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Why Some Children Encounter Reading Problems: The Contribution of Difficulties with Language Processing and Phonological Sophistication to Early Reading Disability

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INTRODUCTORY COMMENTS

Learning to read involves learning to decode a written representation of one's spoken language. Although it is a task which most children accomplish quite readily, it poses a specific difficulty for some 4–10% of children whom we refer to as dyslexic or reading-disabled. Such children tend not to be distinguished from their more successful cohorts by general intelligence, motivation, or prior experience. Yet, something limits their success in learning to read.

Many studies have been directed toward identifying the basis of early reading difficulty, and always they have been implicitly, if not explicitly, guided by certain assumptions as to what skilled reading is "all about." One such assumption, traditionally held by psychologists and educators alike, is that reading is primarily a complex visual skill which places certain demands on differentiation and recognition of visual stimuli. Owing to this assumption, models of skilled reading often have been biased toward clarification of the visual stages of the reading process, and many investigators have sought to blame early reading difficulty on some malfunction in the visual domain. Recently however, visual theo-

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ries of reading disability have reached something of a cul-de-sac, for it seems that, at best, only a few of the children who encounter early reading difficulty suffer from perceptual malfunctions, which somehow prevent recognition, differentiation, or memory of the various orthographic forms (c.f. Rutter, 1978; Stanovich, 1982a; Vellutino, 1979; for recent reviews of these findings).

At present, a more fruitful approach to the problem of early reading disability is being guided by the assumption that reading is, first and foremost, predicated on language skills. In particular, recent research has shown that effectiveness of processes underlying spoken language as well as one's degree of sophistication about phonological structure are critical parameters in successfully learning to read. My goal in what follows will be to elucidate and discuss the consequences of this research and to see how it informs our understanding of specific reading difficulty. I will begin with a review of the requirements of skilled reading, as a way of introducing the role of language skills. From there I will consider some language skills that are essential to beginning reading, and then review findings that link many instances of early reading difficulty to linguistic difficulties. This will be followed by a consideration of the origins of the language deficiencies found among poor beginning readers, and finally, by some concluding remarks about their implications.

DECODING A WRITTEN REPRESENTATION OF SPOKEN LANGUAGE: WHAT SKILLED READING IS "ALL ABOUT"

HOW ORTHOGRAPHIES REPRESENT LANGUAGE

In justifying the assumption that reading is a language skill, the first point to be made concerns the manner in which writing systems, or orthographies, function as symbol systems transcribing spoken language. All orthographies must, somehow, appeal to the reader's intuitive appreciation of the structure of spoken language, as their function is to represent certain units of that language. Yet, individual orthographies may differ in the level of appreciation required, because they can differ in the precise level at which they map onto spoken utterances (Hung & Tzeng, 1981; Liberman, Liberman, Mattingly, & Shankweiler, 1980). Ideographies, for example, represent language at the level of "ideas" (i.e., American Indian petroglyphs), logographies represent words (i.e., Chinese and the Japanese Kanji), and syllabaries represent syllables (i.e.,

Classical Hebrew and the Japanese Kana), whereas alphabets, more or less, represent phonemes (i.e. Spanish, and English).

THE ENGLISH ALPHABET: ITS VIRTUES AND HINDRANCES

The English alphabet does not provide the broad phonetic transcription that Spanish or Serbo-Croatian does. Rather, it provides a morphophonological transcription which represents the word as a sequence of systematic phonemes, although preserving (on the whole) its constituent morphemes (i.e., units of meaning) and underlying phonology. It is distinct from a purely phonetic transcription in that it maps onto a deeper, more abstract level of language. This level corresponds, not so much to the consonants and vowels that speakers and hearers think they pronounce and perceive, as to the way generative phonologists assume that words are abstractly represented in the ideal speaker/hearer's mental dictionary, or lexicon (Chomsky, 1964).

The morphophonological representations of words in the lexicon are systematically related to the phonetic representations underlying pronunciation and perception by an ordered series of phonological rules that alter, insert, or delete segments. As discussed in Liberman *et al.* (1980), an example of the morphophonological nature of transcription by the English alphabet can be found in the way we use *ea* to transcribe the vowels in *heal* and *health*, preserving their abstract morphological and phonological similarity, although blurring certain phonetic distinctions. Insofar as letter sequences stand for morphophonological representations, they can provide a means of access to lexical information, including relevant syntactic and semantic properties. To derive the phonetic representation appropriate to a given letter sequence, the reader need only derive the appropriate morphophonological representation and apply the phonological rules of his language. That is, readers need only apply the very rules that are responsible for the phonetic realization of *heal* and *health* as [hiyl] and [helθ] in normal speech.

This account of the English orthography is, of course, somewhat idealized. Sometimes words are transcribed at a shallower, more phonetic, level than the morphophonological ideal, hence, the different spelling of the vowels in "well" and "wealth." Sometimes, too, the spelling of a word seems neither phonetically nor phonologically principled, such as the spelling of "sword." Certain of these exceptions have the advantage of disambiguating homophones; others are historically based, but their existence does not seriously undermine Chomsky's (1964) claim about the basic operating principle of the English orthography (Liberman *et al.*, 1980).

