Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy

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A FRAMEWORK for conceptualizing the development of individual differences in reading ability is presented that synthesizes a great deal of the research literature. The framework places special emphasis on the effects of reading on cognitive development and on "bootstrapping" relationships involving reading. Of key importance are the concepts of *reciprocal relationships*—situations where the causal connection between reading ability and the efficiency of a cognitive process is bidirectional—and *organism-environment correlation*—the fact that differentially advantaged organisms are exposed to nonrandom distributions of environmental quality. Hypotheses are advanced to explain how these mechanisms operate to create rich-get-richer and poor-get-poorer patterns of reading achievement. The framework is used to explicate some persisting problems in the literature on reading disability and to conceptualize remediation efforts in reading.

Les effets de Matthew sur la lecture: Quelques répercussions des différences individuelles sur l'alphabétisation

POUR MIEUX synthétiser la littérature se référant au sujet de cette recherche, on présente un tableau synoptique permettant la conceptualisation de développement des différences individuelles au niveau de la capacité de lecture. Ce tableau met l'emphase sur les effets de la lecture sur le développement cognitif et sur les relations interdépendantes concernant la lecture même. On retrouve deux concepts de grande importance: le concept de *relation de réciprocité* (dans des situations où le lien de causalité entre la capacité de lecture et l'efficacité d'un processus cognitif est bidirectionnel) et celui de *corrélation existant entre l'organisme et l'environnement* (le fait que les organismes avantagés par action différentielle soient soumis non fortuitement à des variations de qualité au niveau de l'environnement). On avance certaines hypothèses afin d'expliquer comment ces mécanismes fonctionnent pour créer des modèles de rendement en lecture selon lesquels les performances des plus forts vont en s'améliorant et celles des plus faibles en s'affaiblissant. On s'appuie sur le même tableau pour expliquer certains problèmes persistants retrouvés dans la littérature se référant aux difficultés en lecture et on l'emploie comme moyen de conceptualisation des efforts de correction en lecture.

Efectos de Matthew en la lectura: Algunas consecuencias que las diferencias individuales tienen en la adquisición de alfabetismo

EN ESTE ESTUDIO se presenta un marco teórico para conceptualizar el desarrollo de las diferencias individuales en la habilidad de lectura que sintetiza una gran parte de la investigación literaria sobre el tema. Este marco teórico pone un énfasis especial en los efectos que la lectura tiene en el desarrollo cognitivo y en las relaciones de retroalimentación creciente *(bootstrapping)* que involucran lectura. De importancia clave son los conceptos de *relación recíproca*—situaciones donde la conección causal entre la habilidad de lectura y la eficiencia de un proceso cognitivo es bidireccional—y *la correlación entre organismo y medio-ambiente*—el hecho de que organismos diferencialmente avanzados estan expuestos a distribuciones no al azar de calidad ambiental. Se proponen hipótesis para explicar como trabajan

estos mecanismos para crear patrones de aprovechamiento en lectura en donde los patrones avanzados se enriquecen más y los de pobre rendimiento se empobrecen aún más. Se usa el marco teórico para explicar algunos problemas persistentes en la literatura sobre dificultades en lectura y como una forma de conceptualizar los esfuerzos remediales en lectura.

Der Matthew-Einfluß auf das Lesen: Einige der Wirkungen individueller Unterschiede in der Erlernung von Buchwissen

EIN SYSTEM der Planung für die Entwicklung individueller Unterschiede in der Lesefähigkeit ist gegeben, welches einen großen Anteil von Forschungsliteratur miteinander verknüpft. Dieses System konzentriert sich ganz besonders auf die Lese-Einflüsse von Erkenntnis-Entwicklung und von Schnürsenkel-Verhältnissen, die sich aufs Lesen beziehen. Von allergrößter Wichtigkeit sind *Wechsel-Beziehungen* – Situationen in denen die kausale Verbindung zwischen Lesefähigkeit und Wirkungsgrad des Erkennungs-Prozesses hin- und zurückfließt – die Tatsache, daß individuell bevorzugte Organismen nicht-wahllosen Austeilungen von Umwelts-Qualität ausgesetzt sind. Fortschrittliche Hypothesen erklären, wie diese Mechanismen dazu dienen, die-Reichen-werden-reicher und die-Armen-werden-ärmer-Modelle von Lesefähigkeit zu schaffen. Dieses System dient dazu, hartnäckige Probleme in der Literatur über Leseunfähigkeit zu erklären, und auch dazu, Konzepte zur Abschaffung solcher Probleme zu schaffen.

To synthesize the ever-growing body of literature on individual differences in the cognitive skills related to reading is difficult because of the plethora of relationships that have been found. Good and poor readers have been compared on just about every cognitive task that has ever been devised, and group performance differences have been observed on a large number of these tasks (see, for example, Carr, 1981; DeSoto & DeSoto, 1983; Mitchell, 1982; Palmer, MacLeod, Hunt, & Davidson, 1985; Share, Jorm, Maclean, & Matthews, 1984; Singer & Crouse, 1981; Stanovich, 1982a, 1982b, 1986). Mounds of correlations and significant differences have been found. There is, then, at least one sense in which it can be said that we do not lack empirical evidence. The problem is in deciding what it all means.

The aim of this paper is to attempt to clarify the literature by drawing attention to some alternative ways of interpreting relationships between cognitive processes and reading ability. These alternative interpretations have all been discussed before by numerous authors (e.g., Bryant & Bradley, 1985; Byrne, 1986; Chall, 1983; Donaldson, 1978; Ehri, 1979; Morrison & Manis, 1982), but their implications have not been fully explored, nor have they been brought together within a coherent framework. This review presents such a framework and, in addition, a model of the development of individual differences in reading achievement and related cognitive processes that seems to follow logically from it.

Problems with the Existing Evidence

For many years, research on individual differences was plagued by the failure to carry out thorough process analyses on the experimental tasks employed. Thus, it was rarely possible to ascribe any cognitive specificity to an observed group difference. This problem has partially been alleviated due to the general influence of a paradigmatic assumption of cognitive psychology: that performance on any single task is the result of the simultaneous or successive operation of many different information-processing operations. However, it took a long time for reading disability researchers to accept an implication of this assumption: that one could not merely observe a difference on, for example, a

perceptual task, and then announce that "visual processing" was the key to reading failure, based on one's introspection about what the task tapped. It was sometimes hard to understand that no matter how large the performance difference observed on a single task, such an outcome represented not the end, but instead the beginning of a careful task analysis that one hoped would reveal the cognitive locus of the difference. The rise and fall of many of the popular hypotheses in the dyslexia literature mirrors this belated realization (see Vellutino, 1979).

Beyond the issue of inferring the appropriate process difference from task performance lies an even more vexing problem: that of inferring causation. After observing a performance difference in a purely correlational study and carrying out the appropriate task analysis, we are still left with the question of whether the processing difference thus isolated causes variation in reading achievement, whether reading achievement itself affects the operation of the cognitive process, or whether the relationship is due to some third variable. Also, there is the possibility of *reciprocal causation:* that there are causal connections running in both directions.

