviewed in the next section.

Reading and phonological awareness: It's a two-way street

Although studying the development of metaphonological skills is important in its own right, the significance of phonological awareness is considerably enhanced by its well-established relationship with the acquisition of reading skills. Many studies have demonstrated that children's performance in various phonological awareness tests highly correlates with their reading skill in the early school grades in English (Bradley & Bryant, 1985; Calfee et al., 1973; Fox & Routh, 1975; Liberman et al., 1977; Rosner & Simon, 1971; Treiman & Baron, 1981; Tunmer & Nesdale, 1986), as well as in other languages such as Italian (Cossu et al., 1988), Swedish (Lundberg, Olofsson, & Wall, 1980), Spanish (de Manrique & Gramigna, 1984), French (Bertelson, 1987), and Hebrew (Bentin & Leshem, in press). Correlative studies were applied in developing tools for predicting success in reading (Blachman, 1984; Juel, Griffith, & Gough, 1986; Lundberg et al., 1980; Mann, 1984; Share, Jorm, MacLean, & Matthews, 1984); however, they tell us very little about the nature of the relationship. A high positive correlation might exist between two independent skills if they are similarly affected by a third factor. On the other hand, it is also possible that the correlation reflects a causal relationship, as, for example, when one skill is a pre-requisite or trigger for the second.

Theoretical considerations suggest that phonological awareness and the acquisition of the alphabetic principle are directly interdependent, and that the positive correlation might reflect mutual influence and even causal relations between these two skills. The alphabet is the latest and probably the most advanced form of writing (DeFrancis, 1989). One of its most important virtues is that, like speech, it uses a relatively small set of well-defined symbols (the letters) that can be combined in a practically infinite number of ways to represent all the possible words in a language. The representation of words by orthographic patterns is efficient only because the basic units of writing, the letters, are mapped onto the basic units of speech, the phones. Thus, words are not represented in writing by arbitrary and holistically distinguished patterns but rather, the combination of letters that represents a particular word is fully determined by the sequence of phonemes of which the word is composed. Hence, in order to understand a written word the reader must be able to decipher the phonological unit from its written form. Even assuming that

a fluent reader may form direct associations between some written patterns and their meanings, and use these associations to access the semantic information directly, the ability to decipher phonology from writing is a prerequisite for reading and understanding written words at the first encounter, and needs to be mastered before efficient reading can occur. This is the essence of the alphabetic principle, and this is the reason why reading and writing require a reasonable awareness of the internal phonological structure of spoken words. (For detailed discussion of these considerations see, for example, Ehri, 1979; Leong, 1986; Liberman, 1989; Liberman & Liberman, 1990; Liberman, Shankweiler, & Liberman, 1989; Rozin & Gleitman, 1977.)

The above account for the reading process implies that, regardless of the particular teaching method adopted by the teacher, in the process of learning to read children learn the basic mapping rules from the domain of letters to the range of phonemes. Obviously, the acquisition of mapping rules requires explicit knowledge of the members of the domain and of the range. The items in the domain (the letters) are explicitly taught by the teacher. On the other hand, the members of the range (the phonemes) are not explicitly taught in the classroom. When children start learning to read they are expected to be aware of the phonological structure of spoken words, or at least to become aware of it very quickly. Indeed, as reviewed in the previous section, most children become aware of the phonemic structure of spoken words fairly easily, as a consequence of exposure to the alphabet, which leads to the understanding of the alphabetic principle. Unfortunately, for a significant proportion of children mere exposure to the alphabet is not sufficient, and they consequently develop a reading disability. Several studies have demonstrated that these children may be helped by explicit training in phonological awareness in parallel to reading acquisition (Perfetti, Beck, Bell, & Hughes, 1987; Wallach & Wallach, 1976; Williams, 1980) or preferably during kindergarten (Ball & Blachman, 1991; Bentin & Leshem, *in press*; Bradley & Bryant, 1983, 1985; Lundberg, Frost, & Peterson, 1988; Vellutino & Scanlon, 1984). A survey of these studies may shed additional light on the metaphonological prerequisites of reading acquisition.

In their initial longitudinal study, Bradley and Bryant (1985) trained four- and five-year-old children to categorize words on the basis of initial sound, and to be aware of that common sound. Some of the children were also given experience with plastic letters. Children in control groups were trained for conceptual categorization or received no training whatsoever. When they reached school, the reading, spelling and mathematical ability of the children in the four groups were compared. The results of these comparisons showed that the children who had been trained to categorize words on the basis of initial phonemes were better in reading and spelling than the children in the control groups, whereas the mathematical skills of all four groups were equal. It was also found that the reading and spelling performance of children who were given experience with plastic letters in addition to phonemic categorization surpassed that of children who were trained only in sound categorization. Finally, a follow-up of this study (Bradley, 1989) revealed that the advantage gained by the experimental groups was maintained five years later: At the age of 13 years, their reading performance was still better than that of the control groups. It is important to note that in this early study the children were trained to make phonemic distinctions, because in more recent publications the Oxford group seems to be convinced that the form of phonological awareness important for reading acquisition is sensitivity to the onset and rime of syllables (Goswami & Bryant, 1990; Maclean et al., 1987).