There are certain virtues to the way in which the English alphabet represents the English language, and they are worth pointing out. These follow from the rule-governed nature of the relation between letter sequences, morphophonological representations, and phonetic representations. Knowledge of these rules allows the reader to access not only the linguistic representations of highly familiar words, but also those of less familiar ones, and even those of words never before seen in print. Whereas a skilled reader of a logography must have memorized thousands of distinct characters, and even then may encounter difficulty in reading a new word, a skilled reader of English need know only a limited set of phoneme-to-grapheme correspondences and the phonological rules of his spoken language to read any word (or phonologically plausible nonword) on the page. Armed with this basic knowledge, English readers can gain access to extant lexical information through recovery of the morphophonological representation which a string of letters transcribes. They can also derive the phonetic representation needed to read the word aloud (and to temporarily remember the word, as will be discussed later). Finally, they can even build their vocabulary by forming lexical representations for words they have never seen or heard before—a feat which is not possible in logographies, for example, where no systematic analytic code binds orthographic forms to the morphophonological representations which are stored in the mental lexicon.

But all of this comes at a certain cost, which brings me to the hindrances of the English alphabet and alphabets in general. Obviously, successful use of the English orthography demands phonological maturity in the form of tacit knowledge both of the representation of words in the lexicon, and of the phonological rules which relate morphophonological representations to phonetic ones. A comparable level of phonological maturity would not be so critical to the would-be reader of a logography, for example, since decoding logographies does not require application of phonological rules. In addition, alphabetic transcription requires that skilled readers of English go one step further than merely possessing tacit knowledge of phonology: they must achieve a degree of "liguistic awareness" (Mattingly, 1972). That is, would-be readers of English must access their tacit knowledge of phonemes, morphemes, and phonological rules and apply that knowledge in a fashion not required for spoken language. Unless such phonological sophistication is achieved, an alphabet will make no sense as a transcription of utterances and its virtues will remain unrealized (Mattingly, 1972; Liberman *et al.*, 1980). This is not the case for syllabaries, which have the virtue over alphabets in requiring a less fine-grained level of sophistication, and this

is even more true of logographies. Thus, the former demand only an awareness of words, syllables, and certain phonological rules (such as the rules that determine vowel identity in Hebrew, and the rule in Japanese which makes "suki" sound like "ski"), whereas the latter demand only an awareness of words.

WHAT CHARACTERIZES A SKILLED READER?

Let me now put aside these theoretical assertions about the pertinence of phonological sophistication to the reading of words in alphabetically represented languages like English, to consider briefly some experimental evidence about the role of linguistic processes in the skilled reading of words, sentences, and paragraphs.

THE PERTINENCE OF LANGUAGE SKILLS TO LEXICAL ACCESS

The question of whether speech recoding mediates lexical access from print has preoccupied much research on the psychology of skilled reading (see Crowder, 1982; McCusker, Bias, & Hillinger, 1981; Perfetti & McCutchen, 1982, for recent reviews of the role of speech coding in the process of word perception). Some researchers offer a negative answer, based on findings that some high-frequency words may be perceived as visual units, instead of being analyzed into their separate phonetic constituents prior to lexical access. Other evidence has been interpreted as implicating some phonetic mediation in lexical access, and many psychologists now favor "dual access" models in which both phonetic and visual access occur in parallel. In any event, regardless of how the lexicon is accessed, it is, at base, the morphophonological representation of a word in the lexicon that is being accessed, and with it, the word's semantic extensions and syntactic properties. Phonetic recoding of orthographic material may not be necessary to gain lexical access from print, nor even be feasible if we accept Chomsky's (1964) contention, but morphophonological recoding clearly must occur, else lexical access is a vacuous concept.

THE PERTINENCE OF LANGUAGE SKILLS TO READING SENTENCES AND PARAGRAPHS

From the point of lexical access onward, the involvement of speech processes in reading is clear (Perfetti & McCutchen, 1982). First, much evidence attests that temporary memory for such orthographic material as isolated letters, printed nonsense syllables, and printed words in-

volves recoding the material into some kind of "silent speech," or phonetic representation. Both the nature of the errors that subjects make in recalling such material and the experimental manipulations that penalize their memory performance lend support to this conclusion (c.f. Baddeley, 1978; Conrad, 1964, 1972; Drenowski, 1980; Levy, 1977). More importantly, subjects also appear to rely on phonetic representation when they are required to comprehend sentences written in either alphabetic (Kleiman, 1975; Levy, 1977; Slowiaczek & Clifton, 1980) or logographic orthographies (Tzeng, Hung, and Wang, 1977). This is because, regardless of the way in which the orthography allows lexical access, the post-lexical processes involved in reading sentences and paragraphs place certain obvious demands on temporary memory, and temporary memory for language appears to capitalize on phonetic representation. Furthermore, it appears that reading shares not only the temporary-memory system, but also the parsing system that supports recovery of the syntactic structure of spoken language and allows comprehension of spoken discourse. This is obviated by the significantly high correlations found between reading and listening comprehension across a variety of languages and orthographies, including English (c.f. Curtis, 1980; Daneman & Carpenter, 1980; Jackson & McClelland, 1979), and Japanese and Chinese as well (Stevenson, Stiegler, Lucker, Hsu, & Kitamura, 1982).

In summary, then, skilled reading of the English orthography is supported by two linguistic skills: sophistication about phonological structure, and the adequacy of certain processes which are integral to spoken-language comprehension. That is, skilled reading is a derived language skill, of sorts. Recognition of this fact can now set the stage for the subsequent sections of this essay, which comprise a consideration of the role of language-processing skills and phonological knowledge in beginning reading, and a review of experimental findings which suggest that certain such skills tend to be deficient among many children who encounter difficulty in learning to read.