Complicating the picture even further is the possibility that the causal connections between variation in reading achievement and the efficiency of various cognitive processes may change with development. This possibility has been strongly emphasized by some researchers (e.g., Chall, 1983; Satz, Taylor, Friel, & Fletcher, 1978), but has been inadequately reflected in much research on individual differences in the cognitive skills of reading. For example, it is possible that some relationships are *developmentally limited*—that individual differences in a particular cognitive process may be a causal determinant of variation in reading achievement early in development, but at some point have no further effects on the level of reading efficiency. In this case, a correlation between reading achievement and the efficiency of a cognitive process may obtain in adults because the efficiency of the cognitive process determined the ease with which the individual traversed earlier stages of the reading process—stages that laid the foundation for the present level of reading ability—but further progress is dependent on the development of processes other than the one in question. A residual correlation between the efficiency of the process and reading level remains as a remnant of a causal connection present during an earlier developmental stage.

The vast literature on individual differences in the cognitive processes of reading will only be fully understood when we are able to determine which performance linkages reflect causal relationships, which are developmentally limited, which are the result of third variables, which enter into relationships of reciprocal causation, and which are consequences of the individual's reading level or reading history. Achieving such a classification will be easier if it is recognized that certain relationships may change status at different levels of reading development. In this review some tentative classifications for some of the cognitive processes that have received considerable attention in recent research will be hypothesized. In order to provide a context for these hypotheses, I will first present a brief outline of a preliminary (and incomplete) model of the development of individual differences in reading skill.

A Model of the Development of Individual Differences in Reading

Evidence is mounting that the primary specific mechanism that enables early reading success is phonological awareness: conscious access to the phonemic level of the speech stream and some ability to cognitively manipulate representations at this level. Although general indicators of cognitive functioning such as nonverbal intelligence, vocabulary, and listening comprehension make significant independent contributions to predicting the ease of initial reading acquisition, phonological awareness stands out as the most potent predictor (Share et al., 1984; Stanovich, Cunningham, & Cramer, 1984; Stanovich, Cunningham, & Feeman, 1984a; Tunmer & Nesdale, 1985). In-

deed, phonological awareness tasks often correlate more highly with early reading acquisition than do omnibus measures such as general intelligence tests or reading readiness tests (Mann, 1984; Share et al., 1984; Stanovich, Cunningham, & Cramer, 1984; Stanovich, Cunningham, & Feeman, 1984a; Zifcak, 1981).

Of course, although the strength of these correlations serves to draw attention to phonological awareness, it is not proof that variation in awareness is causally connected to differences in the ease of initial reading acquisition. Proving causation requires much stronger evidence, and this evidence is much less plentiful than the purely correlational data. However, a growing body of data does exist indicating that variation in phonological awareness is causally related to the early development of reading skill. This evidence is of several different types. First, there are several studies showing that measures of phonological awareness predict reading ability even when the former are assessed very early in development (Bradley & Bryant, 1983, 1985; Fox & Routh, 1975; Share et al., 1984; Williams, 1984). Secondly, Tunmer and Nesdale (1985) reported a contingency analysis of their first-grade data which indicated that phonemic segmentation skill was a necessary, but not sufficient, condition for reading acquisition (see also Perfetti, Beck, & Hughes, 1981). In addition, the results of some recent longitudinal studies where cross-lagged correlational methods and/or structural equation modeling have been employed have led to the conclusion that early skill at phonological awareness leads to superior reading achievement (Perfetti et al., 1981; Torneus, 1984). Evidence supporting this conclusion also comes from reading-level match designs. When 10-year-old disabled readers perform worse on phonological tasks than nondisabled 6-year-old children reading at the same level (e.g., Bradley & Bryant, 1978), it is somewhat more difficult to argue that the latter are superior because they have had more reading experience. Last, and of course most convincing, are the results of several studies where phonological awareness skills were manipulated via training, and the manipulation resulted in significant experimental group advantages in reading, word recognition, and spelling (Bradley & Bryant, 1983, 1985; Fox & Routh, 1984; Olofsson & Lundberg, 1985; Torneus, 1984; Treiman & Baron, 1983).

It should be noted that several of the studies cited above have also supported Ehri's (1979, 1984, 1985) position that reading acquisition itself facilitates phonological awareness (see also Perfetti, 1985; Perfetti et al., 1981; Wagner & Torgesen, in press), so that the situation appears to be one of reciprocal causation. Such situations of reciprocal causation can have important "bootstrapping" effects, and some of these will be discussed in this review. However, the question in this section is not which direction of causality is dominant. The essential properties of the model being outlined here are dependent only on the fact that a causal link running from phonological awareness to reading acquisition has been established, independent of the status of the opposite causal link.

Many researchers have discussed the reasons phonological awareness is important in early reading acquisition (see Gough & Hillinger, 1980; Liberman, 1982; Perfetti, 1984; Williams, 1984). A beginning reader must at some point discover the alphabetic principle: that units of print map onto units of sound (see Perfetti, 1984). This principle may be induced; it may be acquired through direct instruction; it may be acquired along with or after the build-up of a visually-based sight vocabulary—but it must be acquired if a child is to progress successfully in reading. Children must be able to decode independently the many unknown words that will be encountered in the early stages of reading. By acquiring some knowledge of spelling-to-sound mappings, the child will gain the reading independence that eventually leads to the levels of practice that are prerequisites to fluent reading. The research cited above appears to indicate that some minimal level of explicit phonemic awareness is required for the acquisition of the spelling-to-sound knowledge that supports independent decoding.

It is apparently important that the prerequisite phonological awareness and skill at spelling-to-sound mapping be in place *early* in the

child's development, because their absence can initiate a causal chain of escalating negative side effects. Biemiller (1977-1978; see also Allington, 1980, 1983, 1984) has documented how extremely large differences in reading practice begin to emerge as early as the middle of the first-grade year. In October, the children in the three most able groups in his sample read a mean of 12.2 words per child per reading session, the children in three average ability groups read 11.9 words per child per reading session, and the children in the two least able groups were not reading. By January, the mean for the most able groups was 51.9, for the average ability groups, 25.8, and for the least able groups, 11.5. In April the respective means were 81.4, 72.3, and 31.6. This of course says nothing about differences in home reading, which would probably be at least as large. Thus, soon after experiencing greater difficulty in breaking the spelling-to-sound code, poorer readers begin to be exposed to less text than their peers.

Further exacerbating the situation is the fact that poorer readers often find themselves in materials that are too difficult for them (Allington, 1977, 1983, 1984; Bristow, 1985; Forell, 1985; Gambrell, Wilson, & Gantt, 1981; Jorgenson, 1977). The combination of lack of practice, deficient decoding skills, and difficult materials results in unrewarding early reading experiences that lead to less involvement in reading-related activities. Lack of exposure and practice on the part of the less skilled reader delays the development of automaticity and speed at the word-recognition level. Slow, capacity-draining word-recognition processes require cognitive resources that should be allocated to higher-level processes of text integration and comprehension (LaBerge & Samuels, 1974; Perfetti, 1985; Stanovich, 1980). Thus, reading for meaning is hindered, unrewarding reading experiences multiply, and practice is avoided or merely tolerated without real cognitive involvement. The downward spiral continues—and has further consequences.