Although a substantial positive correlation was found between the early phonological awareness and reading acquisition, I doubt that awareness of subsyllabic segments alone is sufficient for understanding the alphabetic principle. First, although several letter-strings frequently appear together (for example *lingl*), many do not. In fact, in reading, as in speech, the distinction among words is frequently based on one letter. Therefore, I am in greater agreement with the following conclusion drawn by the same group: "... a major step in learning to read may take place when the child learns to break the rime into its constituent sounds by detaching ... the preceding vowel from the final consonant" (Kirtley et al., 1989). In fact, there is ample evidence that in training phonemic segmentation facilitates reading acquisition (e.g., Ball & Blachman, 1991; Cunningham, 1988, in press; Lundberg et al., 1988) but not a single study in which training *only* in rhyming skills facilitated reading acquisition. In this context it is interesting to mention our own training study (Bentin & Leshem, in press), because the structure of Hebrew orthography, in which vowels are represented by diacritical marks appended to the consonants (see Frost & Bentin, this volume), would be the ideal orthography to make use of onset and rimes rather than phonemes in reading.

In our study we trained four groups of five-year-old children selected from the lower end of the distribution of scores on a phonemic segmentation test-battery. Group I was trained in phonemic segmentation; group II was trained in phonemic segmentation and also in recognizing letters of the alphabet and relating them to their sound; group III was trained in general linguistic abilities such as vocabulary enhancement, sentence comprehension, etc.; group IV received no training. Training, in groups of four children, lasted for 10 weeks with two 1/2-hour sessions per week. A year later, the reading performance of these children was assessed and compared with the performance of children who were comparable to the four training groups, except for being at the higher end of the distribution of scores of the initial phonemic awareness battery (Group V). The children were tested after four months and nine months of reading instruction. Each test consisted of lists of items that the children were instructed to read aloud. Two lists included words and two lists nonwords. The lists included an equal number of monosyllabic and disyllabic items. Table 1 presents the percentage of correctly read words in each group, for each stimulus type.

As evident in Table 1, reading skills in the first grade were significantly correlated with the phonemic segmentation skills that were assessed in the kindergarten before training, and were influenced by training segmentation skills. Because there are no standardized reading tests in Hebrew (except for reading comprehension) it is difficult to interpret the absolute scores. Note, however, that these tests were constructed in collaboration with the teachers in the respective schools and were designed to reflect the expected level of reading at each testing time. Therefore, it is suggestive to observe that the reading performance of children who were initially low in phonemic awareness and received no training in phonemic segmentation was about 40%, which according to school standards means failure. In contrast, children from the same population who received training and improved their phonemic awareness scored around 70%, almost as well as children who were initially high in phonemic awareness. These data are particularly important because we tested children who learn to read an orthography in which, because of its specific characteristics, the basic segment usually used by teachers for reading instruction is a consonant-vowel combination.

Table 1

Percentage of correctly read items (SEm) of each stimulus type after 4 months and 9 months of reading instruction. Note that different tests were given each time, to correspond with the respective reading level.

STIMULUS TYPE	FIRST READING TEST				
	GROUP I	GROUP II	GROUP III	GROUP IV	GROUP V
WORDS					
One Syllable	85.5 (4.7)	76.7 (8.5)	63.4 (8.5)	59.9 (6.3)	94.5 (2.0)
Two Syllables	72.9 (4.9)	66.1 (7.9)	46.2 (7.8)	46.3 (7.4)	87.1 (3.7)
NONWORDS					
One Syllable	64.7 (7.9)	43.4 (9.7)	26.1 (7.0)	28.3 (8.2)	75.0 (5.2)
Two Syllables	58.4 (7.8)	45.3 (9.7)	25.5 (7.2)	24.4 (8.5)	64.9 (7.7)
SECOND READING TEST					
WORDS					
One Syllable	66.6 (6.0)	70.7 (5.7)	35.2 (6.1)	38.6 (11.)	68.2 (4.8)
Two Syllables	63.9 (5.6)	66.2 (7.8)	21.8 (4.2)	29.6 (10.)	64.4 (4.5)
NONWORDS					
One Syllable	63.4 (6.3)	59.6 (7.7)	27.0 (5.3)	28.8 (11.)	67.4 (6.8)
Two Syllables	52.7 (5.8)	47.5 (9.7)	16.3 (3.5)	19.6 (8.6)	57.5 (7.5)

In conclusion, the evidence relating reading acquisition to phonological awareness is robust. It suggests that the alphabetic principle requires the ability to isolate and manipulate single phonemes in coarticulated speech. The major factor that triggers this ability is exposure to the alphabet. However, phonemic awareness cannot be triggered by the alphabet unless the early form of phonological awareness is well developed. Children who do not meet this prerequisite must be explicitly trained for phonemic segmentation. Our data show that training phonemic segmentation in kindergarten for a relatively short period is effective in inducing the metaphonological skills required for easy acquisition of reading. With younger children, however, or with children who are language-delayed the training program should probably begin with the establishment or improvement of sensitivity to rhymes and the ability to detect the onset and rime of the syllables.

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