THE IMPORTANCE OF LANGUAGE SKILLS FOR BEGINNING READING

Obviously, beginning readers need to possess the visual skills which allow them to differentiate and remember the various letter shapes. Yet, they also need to be able to perceive and recognize spoken words and to combine them into phrases, sentences, and paragraphs. Without spoken English, there would be nothing for the English orthography to transcribe; the well-known difficulties of deaf readers attest to the importance of spoken-language skills for successful reading.

LANGUAGE PROCESSING SKILLS ESSENTIAL TO WOULD-BE READERS

Beginning readers should possess language-processing skills at five different levels. First of all, they should be capable of distinguishing the phonemes of their language, so that they can hear the difference between "cat" and "hat," for example. They also need to have a mental lexicon, although they need not necessarily possess mature morphophonological representations in their lexicons, given some evidence that the experience of reading, in and of itself, serves to stimulate and further phonological development (Moskowitz, 1973; Read, 1975). Beginning readers also should have an adequate means of storing language in temporary (short-term) memory, as this both supports retention of sufficient words to understand sentences and paragraphs, and may have a significant impact on the learning of syntax (Daneman & Case, 1981). Further, they should be able to recover the syntactic structure of phrases and sentences, although their mastery of syntax, like their mastery of phonology, may be facilitated by the experience of reading, in and of itself (Goldman, 1976). Finally, it goes without saying that beginning readers need to have a grasp of the semantics of language, so that they can understand what words and sentences mean.

PHONOLOGICAL SOPHISTICATION SKILLS ESSENTIAL TO WOULD-BE READERS

Such language-processing skills, however, are not sufficient. The nature of the English orthography, as explained above, necessitates that successful readers not only be able to process spoken language, but also be conscious of certain abstract units of that language—words, syllables, and especially, phonemes. Otherwise, the alphabet will make no sense as a transcription of their spoken language. But there is the special catch to learning to read an alphabetic orthography that was noted above: Whereas sophistication about words is sufficient for learning a logography, and sophistication about words and syllables is sufficient for syllabaries, children must know about these units and also about phonemes if the alphabet is to make sense and if they are to derive its full advantages.

Phonemes, however, are more abstract units than either words or syllables. Reflexively and unconsciously, we perceive them when we listen to the speech stream, because we have a neurophysiology uniquely and elegantly adapted to that purpose (cf. A. M. Liberman, 1982, Mann & Liberman, 1984). Yet, phonemes cannot be mechanically isolated from each other, or produced in isolation (Liberman, Cooper,

Shankweiler, & Studdert-Kennedy, 1967) as can syllables and words. In a tacit sense, of course, infants may distinguish phonemes (see Miller & Eimas, 1983, for a recent review of the speech-perception capabilities of infant listeners) and preschool-aged children may employ phonetic representation when holding linguistic material in short-term memory (Alegria & Pignot, 1979; Eimas 1975). But successful beginning readers must not only distinguish words such as "cat" and "hat," and be capable of holding them in memory, they must further possess the linguistic sophistication which allows them to cognize that, among other things, these words differ in one phoneme, namely the first, and share a final phoneme which is the initial one in "top." Otherwise, the alphabet will remain a mystery to them, and its virtues unrealized.

This is not to imply that there is anything inherently undesirable about reading a syllabary or logography. Ultimately, the utility of a given orthography rests upon the nature of the spoken language it transcribes. For example, a logography is appropriate for Chinese because it is independent of profound dialect differences and allows people who cannot understand each other's speech to read the same text. Likewise, for Japanese, the Kana syllabaries are quite utilitarian, given that there are only 100 or so syllables in the Japanese language. English, however, has less profound dialectical variation than Chinese, and employs more than 10 times as many syllables as Japanese. Hence, an alphabet is appropriate, and it would be a disservice to present the English writing system otherwise. Yet, to present it in its true light requires that the would-be reader possess both language-processing skills and phonological sophistication.

THE PROBLEM OF SPECIFIC READING DIFFICULTY

It has been suggested that the use of alphabetic transcriptions for Indo-European languages is particularly adaptive to man's cognitive and linguistic abilities, and that it is responsible for making the skills of reading and writing more widely available in Western civilization (Russell, 1982a). Nonetheless, for a minority of children (the 4–10% alluded to previously) learning to read the English alphabet presents something of an obstacle. What limits these children's success in learning to read, what factors distinguish them from those children who readily become skilled readers? Let me now turn to these issues.

As noted by Rutter (1978), learning to read is a specific example of a complex learning task which correlates about 0.6 with IQ. Yet, a low IQ

cannot be the sole basis of reading problems, as there are children who are backward in reading ability but average in intelligence (Rutter & Yule, 1973). Such children are said to have a specific reading difficulty, as their actual reading ability lags between 1–2 years behind that predicted on the basis of their age, IQ, and social standing. They will be the focus of this review.

SOME FACTORS WHICH DO NOT OFTEN CAUSE SPECIFIC READING DIFFICULTY

As noted above, there is good evidence that deficient visuospatial skills are not very important determinants of specific reading difficulty. Let me briefly mention two pieces of supporting evidence. First, 5–6-year-old children identified as having deficient visual perception and/or visuomotor coordination skills show no more instances of reading difficulty at age 8–9 than do matched controls who possess no such deficits (Robinson & Schwartz, 1973). Second, although it is true that all young children tend to confuse spatially reversible letters such as *b, d, p, g* until they are 7 or 8 years old (Gibson, Gibson, Pick, & Osser, 1962), letter and sequence reversals actually account for only a small proportion of the reading errors made by children in this age range (Shankweiler & Liberman, 1972). Even children who have been formally diagnosed as dyslexic make relatively few letter- and sequence-reversal errors (Fisher, Liberman, & Shankweiler, 1977).