The better reader more rapidly attains a stage of proficiency where decoding skill is no longer the primary determinant of reading level. As word recognition becomes less resource-demanding by taking place via relatively automatic processes of visual/orthographic access, more general language skills become the limiting factor on reading ability (Chall, 1983; Sticht, 1979). But the greater reading experience of the better reader has provided an enormous advantage even here. Reading itself is an important contributor to the development of many language/cognitive skills. For example, much vocabulary growth probably takes place through the learning of word meanings from context during reading (Nagy & Anderson, 1984; Nagy, Herman, & Anderson, 1985; Sternberg, 1985). Similarly, much general information and knowledge about more complex syntactic structures probably also takes place through reading itself (Donaldson & Reid, 1982; Mann, 1986; Perfetti, 1985, pp. 172-173, 195). In short, many things that facilitate further growth in reading comprehension ability—general knowledge, vocabulary, syntactic knowledge—are developed by reading itself. The increased reading experiences of children who crack the spelling-to-sound code early thus have important positive feedback effects. Such feedback effects appear to be potent sources of individual differences in academic achievement (Walberg, Strykowski, Rovai, & Hung, 1984).

Paring Down the Number of Causal Relationships

It will be argued here that these bootstrapping effects of reading experience and other secondary effects have been inadequately considered in the extensive literature on individual differences in the cognitive processes of reading. Although it might seem that a consideration of the effects of these reciprocal relationships would complicate our models, it actually has great potential to clarify reading theory. If only a few of these reciprocal effects control a large portion of the variance in reading ability, we will be able to exercise parsimony elsewhere. Such a consideration will

suggest that much of the explanatory power available from all of the variables that have been linked to reading ability in individual difference studies is superfluous; and this should spur us to eliminate some as causal factors accounting for variance in reading achievement.

It is only by trying to pare down the number of potential causal relationships by classifying some as spurious, some as consequences of reading, and some as developmentally limited that any clarity will be brought to the reading literature. In the remainder of this review some specific examples of candidates for possible "paring" will be discussed. A number of hypotheses are also advanced for incorporating reciprocal relationships and feedback effects within a general model of developmental changes in the cognitive processes related to reading. The tentative causal model I have outlined will be elaborated in the course of the discussion. Many of the hypotheses to be advanced are quite tentative, as the empirical evidence relating to several of them is far from definitive. The following discussion was not intended to be exhaustive, and it certainly will not present the final and definitive classification of process linkages; but hopefully it will serve to focus future research efforts.

The easiest processing differences to eliminate as causes of individual differences in reading ability should be those where performance differences arise merely because the individuals are reading at different levels—in short, situations where the efficiency of reading is determining how efficiently the cognitive process operates, rather than the converse. We will turn first to some possible examples of this type of relationship.

Eye Movements: A Consequence of Reading Level

There may be many processes that we are prone to view as causal determinants of reading efficiency, but that are in fact determined by that efficiency. One might have thought that the classic example of this reverse causal path in reading—individual differences in eye movement patterns—would make us all more cautious about interpreting every one of the enormous number of cognitive performance differences between good and poor readers that are present in, for example, adult readers (e.g., M. Jackson & McClelland, 1975, 1979; Palmer et al., 1985) as if each of the processes were a cause of the current level of reading ability.

The relationship of certain eye movement patterns to reading fluency has repeatedly, and erroneously, been interpreted as indicating that reading ability was determined by the efficiency of the eye movements themselves. For example, researchers have repeatedly found that less skilled readers make more regressive eye movements, make more fixations per line of text, and have longer fixation durations than skilled readers (Rayner, 1985a, 1985b). The assumption that these particular eye movement characteristics were a cause of reading disability led to the now thoroughly discredited "eye movement training" programs that repeatedly have been advanced as "cures" for reading disabilities. Of course, we now recognize that eye movement patterns represent a perfect example of a causal connection running in the opposite direction. Poor readers do show the inefficient characteristics listed above; but they are also comprehending text more poorly. In fact, we now know that eye movements rather closely reflect the efficiency of ongoing reading—with the number of regressions and fixations per line increasing as the material becomes more difficult, and decreasing as reading efficiency increases (Aman & Singh, 1983; Just & Carpenter, 1980; Olson, Kliegl, & Davidson, 1983; Rayner, 1978, 1985a, 1985b; Stanley, Smith, & Howell, 1983; Tinker, 1958)—and this is true for all readers, regardless of their skill level. When skilled readers are forced to read material too difficult for them, their eye movement patterns deteriorate and approximate those usually shown by the less skilled reader. The eye movement patterns of the latter look more fluent when they are allowed to read easier material. In short, the level of reading determines the nature of the eye movement patterns, not the reverse.

The example of eye movements should illustrate the importance of considering whether individual differences in a particular cognitive

process may reflect the reading level of the subject, rather than be a cause of it. We will next consider the less firmly established, and therefore more controversial, case of the effect of context on word recognition.

Context Effects On Word Recognition: A Consequence of Reading Level?

Few areas of reading research are so fraught with confusion as are investigations of context use. One reason for this is that reading researchers have often failed to distinguish between levels in the processing system when discussing contextual effects (Gough, 1983; Mitchell, 1982; Stanovich, 1980, 1982b, 1984). The failure to distinguish the specific processing subsystems that are being affected by a particular experimental manipulation is one of the main reasons why there is still considerable looseness and confusion surrounding the term "context effect" in the reading literature. The point is that there can be many different *types* of context effects.

It will be argued here that the literature on context effects is considerably clarified if care is taken to distinguish the different types of context effects that are discussed in reading research. For example, the claim that variation in the use of context in part determines reading efficiency, and that contextual effects are more implicated in the performance of better readers, has often been made in the reading literature:

> Skill in reading involves not greater precision, but more accurate first guesses based on better sampling techniques, greater control over language structure, broadened experiences and increased conceptual development. (Goodman, 1976, p. 504)
>
> Guessing in the way I have described it is not just a preferred strategy for beginners and fluent readers alike; it is the most efficient manner in which to read and learn to read. (Smith, 1979, p. 67)
>
> The more difficulty a reader has with reading, the more he relies on the visual information; this statement applies to both the fluent reader and the beginner. In each case, the cause of the difficulty is inability to make full use of syntactic and semantic redundancy, of nonvisual sources of information. (Smith, 1971, p. 221)
>
> Less often the possibility is considered that use of context makes better readers. (Smith, 1982, p. 230)

It will be argued here that the truth of this hypothesis—that more fluent readers rely more on context—is critically dependent on the distinction between the use of context as an aid to *word recognition* and its use to aid *comprehension processes.* The claim appears defensible when referring to the latter; but appears to be largely incorrect when applied to the word-recognition level of processing.