It is also unlikely that a problem with cross-modal integration of visual and auditory information is a basis of reading failure. Difficulties with cross-modal integration were once thought to cause reading difficulty because of findings that poor readers do less well than controls on tasks that required the matching of a temporal sequence of auditory taps to a spatial sequence of visual dots (Birch & Belmont, 1964; see reviews by Benton, 1975; Rutter & Yule, 1973). However, others have since then shown that poor readers have difficulty with perceptual discrimination and temporal/spatial integration of sequences within a given sensory modality (c.f. Blank, Weider, & Bridger, 1968; Bryden, 1972) which calls for a more general explanation. To account for these additional findings, several psychologists (c.f. Rutter, 1978; Vellutino, 1979) have suggested that the problem is not so much with cross-modal integration as with perceptual linking, perhaps owing to a difficulty in verbal coding. This possibility, that verbal coding is problematic for poor readers, is well supported in the literature, and will be discussed in a later section.

An inadequate short-term memory for all types of material, both linguistic and nonlinguistic, also has been cited as the cause of early read-

ing problems (Morrison, Giordani, & Nagy, 1977), as has inadequate short-term retention of the order of items in a series (Corkin, 1974). Hypotheses of this variety are, perhaps, too general, for they cannot account for some other findings that good and poor readers do not differ on all tasks which require temporary memory of items or their order. Good and poor beginning readers are equivalent, for example, in ability to remember faces (Liberman, Mann, Shankweiler, & Werfelman, 1982) or visual stimuli which cannot readily be assigned verbal labels (Katz, Shankweiler, & Liberman, 1981; Liberman *et al.*, 1982; Swanson, 1978). Only when the to-be-remembered stimuli can be linguistically coded do children who are poor readers consistently fail to do as well as good readers (Liberman *et al.*, 1982; Katz *et al.*, 1981; Swanson, 1978).

Various other general accounts of reading disability have been offered in the literature (see, for example, Carr, 1981, for a review), but they also fail to explain why poor readers often do as well as good readers on nonliguistic tasks, but consistently lag behind good readers in performance on many linguistic tasks. (For recent reviews, see Mann, 1984a; Stanovich, 1982a; Vellutino, 1979.) For the sake of brevity, such general accounts will not be discussed here.

INADEQUATE LANGUAGE SKILLS ARE OFTEN ASSOCIATED WITH READING DIFFICULTY

The importance of deficient language skills to early reading difficulty is evident when one considers the variety of studies which demonstrate the ability of certain linguistic tasks, as opposed to the failure of comparable nonlinguistic ones, to distinguish good and poor beginning readers (see, for example, Brady, Shankweiler, & Mann, 1983; Katz *et al.*, 1981; Liberman *et al.*, 1982; Mann & Liberman, 1984; Swanson, 1978). It is further evident when one considers, as did Rutter (1978), the frequency of reading difficulties in children with various sorts of handicaps. Whereas children deficient in visual-perceptual and/or visual-motor skills do not encounter reading difficulty any more frequently than matched controls (Money, 1973; Robinson & Schwartz, 1973), speech and language-retarded children encounter reading problems at least six times more often than do controls (Ingram, Mason, & Blackburn, 1970, 1976).

Considered broadly, the language disabilities that tend to be found among children who are poor readers fall within the two categories introduced in previous sections: language processing and phonological

sophistication. Before considering each category, however, it is important to mention the issue of whether reading disability involves a single common deficit, or a family of subsyndromes. Certainly, this issue is a real one which many investigators have considered in some detail (see, for example, Carr, 1981; Ellis, 1985; Jorm, 1979; Vernon, 1979). Nonetheless, as Stanovitch (1982a) has noted, progress in science must first come through the search for unity in the face of diversity. At this time, we are still making progress towards discovering that, as a population, poor readers tend to be deficient in a variety of language skills. The question of whether the population of children with specific reading difficulty is homogeneous or heterogeneous in its profile of language difficulties cannot yet be resolved.

THE RELATION BETWEEN READING DIFFICULTY AND DIFFICULTIES WITH LANGUAGE PROCESSING

The past decade has witnessed considerable interest in the psychology of early reading problems. In it, study after study has uncovered some link between early difficulties in learning to read and difficulties with some aspect of spoken-language processing. Such a link is clearly established beyond question, not only in English (cf. Mann, 1984a), but in Swedish (Lundberg, Oloffson, & Wall, 1980), and in Japanese and Chinese as well (Stevenson *et al.*, 1982). In the case of English, there also have been considerable attempts to more precisely specify the nature of the language problems that typify poor-beginning readers. For example, it has been asked whether the nature of the language problem is a general one, encompassing all levels of language processing, as opposed to being specifically confined to certain levels of processing. Let me address this issue after considering, in turn, each of the five levels of language processing that were identified in an earlier section as being important to beginning reading: phonetic perception, the mental lexicon, phonetic short-term memory, syntax, and semantics.

PHONETIC PERCEPTION

With regard to this initial level of processing, some of my colleagues and I (Brady *et al.*, 1983) recently discovered that a group of poor readers in the third grade who did not differ from the good readers of their classrooms in age, IQ, audiometry scores, or ability to identify either clearly recorded or noise-masked environmental sounds were none-

theless deficient in the ability to identify noise-masked, spoken words. As long as the words were not masked by noise, the good and poor readers performed equivalently, implying that, as other research has suggested (Goetzinger, Dirks, & Baer, 1960), the speech perception difficulties of poor readers are most evident when speech perception is stressed. One potential explanation of these results is that the problem for the poor readers lies not in the initial encoding of phonetic information so much as in stages of lexical access. For example, poor readers might have a less extensive vocabulary, and hence, be less successful at identifying less familiar words. We may discard such an explanation, however, because the perceptual difficulties of those subjects studies by Brady *et al.* (1983) occurred for frequent and infrequent words alike. Thus, a more likely explanation is that poor readers possess some subtle, quite specific, difficulty with speech perception (Brady *et al.*, 1983).