We must first ask the question: Do less skilled readers use contextual information to facilitate word recognition when it is available; and if they do, to what extent do they rely on it? Many discrete-trial reaction-time studies of context effects have been conducted to investigate this question. Note that many of these studies have ensured the condition "when it is available" by using materials that were well within the reading capability of the least skilled subjects in the study. (This will become an important consideration in a later discussion.) Most of these studies have used priming paradigms where a context (sometimes a word, sometimes a sentence, and sometimes several sentences or paragraphs) precedes a target word to which the subject must make a naming or lexical decision response. Although this paradigm does not completely isolate the word-recognition level of processing (see Forster, 1979; Seidenberg, Waters, Sanders, & Langer, 1984; Stanovich & West, 1983; West & Stanovich, 1982), it does so more than the other methodologies that have been used in the developmental literature. The finding has consistently been that not only do the poorer readers in these studies use context, but they often show somewhat larger contextual effects than do the better readers (Becker, 1982; Briggs, Austin, & Underwood, 1984; Perfetti, Goldman, & Hogaboam, 1979; Perfetti & Roth, 1981; Schvaneveldt, Ackerman, & Semlear, 1977; Schwantes, 1981, 1982, 1985; Schwantes,

Boesl, & Ritz, 1980; Simpson & Foster, 1985; Simpson & Lorsbach, 1983; Simpson, Lorsbach, & Whitehouse, 1983; Stanovich, Nathan, West, & Vala-Rossi, 1985; Stanovich, West, & Feeman, 1981; West & Stanovich, 1978; West, Stanovich, Feeman, & Cunningham, 1983).

Some investigators have employed oral reading error analyses in order to examine individual differences in the use of context to facilitate word recognition. However, the use of the technique for this purpose is problematic. An oral reading error occurs for a variety of complex and interacting reasons (see Kibby, 1979; Leu, 1982; Wixson, 1979). Most critical for the present discussion is the fact that such errors often implicate levels of processing beyond word recognition. For example, hesitations and omissions are probably some complex function of word-recognition and comprehension processes (e.g., Goodman & Gollasch, 1980). Self-corrections in part reflect comprehension monitoring. Nevertheless, analysis of initial substitution errors has been used to throw light on the use of context to aid word recognition, and it is likely that these errors do partially implicate processes operating at the word-recognition level. So it is probably useful to consider this evidence if it is clearly recognized that it does not isolate the word-recognition level of processing as cleanly as the reaction-time studies.

Fortunately, there turns out to be no dilemma because the results of oral reading error studies largely converge with those of the reaction-time studies. When skilled and less skilled readers are in materials of comparable difficulty (i.e., materials producing similar error rates), the relative reliance on contextual information relative to graphic information is just as great—in many cases greater—for the less skilled readers (Allington & Fleming, 1978; Batey & Sonnenschein, 1981; Biemiller, 1970, 1979; A.S. Cohen, 1974-1975; Coomber, 1972; Harding, 1984; Juel, 1980; Lesgold & Resnick, 1982; Perfetti & Roth, 1981; Richardson, DiBenedetto, & Adler, 1982; Weber, 1970; Whaley & Kibby, 1981). The findings from other paradigms, such as text disruption manipulations (Allington & Strange, 1977; Ehrlich, 1981; Schwartz & Stanovich, 1981; Siler, 1974; Strange, 1979) and timed text reading (Biemiller, 1977-1978; Doehring, 1976; Stanovich, Cunningham, & Feeman, 1984b) also converge with this conclusion.

Reconciling Differing Views on Context Use

In light of this evidence, it might seem difficult to understand how the claim that poor readers are less reliant on context for word recognition arose and gained popularity. There are several possible explanations, and they are not mutually exclusive. First is the tendency to conflate different levels of processing, discussed earlier. Skilled readers *are* more prone to use context to facilitate comprehension processes (see Stanovich, 1982b), so it is perhaps not surprising that there was a tendency to overgeneralize this relationship to the case of word recognition. Secondly, the popularity of the hypothesis may also have arisen from understandable confusion surrounding information processing concepts. For example, theorists proposing top-down models of reading have often defended the position that skilled readers rely less on graphic cues:

> As the child develops reading skill and speed, he uses increasingly fewer graphic cues. (Goodman, 1976, p. 504)
>
> But if in fact you are not making errors when you read, you are probably not reading efficiently, you are processing more visual information than you need. (Smith, 1979, p. 33)
>
> The more difficulty a reader has with reading, the more he relies on visual information; this statement applies to both the fluent reader and the beginner. (Smith, 1971, p. 221)
>
> One difference between the good beginning reader and the one heading for trouble lies in the overreliance on visual information that inefficient—or improperly taught—beginning readers tend to show, at the expense of sense. (Smith, 1973, p. 190)

Smith's (1971) well-known hypothesis is that, because the good reader is sensitive to the redundancy afforded by sentences, he or she develops hypotheses about upcoming words and is then able to confirm the identity of a word by

sampling only a few features in the visual display. Good readers should then process words faster because their use of redundancy lightens the load on their stimulus-analysis mechanisms. Despite its surface plausibility, this notion is contradicted by much recent data.

Advances in eye movement technology have quite recently made available a host of powerful techniques for collecting data relevant to this hypothesis. The results of studies employing these new methodologies have consistently indicated that fluent readers rather completely sample the visual array—even when reading fairly predictable words (Balota, Pollatsek, & Rayner, 1985; Ehrlich & Rayner, 1981; Just & Carpenter, 1980; McConkie & Zola, 1981; Rayner & Bertera, 1979; Rayner, Inhoff, Morrison, Slowiaczek, & Bertera, 1981; Zola, 1984). Fluent readers are not engaging in the wholesale skipping of words, nor are they markedly reducing their sampling of visual features from the words fixated. Although Smith's (1973) conclusion that "it is clear that the better reader barely looks at the individual words on the page" (p. 190) could not be evaluated at the time it was made, current research using the latest eye movement technology has rendered it untenable.

It appears that in the top-down models of reading, use of the features in the visual array was conflated with the cognitive resources necessary to process those features. In fact, it is not that the good reader relies less on visual information, but that the visual analysis mechanisms of the good reader use less *capacity.* That is, good readers are efficient processors in every sense: They completely sample the visual array *and* use fewer resources to do so. The good reader is not less reliant on the visual information, but the good reader does allocate less capacity to process this information. In short, it is important to note that the attentional resources allocated to graphic processing and the amount of graphic information itself are two different things.

Perhaps a third reason for the popularity of the context-use hypothesis as an explanation of differences in reading ability is that there is considerable confusion about the distinction between the importance of a mechanism as a determinant of a general developmental sequence and as a determinant of individual differences in the developmental sequence (McCall, 1981). The reasoning error involved seems to have been one of taking an idea that was valid in one sphere and extending it into a domain where it was not applicable. The error was not in emphasizing that context use occurs in reading, but in generalizing it as a mechanism that could explain individual differences. For example, research cited earlier indicates considerable use of context by early readers. This context use is clear from the reaction-time studies and from the fact that oral reading error studies of first-grade children have found that 70% to 95% of the initial errors are contextually appropriate (Biemiller, 1970, 1979; Weber, 1970). Note, however, that if the variability in context use is low relative to the variability in other factors that determine reading ability (phonological awareness, for example), then context use will not be strongly related to individual differences in reading ability, despite its importance as an underlying factor in every child's reading performance.