Another suggestion to this effect comes from studies which compare the categorical perception of synthetic speech stimuli by good- and poor-beginning readers. In such studies, categorical perception was evident in both groups of subjects, yet the poor readers differed from the good readers either in failing to meet the level of intercategory discrimination predicted on the basis of their identification responses (Brandt & Rosen, 1980) or in failing to give as consistent identification responses (Godfrey, Syrdal-Lasky, Millay, & Knox, 1981). These findings have been interpreted as the reflection of deficient speech-perception processes on the part of poor readers. However, it is important to note that they, and the results obtained by Brady *et al.* (1983), could also reflect deficient phonetic-memory processes, as memory plays an obvious role in discrimination, and in many identification tasks.

THE MENTAL LEXICON

As noted, the findings of Brady *et al.* (1983) do not suggest an inferior vocabulary on the part of poor readers. Indeed, recognition vocabulary, in and of itself, is not a very significant associate of early reading ability (Mann & Liberman, in press). Certain findings, however, involving production vocabulary do suggest that aspects of the mental lexicon may, nonetheless, be deficient among poor readers. Specifically, the speed of object-naming is slower among poor readers, and poor readers tend to make more naming errors than good readers do (see, for example, Denckla & Rudel, 1976; Katz, 1982).

In a very interesting study, Katz (1982) recently reported that poor readers are particularly prone to difficulties in producing low-frequency

and polysyllabic names, and suggested that, for such words, these children may possess less phonologically complete lexical representations than good readers do. On the basis of his research, he further suggests that, because poor readers often have access to aspects of the correct phonological representation of a word even though they are unable to produce that word correctly, their problem may be attributable to phonological deficiencies in the structure of the lexicon rather than to the process of lexical access, per se.

PHONETIC SHORT-TERM MEMORY

Questions concerning deficiencies in linguistic short-term memory have given rise to one of the more fruitful lines of research in the field. It often has been noted that poor readers tend to be deficient in ordered recall of strings of nameable objects, letters, digits, nonsense syllables, or words, whether the stimuli are presented by ear or by eye. They also fail to recall the words of spoken sentences as accurately as good readers (see Jorm, 1979; Mann, 1984a; Mann, Liberman, & Shankweiler, 1980; Torgesen & Houck, 1980, for references to these effects). Normally, such linguistic materials as these are held in short-term memory through use of phonetic representation. Hence, it was suggested by Shankweiler, Liberman, Mark, Fowler, & Fisher (1979) that the linguistic short-term memory difficulties of poor readers might reflect a problem with using phonetic representation.

Several experiments have supported this hypothesis by showing that in recall of letter strings (Shankweiler *et al.*, 1979), word strings (Mann *et al.*, 1980; Mann & Liberman, 1984), and sentences (Mann *et al.*, 1980), poor readers are less affected than good readers by a manipulation of phonetic confusability (i.e., rhyme), which hinders use of phonetic representation. Indeed, good readers can be made to appear as poor readers in the face of this penalizing manipulation, which has led to the postulation that poor readers are, for some reason, less effective in their use of phonetic representation under normal circumstances (Mann *et al.*, 1980; Shankweiler *et al.*, 1979). Further evidence that phonetic representation in short-term memory is a specific problem for poor readers accrues from studies of the errors that poor readers make when attempting to recall or recognize spoken words (Byrne & Shea, 1979; Brady *et al.*, 1983.) Support also comes from the finding that differences between good and poor readers in the use of phonetic representation can precede the attainment of reading ability, and may actually serve to presage future reading problems (Mann, 1984b; Mann & Liberman, 1984).

SYNTAX

One possible outcome of a difficulty with phonetic representation in short-term memory is a difficulty with comprehension of sentences whose processing somehow stresses short-term memory. This recently has been shown to be the case in a study (Mann, Shankweiler, & Smith, 1984) which finds that good and poor readers differ in both the ability to repeat and to comprehend spoken sentences which contain relative clauses. Other indications that poor readers have a deficit grasp of the easy/eager distinction (Byrne, 1981), the promise/tell distinction (Goldman, 1976), and the double-object construction (Fletcher, Satz, & Scholes, 1981) raise the possibility that poor readers might also be deficient in syntactic processes, above and beyond their problems with short-term memory. Research by my colleagues and myself does not suggest that poor readers have any difficulty with syntactic structure above and beyond the difficulties brought about by their memory constraint (Mann, 1984b; Mann *et al.*, 1984). Byrne (1981), however, has interpreted his research as suggesting otherwise, although Goldman (1976) is correct in noting that such syntactic differences as have been reported among good and poor readers could be either the cause of reading difficulty or a consequence of different amounts of reading experience. At present, the issue of whether poor readers are deficient in syntactic skills is far from resolved, and will have to await further research. Such deficits as do exist are relatively subtle, with poor readers merely performing like somewhat younger children than the good readers.