This point is similar to cautions researchers have raised about interpreting the effects of heredity and environment on intelligence test performance. It is often pointed out that if the variability in one factor is restricted, then the other will necessarily be more strongly related to individual differences. For example, individual differences in the intelligence scores among identical twins must be entirely due to environmental differences because they share the same genetic background. This of course does not mean that the general developmental sequence of identical twins is not partially under genetic control. However, although heredity is contributing to the development of the organism, it cannot be linked to individual differences in this case.

We must raise the question of whether an analogous phenomenon is not occurring in the case of contextual facilitation. All the empirical evidence indicates considerable use of context by first-grade children, and models of first-grade reading acquisition often include at least

one stage defined in part by context use. For example, Biemiller's (1970) proposed early reading stages include an initial stage of contextual dependency, a stage of increasing attention to graphic processing, and a stage where the integration of both graphic and contextual cues occurs. Bissex's (1980) case study can be interpreted within this framework; she particularly emphasizes the importance of the third stage, in which both contextual and graphophonemic information is used in an integrated manner. But even if we accept the importance of a stage of graphic and contextual cue integration, the question arises whether passage into this stage is blocked by the inadequate development of context-use skills or by the failure to develop skills of graphophonemic processing. All children may indeed go through this stage, but is the speed of its attainment actually determined by variation in context-use skills? The research reviewed above suggests that the answer may be no: that stages may indeed exist that are defined in part by context use, but that the existence of such stages may misleadingly suggest that context use is a source of individual differences. Instead, it appears that compared to other prerequisite skills—such as phonological awareness—the variability in the ability to use context to facilitate word recognition is so relatively low that it may not be a major determinant of individual differences in reading acquisition. The very ubiquity of contextual facilitation—the thing that has led some theorists to single it out as a mechanism for generating ability differences—is precisely the thing that prevents it from being a cause of individual differences.

The hypothesis about context use among readers of differing skill generated from the top-down models thus needs several modifications in order to bring it into congruence with current research evidence. First, it is not that good readers are less reliant on visual information, but that they expend less capacity to process visual information fully. Secondly, the reason that they expend less capacity is not because they rely on context, but because their stimulus-analysis mechanisms are so powerful. These modifications are all more completely explicated in Perfetti's (1985) verbal efficiency theory. Once these alterations are made, it is possible to see more congruence between some of the insights that were the source of the top-down models and those of more bottom-up models like verbal efficiency theory. For example, both classes of model are in agreement on the necessity of expending processing capacity on higher-level comprehension processes rather than on word recognition. In fact, there are considerable grounds here for a rapprochement between the proponents of various global models of the reading process. Long before most cognitive psychologists became interested in reading, top-down theorists were investigating critical processing issues in the domain of context use. The latter were responsible for the crucial insight that readers need to allocate attentional capacity to comprehension rather than to word recognition in order to become fluent. However, recent work by cognitive and developmental psychologists—some of whom are of a more bottom-up persuasion—has helped to specify accurately the key mechanism that allows capacity to be allocated to comprehension. This mechanism turns out to be efficient decoding rather than context use. Both groups of researchers have thus made important contributions to our current knowledge of the interrelationships between decoding, context use for word recognition, and comprehension.

Compensatory Processing and Decoding Skill

The common finding that the magnitude of contextual facilitation effects is inversely related to the word-recognition skill of the reader has been seen as an example of interactive-compensatory processing (Perfetti & Roth, 1981; Stanovich, 1980, 1984; Stanovich, West, & Feeman, 1981) because it presumably results from the fact that the information processing system is arranged in such a way that when the bottom-up decoding processes that result in word recognition are deficient, the system compensates by relying more heavily on other knowledge sources (e.g., contextual information). The extent to which the compensatory processing in children is obligatory and the ex-

tent to which it is strategic is an issue of much complexity and is currently being debated in the literature (see Briggs, Austin, & Underwood, 1984; Simpson & Lorsbach, 1983; Stanovich, Nathan, West, & Vala-Rossi, 1985; Stanovich & West, 1983), but the current evidence appears to indicate that to a considerable extent it is obligatory and automatic. It appears that reading skill is not determined by skill at contextual prediction, but rather that the level of word-recognition skill determines the extent to which contextual information will be relied on to complete the process of lexical access. The slower the word decoding process, the more the system draws on contextual information. In the interactive-compensatory model, the magnitude of context effects is thus conceived to be largely a consequence of the efficiency of reading—making it analogous to the case of eye movements.

Perfetti (1985, p. 149) has provided the data that most convincingly demonstrate that the magnitude of contextual facilitation effects (at the word-recognition level) are a function of decoding skill. He has shown that words and individuals are "interchangeable." When the target word in a discrete-trial experiment is visually degraded so that the recognition speed of a good reader is as slow as that of a poor reader, the good reader shows as large a contextual effect as the poor reader. Increased word difficulty appears to operate in the same way (Perfetti et al., 1979; Stanovich, 1984; Stanovich & West, 1981, 1983; Stanovich, West, & Feeman, 1981). Perfetti (1985) has shown that in his data there is a linear relationship between the contextual facilitation effect and the isolated word-recognition time across a wide variety of conditions of word difficulty, visual degradation, and reading skill. He concluded, "In other words, it does not matter whether a word's isolated identification time is measured from a high-ability or low-ability reader or from a degraded or normal word. The context effect simply depends on the basic word-identification time" (p. 149).

Unfortunately, the function relating word-recognition difficulty and the magnitude of the context effect presented by Perfetti (1985) turns out to be a special case rather than a completely generalizable relationship. It applies only under conditions where both the skilled and the less skilled readers have adequately processed the context. It is restricted to such conditions because the compensatory processing can only occur when the contextual information is available to supplement bottom-up analyses. Availability of context was ensured in the case of the reaction-time studies because materials were used in those studies that were well within the capability of the poorest readers; and it can be crudely controlled in the case of the oral reading error studies by looking at performance in materials where the overall error rates have been equated. However, in classroom reading situations, poorer readers will more often be dealing with materials that are relatively more difficult (Allington, 1977, 1983, 1984; Bristow, 1985; Forell, 1985; Gambrell, Wilson, & Gantt, 1981; Jorgenson, 1977), and in which they may experience decoding problems. These decoding problems will reduce the context available to the poorer reader. Thus, even though both groups may be reading the same materials, the poorer reader will have, in effect, less contextual information to utilize. This could lead such readers to display less contextual facilitation. (There may also be reader-skill differences in general knowledge and semantic memory that could affect contextual processing, but so little is known about this possibility that it will not be considered here.) The point is that we must eventually refine our theories of context use in order to distinguish the nominal context (what is on the page) from the effective context (what is being used by the reader).

Thus, in order to fully trace out the function relating contextual facilitation to the recognition time for the target word in isolation, we must consider another dimension: the difficulty of the material preceding the target word. And this added dimension will interact with reading skill in determining the amount of contextual facilitation observed. For a given target word, in very easy materials (at or below the reading level of the less skilled readers), poorer readers will show more contextual facilitation (Perfetti, 1985; Stanovich, 1980, 1984). But as the mate-

rial becomes more difficult, this difference will disappear, and eventually a level of difficulty will be reached where the better readers display larger facilitation effects because the prior text (which forms the context for the word currently being recognized) is simply too difficult for the poorer readers to decode. In short, the relationship between the difficulty of the target word, the difficulty of the contextual material, the ability of the reader, and the amount of contextual facilitation is a complex one. Note, however, that taking the difficulty of the contextual material into account does not change the source of individual differences in contextual facilitation: They are directly determined by the decoding ability of the subject (and the difficulty level of the contextual material and of the target word).