SEMANTICS

As for the question of semantic impairments among poor readers, here, at least, there is no reason to presume any real deviance exists. If anything, poor readers place greater reliance on semantic context and semantic representation than do good readers, perhaps in compensation for their other language difficulties (see Stanovitch, 1982b, for a recent review, and also see Byrne & Shea, 1979; Simpson, Lorsbach, & Whitehouse, 1983, but see Vellutino & Scanlon, 1985, for an opposing view.)

A GENERAL IMPAIRMENT?

To summarize, then, phonetic perception, phonological aspects of lexical structure, and phonetic representation in short-term memory all tend to be deficient among many reading-disabled children. Correlations among such behaviors as speed of naming and digit span (Spring,

1976; Torgesen & Houck, 1980) also have been noted, and these, together with the logical interrelation between phonetic perception, morphophonological representation in the mental lexicon, and post-lexical phonetic representation in short-term memory, could suggest that poor readers have a pervasive difficulty with phonological processes. One could even entertain the possibility that all of the phonological difficulties of poor readers derive from an initial problem with phonetic perception (Brady *et al.*, 1983).

Aside from their difficulties in the domain of phonological processing, poor readers may also possess a specific difficulty with syntactic structure—although the data are equivocal in this regard—and it could well be the case that what appear to be syntactic deficiencies are really second-order consequences of either phonological difficulties or a lack of reading experience. In any event, however, semantic processes do not appear to be deficient among disabled beginning readers; it is, therefore, unlikely that reading disability is associated with a generalized language impairment. At most, the impairment would seem to involve the more formal phonological and syntactic aspects of language processing.

THE RELATION BETWEEN READING DIFFICULTY AND DEFICIENT PHONOLOGICAL SOPHISTICATION

Let me put aside the issue of deficient language processing to consider some of the evidence which suggests that deficient linguistic sophistication is also a factor in reading difficulty. Possessing adequate phonetic perception and short-term memory skills, an adequate mental lexicon, and the ability to recover the syntactic and semantic structure of utterances is only part of the requirement of reading success. Successful readers of the alphabet must go beyond these tacit language-processing abilities to achieve a degree of phonological sophistication; they must become explicitly aware of the phonological units of their language and of the phonological rules that relate lexical representations to phonetic representations. Thus, this section turns to studies concerned with the pertinence of phonological sophistication to success in learning to read an alphabetic orthography.

EVIDENCE FROM THE ANALYSIS OF READING ERRORS

Considerable evidence that deficient phonological sophistication is responsible for making beginning reading difficult can be found in the

nature of the oral reading errors made by all young children (Shankweiler & Liberman, 1972), including dyslexics (Fisher *et al.*, 1977). As noted earlier, these errors do not tend to involve visual confusions such as letter or sequence reversals to any appreciable degree. What they do appear to reflect is a problem with integrating the phonological information that letter sequences convey. Hence, children often tend to be correct as to the pronunciation of the first letter in a word, but have more and more difficulty with subsequent letters, and a particular problem with vowels as opposed to consonants. For more detailed presentation of these findings and their implications, the reader is referred to papers by Shankweiler and Liberman (1972) and Fisher *et al.* (1977), and also to a paper by Russell (1982b) that suggests that deficient phonological sophistication may account for the reading difficulties of adult dyslexics.

EVIDENCE FROM TASKS WHICH MEASURE PHONOLOGICAL SOPHISTICATION DIRECTLY

There is also considerable evidence that early reading skill is related to performance on tasks that measure phonological awareness directly. Phonological sophistication develops later than phonetic perception and the use of phonetic representation. For example, in a sample of 4-, 5-, and 6-year-olds studied by Liberman, Shankweiler, Fisher, and Carter (1974, none of the nursery school children could identify the number of phonemes in a spoken word, whereas half of them managed to identify the number of syllables. Only 17% of the kindergartners could count phonemes, whereas, again, about half could count syllables. At 6, 90% of the children could segment by syllable, and 70% were able to segment by phoneme. From such findings, it is clear that linguistic sophistication develops considerably between the ages of 4 and 6. It is also clear that awareness of phonemes is slower to develop than awareness of syllables. Finally, both types of awareness markedly improve at just the age when children are learning to read (Liberman *et al.*, 1974).

Numerous experiments involving widely diverse subjects, school systems, and measurement devices have shown a strong, positive correlation between a lack of awareness about phonemes, and current problems in reading (see, for example, Alegria, Pignot, & Morais, 1982; Fox & Routh, 1976; Lundberg *et al.*, 1980; Liberman *et al.*, 1980; Perfetti, Beck, & Hughes, 1981). There is also evidence that lack of awareness about syllables is associated with reading disability (Katz, 1982). Finally, studies of kindergarten children provide evidence that problems with phoneme segmentation (see, for example, Blachman, 1980; Helfgott, 1976;

Mann, 1984b; Stanovich, Cunningham & Cramer, 1984) and syllable segmentation (Mann & Liberman, 1984) can presage future reading difficulty. For example, 85% of a population of kindergarten children who went on to become good readers in the first grade correctly counted the number of syllables in spoken words, whereas only 17% of the future poor readers could do so (Liberman *et al.*, 1974).

SOME POSSIBLE ORIGINS OF DEFICIENT LANGUAGE SKILLS

Having reviewed some, though certainly not all, of the many findings which link reading difficulty to problems with language skills, let me turn to consideration of a related line of research which concerns the basis of these problems. There are both theoretical and practical matters at stake in such research, for it may provide insight into the psychology of written and spoken language development, while pointing to effective remedies for reading difficulty.