Consideration of the difficulty factor may throw light on a question that is often raised in response to the reaction-time and oral reading error studies cited above: If poor readers use context so much, how can we explain the frequently reported description of problem readers as plodding through text, not using context, and understanding little? How should we interpret the performance of such readers? One interpretation that flows from the top-down perspective is that these children have learned inefficient word-recognition strategies:

> Excessive stress, in reading instruction and materials, on phonics or word attack skills, will tend to make recoding an end in itself, and may actually distract the child from the real end: decoding written language for meaning. (Goodman, 1968, p. 21)
>
> Trying to sound out words without reference to meaning is a characteristic strategy of poor readers; it is not one that leads to fluency in reading. (Smith, 1982, p. 145)
>
> If you had read the backwards passage aloud, incidentally, you probably would have sounded very much like many of the older "problem readers" at school, who struggle to identify words one at a time in a dreary monotone as if each word had nothing to do with any other. Such children seem to believe—and may well have been taught—that meaning should be their last concern. (Smith, 1978, p. 154)

An alternative conceptualization would view the lack of contextual facilitation shown by such a reader as the result of extremely poor decoding skills. The research reviewed above strongly supports the view that the word recognition of poor readers *is* facilitated by contextual information *when they understand the context.* When poor readers are in difficult materials, their slow and inaccurate word decoding processes may in fact degrade the contextual information that they receive, rendering it unusable (Kibby, 1979). The observation that, under such conditions, poor readers do not rely on context should not—according to this interpretation—be viewed as indicating that they *never* use context to facilitate word recognition.

Using a longitudinal research design, some colleagues and I (Stanovich, Cunningham, & Feeman, 1984b) tested these alternative explanations. In the fall and again in the spring, we assessed the speed and accuracy with which skilled and less skilled first-grade children read coherent story paragraphs and random word lists. A recognition efficiency score was constructed that reflected the mean number of words read correctly per second. Of course, the skilled readers were better in both types of materials. In the fall, they also displayed more contextual facilitation, but again, they were decoding the passages much better. The question one needs to ask is whether the less skilled readers displayed as much contextual facilitation as the skilled readers *when at a comparable level of context-free decoding ability.* The data from our study (Stanovich, Cunningham, & Feeman, 1984b) are relevant to this question because the decoding efficiency of the less skilled readers on the random lists measured in the spring was similar to that displayed by the skilled readers measured in the fall. Thus, by comparing the analogous efficiency scores for the coherent paragraphs, it is possible to address the question of whether these two groups were getting a similar contextual "boost" when at comparable levels of context-free decoding ability. In the data we collected (Stanovich, Cunningham, & Feeman, 1984b; see also Kibby, 1979), the question was answered in the affirmative: The recognition efficiency scores

of the less skilled readers actually displayed somewhat more contextual facilitation than those of the skilled readers.

A final point that emerges from the research on contextual facilitation effects is the importance of differentiating the presence of a knowledge base from the use of that knowledge. For example, Perfetti, Goldman, and Hogaboam (1979) found that the same skilled readers who displayed smaller context effects than less skilled readers on a word-recognition task were superior on a cloze-like prediction task. Of course, the finding that skilled readers possess superior prediction abilities is nothing new; it merely reconfirms older findings of a relationship between reading ability and cloze performance (Bickley, Ellington, & Bickley, 1970; Ruddell, 1965). What is new—and the important lesson in the Perfetti et al. (1979) results—is that the presence of prediction abilities does not necessarily imply that these abilities are *used* to facilitate ongoing word recognition. In fact, the Perfetti et al. (1979) results suggest just the opposite. Though the better readers possessed superior prediction abilities, they *also* were superior decoders, and the data appear to indicate that the latter is the critical causal mechanism sustaining fluent reading. The context-free decoding efficiency of the better readers is so high that they are less in need of contextual support. They have more knowledge of contextual dependencies, but are simultaneously less reliant on this knowledge, because they possess other processing advantages that are more important for word recognition—namely, context-free decoding skills.

The Phenomenon of "Word Calling"

This discussion of contextual facilitation effects on word recognition is obviously related to the phenomenon described as "word calling" in the reading literature. Despite the frequency with which this term occurs in reading publications, it is rare to find an author who spells out the clear, operational meaning of the term as it is being used. However, the implicit assumptions behind its use appear to be as follows: (1) Word calling occurs when the words in the text are efficiently decoded into their spoken forms without comprehension of the passage taking place. (2) This is a bad thing, because (3) it means that the child does not understand the true purpose of reading, which is extracting meaning from the text. (4) Children engaging in word calling do so because they have learned inappropriate reading strategies. (5) The strategic difficulty is one of overreliance on phonic strategies. These assumptions can be detected in the following representative quotations:

> Trying to sound out words without reference to meaning is a characteristic strategy of poor readers. (Smith, 1982, p. 145)
>
> Preoccupation with teaching children to recode may actually short circuit the reading process and divert children from comprehension. It is even possible that children will reach a high level of proficiency in recoding, actually taking graphic input and recasting it as very natural sounding speech, with little or no awareness of the need for decoding for meaning. (Goodman, 1968, p. 20)
>
> In fact, few children who become remedial readers lack the ability to attack words. (Smith, Goodman, & Meredith, 1976, p. 270)
>
> Remedial reading classes are filled with youngsters in late elementary and secondary schools who can sound out words but get little meaning from their reading. (Goodman, 1973, p. 491)

The idea of a "word-caller" phenomenon embodying the assumptions outlined above has gained popularity despite the lack of evidence that it applies to an appreciable number of poor readers. There is no research evidence indicating that decoding a word into a phonological form often takes place without meaning extraction, even in poor readers. To the contrary, a substantial body of evidence indicates that even for young children, word decoding automatically leads to semantic activation *when the meaning of the word is adequately established in memory* (Ehri, 1977; Goodman, Haith, Guttentag, & Rao, 1985; Guttentag, 1984; Guttentag & Haith, 1978, 1980; Kraut & Smothergill, 1980; Rosinski, 1977). Inadequate attention has been directed to the possibility that "word calling" may simply be a consequence of a low level of reading ability. This might occur in a number

of different ways. First, reports of "word calling" rarely definitively establish whether the words that are "called" are even in the child's listening vocabulary. If the child would not understand the meaning of the word or passage when spoken, then overuse of decoding strategies can hardly be blamed if the child does not understand the written words. In short, a minimal requirement for establishing "word calling" as defined by the assumptions outlined above is the demonstration that the written material being "called" is within the listening comprehension abilities of the child (see Gough & Tunmer, 1986; Hood & Dubert, 1983).