ORIGINS OF PROBLEMS WITH LINGUISTIC PROCESSING

As Rutter and Madge (1976) have noted, low socioeconomic status and large family size tend to be associated with low verbal intelligence and poor reading. In discussing their findings about "cycles of disadvantage," these investigators note that both genetic and environmental influences are to be held responsible. However, for the most part, those formal explanations of the language-processing problems found among poor-beginning readers that have appeared in the literature have been concerned with genetic antecedents.

That reading problems and language problems do tend to run in certain families was first noted by Thomas (1905), and has received considerable attention in recent literature (see, for example, Owen, 1978; Owen Adams, Forrest, Stolz, & Fischer, 1971; Rutter, 1978; Smith and Pennington, 1983). This, of course, suggests the possibility of a biological basis. Perhaps, the first such explanation was offered by Orton (1937) in his now-famous theory of strephosymbolia. In that theory, mirror reversals, which Orton erroneously thought to be the predominant symptom of reading disability, were attributed to insufficiently developed cerebral dominance. This insufficiency further manifested itself, according to Orton, in such abnormalities of lateral preference as mixed dominance.

Orton's (1937) theory has given rise to considerable research. On the

one hand, it has been falsified by findings that reading difficulty is not associated with any particular pattern of handedness, eyedness, or footedness (see Rutter, 1978, for a review). It also has motivated a number of studies of cerebral lateralization for language processing among good and poor readers, with mixed results. Some studies have provided evidence that poor readers show a reversal of the normal anatomical asymmetries between the left and right hemispheres, in conjunction with a lower verbal IQ (Hier, LeMay, Rosenberger, & Perlo, 1978). Others have reported that poor readers may show a lack of cerebral dominance for language processing (Keefe & Swinney, 1979; Zurif & Carson, 1970). But there can, at best, be only a weak association between abnormal lateralization and poor reading, as not all of the individuals who display abnormal cerebral lateralization are poor readers (Hier *et al.*, 1978). It must also be recognized that several other studies have failed to find that good and poor readers differ in the extent or direction of the lateralization for language processing (Fennel, Satz, & Morris, 1983; McKeever & van Deventer, 1975; Witelson, 1977). Recently, it has been suggested that most differences between the performance of normal and disabled readers on dichotic listening tasks, which are the most-often-used tests of cerebral lateralization, may reflect the known memory difficulties of disabled readers (Watson & Engle, 1982). Only those dichotic listening tasks which stress short-term memory tend to reveal differences between good and poor readers, perhaps, because they cause the poor readers to perform at a floor level of accuracy which does not permit the expected left hemisphere advantage to emerge.

All in all, the data are not particularly supportive of Orton's (1937) thesis about incomplete cerebral dominance as the explanation of reading difficulty. Yet, Orton may still have been correct in the spirit, if not the letter, of his explanation. If we accept the left hemisphere to be the mediator of language processing (in the majority of individuals), and if we accept that language processes are deficient among poor readers, then certainly, we may suppose that some anatomical or neurochemical abnormality of the left hemisphere is implicated in early reading difficulty. But thus far, we have no reason to view this difference as the result of incomplete dominance.

A more adequate biological theory of poor readers' language difficulties involves the concept of a maturational lag (see, for example, Fletcher *et al.*, 1981; Satz & Sparrow, 1970) which may be specific to language development (Byrne, 1981; Mann & Liberman, in press). Maturational lag has been offered to explain the speech-perception difficulties of poor readers (Brandt & Rosen, 1980), their problems with phonetic represen-

tation in temporary memory (Mann & Liberman, 1984; Watson and Engle, 1982), and their sentence comprehension problems (Byrne, 1981; Mann *et al.*, in press). It has the virtue of providing a ready explanation for one of the more common findings in the field, namely, that the performance of poor readers never really deviates from that of good readers, but merely involves more of the kinds of errors typical of slightly younger children (Mann *et al.*, 1984).

Maturational-lag theories also are consistent with some other observations about the population of poor readers. First, there is the observation that boys encounter reading problems more often than girls (Liberman & Mann, 1980; Rutter & Yule, 1973). It is well known that boys mature less rapidly than girls do. It also has been shown that a slower rate of physical maturation tends to be associated with a pattern of mental abilities in which spatial processing skills are superior to language (Waber, 1977). Given these observations, one should, indeed, expect to find that, among children at a given age, there should be disproportionately many boys with lesser language skills, and therefore, disproportionately many boys who encounter reading difficulty. A second observation which may be explained by maturational lag is that children with low birth weight are at risk for reading problems (Rutter & Yule, 1973). Low birth weight often reflects a premature birth, and prematurely born infants may reach the first milestones of language development relatively later in postgestational life than do those infants born at full term (Gleitman, 1981). Hence, they show a lag in language development and might be expected to encounter reading problems.

The primary difficulty with the concept of maturational lag is that it cannot, as yet, explain why only certain language difficulties tend to be found among poor readers. Perhaps, we might want to conceive of a maturational lag in phonological processes, given the findings summarized earlier. Another problem with maturational-lag theories is that the language-processing difficulties of poor readers can persist past early childhood to adolescence (McKeever & van Deventer, 1975) and beyond (Jackson & McClelland, 1979). That is, the language-processing skills of poor readers may never really "catch up" to those of good readers. Perhaps, the concept of a lag in development will need to be refined to allow for the possibility that language development in poor readers reaches a premature plateau. In any event, such problems are not insurmountable, and the possibility that reading difficulty involves a specific maturational lag in the development of language-processing skills is a most intriguing one which should spark considerable research in the coming decade.