Secondly, it is necessary to show that the "word calling" is not a simple consequence of poor decoding. Although reasonably efficient decoding would appear to be an integral part of any meaningful definition of "word calling," decoding skills are rarely carefully assessed before a child is labelled a "word caller." Instead, a rough index of decoding accuracy is usually employed, and any child near the normal range on this index is considered a candidate for the label. As other investigators have previously noted (e.g., LaBerge & Samuels, 1974; Perfetti, 1985, 1986), one does not obtain a clear picture of a child's decoding abilities unless speed and automaticity criteria are also employed. It is quite possible for accurate decoding to be so slow and capacity-demanding that it strains available cognitive resources and causes comprehension breakdowns. Such accurate but capacity-demanding decoding with little comprehension should not be considered "word calling" as defined above. To the contrary, it is a qualitatively different type of phenomenon. Comprehension fails not because of over-reliance on decoding, but because decoding skill is not developed *enough.*

Consequences of Reading History and Practice

The previous sections have outlined how individual differences in eye movements and context use for word recognition may be considered to be consequences of the reading level of the subject. Because these cognitive processes operate primarily during the act of reading itself, they are most accurately assessed by experimental methodologies that do not depart too far from the real-time processing requirements of reading. These types of processes may represent one class of the consequences of reading: processing differences that arise due to the differential efficiency of ongoing reading in individuals of varying skill.

However, individual differences in other types of cognitive processes may be linked to reading because the processes are affected by the differential behavioral histories of individuals who acquire reading at varying rates. For example, as discussed in the introduction, readers of differing skill soon diverge in the amount of practice they receive at reading and writing activities. They also have different histories of success, failure, and reward in the context of academic tasks. The long-term effects of such differing histories could act to create other cognitive and behavioral differences between readers of varying skill. Consider some possible examples. Many of the motivational differences between good and poor readers that are receiving increasing attention (see Johnston & Winograd, 1985; Oka & Paris, 1986) may well be consequences of the histories of success and failure associated with groups of differing skill. There is already some evidence suggesting that differences in self-esteem, rather than being the cause of achievement variability, are actually consequences of ability and achievement (Bachman & O'Malley, 1977; Maruyama, Rubin, & Kingsbury, 1981).

Ehri's (1984, 1985) work has elegantly demonstrated the effect that experience with print has on knowledge of sound structure and metalinguistic functioning. Others have speculated that the development of the ability to comprehend more complex syntactic structures is in part the result of reading experience (Donaldson & Reid, 1982; Mann, 1986; Perfetti, 1985). The status of the relationship between naming speed and reading ability is currently being debated by researchers, some of whom think that variation in this skill is a cause of reading abil-

ity differences, whereas others think it is a consequence of the differential reading histories of the subjects (M. Jackson, 1980; N.E. Jackson & Biemiller, 1985; Perfetti, 1985; Stanovich, 1986; Wolf, 1984).

Torgesen (1985) has raised the interesting possibility that some of the memory performance differences between readers of varying skill might be consequences of reading once-removed. He speculated that, because a good deal of knowledge acquisition takes place via reading, the knowledge base of less skilled readers may be less developed because of their lack of reading practice. It has also been demonstrated that performance on many memory tasks is affected by the nature of the subject's knowledge base. The poorer reader might therefore display relative inferiority on such tasks due to a lack of reading experience (see Bjorklund & Bernholtz, 1986).

On a broader level, much of the literature on the consequences of literacy (Donaldson, 1978; Goody, 1977; D. Olson, 1977; D. Olson, Torrance, & Hildyard, 1985; Scribner & Cole, 1981) may be viewed as demonstrating the importance of some of the more global consequences of reading. This research also illustrates that it is a mistake to dismiss cognitive differences that are consequences of the reading histories of the individuals as unimportant. Such an unfortunate inference explains why many investigators resist the conclusion that individual differences in the process they are studying are actually caused by variation in reading skill. Surely the literature on the consequences of literacy—speculative and empirically sparse though it is—has at least suggested that the cognitive consequences of the acquisition of literacy may be profound. A few reading theorists have warned that we should be giving increasing attention to these types of effects. For example, Chall (1983) has stated, "The influence of the development of reading and writing—'literate intelligence'—on general cognitive development has unfortunately been underestimated. Indeed, when reading development is delayed by personal or environmental factors or both, the effects on the person, unless given special help, are too often disastrous" (pp. 2-3).

The Reading-Level Match Design

Because of concern that some of the processing differences that have been attributed as causes of variation in reading ability are instead simple consequences of the overall level of reading or of the reading histories of the subjects, the reading-level match design has grown in popularity (Backman, Mamen, & Ferguson, 1984; Bryant & Goswami, 1986). In this research design, the performance of a group of older disabled readers is compared with that of a younger nondisabled group reading at the same level. The reading-level match design is often employed in order to rule out differential practice explanations of correlations between cognitive skills and reading ability. When 10-year-old disabled readers are found to perform worse on a cognitive task than normally progressing 6-year-old children (as in Bradley & Bryant, 1978), it is difficult to invoke the differential practice explanation; or at least, the inferior performance of the 10-year-olds is much less likely to be due to relative lack of experience than a performance deficit displayed in comparison to a control group of equal chronological age.

The recent exciting research on individuals with acquired dyslexia and the resulting debate about what these cases tell us about the nature of developmental dyslexia (Coltheart, Masterson, Byng, Prior, & Riddich, 1983; Ellis, 1984; Snowling, 1983) also point to the need for a reading-level match design, which should help to alleviate some of the interpretive problems in this research area. For example, the claim that the acquired dyslexic cases reveal a qualitatively distinct syndrome reflecting the breakdown of a specific mechanism that is the cause of their reading problems will only be sustained when it is demonstrated that the performance patterns observed do not merely reflect a depressed overall level of reading skill—in short, that normal children reading at the same level do not show similar performance patterns (Bryant & Impey, 1986; Prior & McCorriston, 1985).

The results from reading-level match designs also have important implications for de-

velopmental lag theories of variation in reading achievement (Beech & Harding, 1984; Fletcher, 1981; Stanovich, Nathan, & Vala-Rossi, 1986; Treiman & Hirsh-Pasek, 1985). These theories posit that the less skilled reader is traversing the same stages of cognitive development as the skilled reader, but at a slower rate. Thus, reading will be commensurately delayed because the prerequisite cognitive subskills are inadequately developed. The strong form of the lag hypothesis posits that the performance profiles of less skilled readers should be similar to those of younger readers at a similar level of achievement; that is, when older less skilled children and younger skilled children are matched on reading level, their performance should not differ on any other reading-related cognitive task (see Fletcher, 1981). However, Bryant and Goswami (1986) have pointed to the ambiguity inherent in null findings obtained with a reading-level match. That is, all processes—like eye movements—that are basically epiphenomena of the efficiency of reading will display precisely the pattern predicted by the developmental lag model. However, unlike the lag model, in which it is assumed that reading level is determined by the lagging cognitive processes, an alternative explanation in terms of the consequences of reading posits that the operation of the process is determined by the reading level.

Developmentally Limited Relationships: Phonological Awareness and Phonological Recoding Ability?