ORIGINS OF DEFICIENT PHONOLOGICAL SOPHISTICATION

In discussing the origins of deficient linguistic sophistication, it should be noted that such deficiencies tend to correlate, somewhat, with deficient language-processing skills (Mann & Liberman, 1984). Thus, to the extent that a maturational lag may explain deficient processing skills, it may help to explain deficient linguistic sophistication as well. However, the correlation is less than perfect, leaving room for the possibility that the two syndromes are independent. Certainly, it is logical to think that children who are deficient in processing skills might also lack linguistic sophistication, as the latter probably presumes the former. However, there may be some children who possess normal processing skills, but lack linguistic sophistication.

In considering the basis of deficient phonological awareness, let me begin by noting the spurt in phonological awareness that occurs at age 6 (Liberman *et al.*, 1974). Phonological awareness is a cognitive skill of sorts, and, as such, must surely demand the attainment of a certain degree of intellectual maturity. Yet, 6 is the age at which most children in America begin to receive instruction in reading and writing, and there is reason to suspect that not only may phonological awareness be important for the acquisition of reading, but being taught to read may, at the same time, help to develop phonological awareness (see, for example, Alegria *et al.*, 1982; Liberman *et al.*, 1980; Morais, Carey, Alegria, & Bertelson, 1979).

The strongest evidence that phonological awareness is facilitated by reading instruction concerns awareness about phonemes. For example, it has been reported that illiterate adults are unable to manipulate the phonetic structure of spoken words (Morais *et al.*, 1979). Another study, conducted in Belgium, reveals that first-graders taught largely by a phonics method did spectacularly better on a task requiring phoneme segmentation than did other children taught largely by a whole-word method (Alegria *et al.*, 1982). Another longitudinal study of first-graders in America reveals that there is a reciprocal causal relationship between phoneme awareness and reading skill (Perfetti *et al.*, 1981). All in all, it seems that awareness of phonemes is enhanced by methods of reading instruction that direct the child's attention to the phonetic structure of words, and even may depend on such instruction.

However, experience alone cannot be the only factor behind some childrens' failure to achieve phoneme awareness. This is aptly shown by a finding that among a group of 6-year-old skilled readers and 10-year-old disabled readers who were matched for reading ability, the disabled readers performed significantly worse on a phoneme awareness task,

even though they would be expected to have had more reading instruction than the younger children (Bradley & Bryant, 1978). Here, it could be argued that some constitutional factor limited the disabled readers' ability to profit from instruction, and thus limited their attainment of phonological sophistication.

The possibility that a constitutional factor underlies the development of phonological awareness also is consistent with findings about the development of syllable segmentation. Both our work (Liberman *et al.*, 1974; Mann, 1984b; Mann & Liberman, 1984), and that of others (Alegria *et al.*, 1982) suggests that awareness of syllable-sized units can be expected to precede awareness of phoneme-sized units, and is probably a natural cognitive achievement that does not necessarily depend on reading instruction for its development. Most children can manipulate the syllables of an utterance by the time they are 6 years old; moreover, their ability to do so apparently is less influenced by the particular method of reading instruction (Alegria *et al.*, 1982). We might, therefore, return to the possibility of a maturational lag in language development as a constitutional factor responsible for some children's failure to develop phonological awareness despite favorable experience.

CONCLUDING REMARKS

This chapter has proceeded from a consideration of the importance of language skills to both skilled and beginning reading, to a review of evidence that deficient language-processing skills and deficient linguistic awareness are important factors in early reading disability, to a discussion of the possible origins of these deficiencies. One of the practical benefits of the research described herein is that it can suggest ways of presaging and remediating early reading difficulty. By way of a conclusion, let me make some of those benefits explicit.

One obvious benefit concerns screening devices for identifying children at risk for early reading problems. Such phonological processing skills as the ability to rapidly access the names of objects and the ability to make effective use of phonetic representation in short-term memory have already been shown to be effective kindergarten predictors of first-grade reading success (see, for example, Blachman, 1980; Mann, 1984b; Mann & Liberman, 1984). The time to refine such tests for larger-scale use is now upon us. Likewise, tests of phoneme and syllable awareness can presage reading success (Liberman *et al.*, 1974; Mann, 1984b; Mann & Liberman, 1984; Stanovich *et al.*, 1984), and they, too, should be refined for practical application.

Another benefit: Identifying the linguistic problems associated with specific reading difficulty may help to point the way to effective procedures for remediation. For example, if a maturational lag in language development is the cause of reading difficulty, then, perhaps, we should attempt to identify children at risk for such a lag, and consider the delay of beginning reading instruction until a time when language skills will be more optimal. We might also want to take seriously the possibility that environmental enrichment can mitigate the extent of these children's language difficulties, and pursue research to that effect. In any event, if it is accepted that reading difficulty can involve a specific lag in language development, as opposed to slower development in general, then, it is by no means desirable to withhold all forms of beginning instruction from the child who is considered at risk for specific reading difficulty. For example, instruction in mathematics, geography, and science should not be withheld.

Certainly, the brightest prospects for remediation are offered by findings that reading instruction can facilitate phoneme awareness. Some very interesting and practical advice on how to facilitate linguistic sophistication is currently available (Liberman, 1982; Mann, 1984b; Mann & Liberman, 1984; Liberman, Shankweiler, Blachman, Camp, & Werfelman, 1980). Perhaps, the best favor we can do for all children is to let them in on the secrets of the alphabetic principle as early as possible (Liberman, 1982; Liberman & Mann, 1980). This, of course, means phonics, phonics, and more phonics, but phonics integral to beginning reading instruction.

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