In the tentative causal model previously outlined, it was posited that phonological awareness is an enabling subskill in early reading, and that individual differences in this subskill contribute to variance in reading ability. A growing body of evidence appears to indicate that some level of phonological awareness is necessary for the discovery and exploitation of the alphabetic principle (Perfetti, 1984, 1985). The major advantage conferred by the alphabetic principle is that it allows children to recognize words that are in their vocabulary but have not been taught or encountered before in print. It is necessary for the child to make this step toward independent reading, and recognizing unknown words via phonological recoding seems to be the key to it (Ehri & Wilce, 1985; Jorm & Share, 1983). The point of phonological mediation is to provide the child with what Jorm and Share (1983) have termed a "positive learning trial" for an unknown word. Phonological mediation enables the child to associate a visual/orthographic representation of the word with its sound and meaning (Barron, 1986; Ehri, 1984, 1985). Once this early hurdle is cleared, the child will begin to attain the amount of reading practice that leads to other positive cognitive consequences.

However, just because phonological awareness enables word recognition via phonological recoding in beginning reading, it does not follow that this mechanism determines reading ability at all developmental levels. To the contrary, there is mounting evidence indicating that there is a developmental trend away from phonologically mediated word recognition in early reading stages toward direct, nonmediated visual access at more advanced stages of reading (Backman, Bruck, Hebert, & Seidenberg, 1984; Ehri, 1985; Ehri & Wilce, 1985; Juel, 1983; Reitsma, 1984; Waters, Seidenberg, & Bruck, 1984). (The controversy concerning the existence of an initial paired-associate learning stage will not be entered into here; see Ehri & Wilce, 1985; Gough & Hillinger, 1980.) Early development of decoding skill leads to many positive learning trials that provide opportunities for visual/orthographic codes to become established in memory as future access mechanisms for the recognition of words (Barron, 1986; Ehri, 1984, 1985; Henderson, 1982; Jorm & Share, 1983). Of course, the efficiency with which visual/orthographic codes are established may depend upon *more* than just phonological recoding skill. That is, equally proficient phonological decoders may still differ in their ability to form visual/orthographic codes. But this caveat does not change the essential features of the present discussion.

It appears that for fluent adults the vast majority of words that are encountered in print are recognized by direct visual access (Ellis, 1984; Henderson, 1982; Mason, 1978; McCusker, Hillinger, & Bias, 1981; Seidenberg, Waters, Barnes, & Tanenhaus, 1984; Waters et al., 1984). Phonological information appears to be activated prior to lexical access only for low-frequency or very difficult words (McCusker et al., 1981; R. Olson, Kliegl, Davidson, & Foltz, 1985; Perfetti, 1985, p. 59; Seidenberg, Waters, Barnes, & Tanenhaus, 1984; Waters & Seidenberg, 1985). Reader skill appears to mimic the frequency variable: The less skilled the reader, the more likely it is that phonological information is activated prior to word recognition (Waters et al., 1984). The existing evidence is consistent with a class of models in which phonological codes are automatically activated as a consequence of visual processing, are not under strategic control, and are determined solely by the time course of visual access (Perfetti, 1985; Seidenberg, 1985b; Seidenberg, Waters, Barnes, & Tanenhaus, 1984). Note that, according to these models, phonological information is less implicated in the *lexical access* processes of the fluent reader. They do not claim that phonological information is not implicated in reading at all. Instead, they posit that even in the fluent reader, such information is activated postlexically, where it serves to support comprehension processes operating on the contents of working memory.

The developmental trend toward word recognition via direct visual access suggests that individual differences in phonological awareness and phonological recoding skills observed at advanced stages of reading may be examples of *developmentally limited* relationships: those where individual differences in processes that cause variance in reading ability early in development at some point cease to be causal factors. The suggestion that phonological recoding skill may be involved in a developmentally limited relationship with reading has been advanced previously by Mason (1978). She speculated on the finding that, for adult college students as well as for young children, pseudoword naming (presumably an indicator of phonological decoding skill) is one of the best predictors of reading ability, even though other evidence indicates that adults recognize most words by direct visual access: "I suspect that the nonword decoding task differentiates skilled and less skilled readers because it provides a measure of linguistic awareness that, in turn, determines the ease with which reading *was* acquired in adult readers" (p. 579). Thus, just as when we gaze at the night sky we are actually observing the past history of stars, when we measure differences in phonological decoding skills in adults we may be tapping the mechanisms that earlier in their developmental histories led different individuals to diverge in the rates at which they acquired reading skill, but are not currently causing further variation in reading fluency.

Of course, some indicators of phonological skill may be tapping the speed with which phonological information is accessed *postlexically,* and these—unlike the use of phonological information for decoding purposes—may still be a determinant of current reading ability. That is, the availability of the phonological information that follows lexical access in the more advanced reader may be a critical factor in determining reading ability. Because of the integrated nature of orthographic and phonological codes in the fluent reader (Ehri, 1984; Jakimik, Cole, & Rudnicky, 1985; Perin, 1983; Seidenberg & Tanenhaus, 1979), fast visual access rapidly and automatically activates the phonological codes that serve a reference-securing function in working memory which facilitates comprehension (Perfetti, 1985). This is why it is important to note that in this section we are concerned with the use of phonological information at a prelexical stage.

In their study of developmental changes in the use of spelling-sound correspondences, Backman, Bruck, Hebert, and Seidenberg (1984) emphasized the importance of a distinction already discussed: the distinction between the availability of knowledge and the actual use of that knowledge in the word-recognition process. They highlighted two important trends in their data. Older and more skilled readers displayed a greater tendency to recognize words

without phonological mediation. They made fewer errors on words with homographic spelling patterns. At the same time, however, the more skilled readers were more rapidly expanding their knowledge of spelling-sound correspondences. This knowledge was indicated by a greater proportion of rule-governed errors and fewer errors on nonwords. These differences between readers of varying skill mirror an earlier developmental hypothesis of Venezky's (1976): "The reliance on letter-sound generalizations in word recognition slowly decreases as word identification ability increases, and the mature reader probably makes little use of them in normal reading. Nevertheless, the abililty to apply letter-sound generalizations continues to develop at least through Grade 8" (p. 22).

The conclusion of Backman, Bruck, Hebert, and Seidenberg (1984) that "children's knowledge of spelling-sound correspondences is increasing at the very time they are learning to recognize many words without using it" (p. 131) parallels that of Perfetti et al. (1979) in the domain of context effects on word recognition. The latter investigators found that although good readers were better at contextual prediction, they were less dependent on such prediction for word recognition, demonstrating that the existence of a knowledge base does not necessarily mean that the information from it is used to facilitate word recognition. The studies by Perfetti et al. (1979) and by Backman, Bruck, Hebert, and Seidenberg (1984) both indicate that the operation of rapid visual-access processes short-circuits the use of other information.

Backman, Bruck, Hebert, and Seidenberg (1984) elaborated their conclusions by distinguishing between the pre- and postlexical activation of phonological information. They noted that the finding that less skilled readers rely more on prelexical phonological information "does not mean that less skilled readers rely more on phonological information than do good readers, only that they utilize this information more in the *initial decoding* of words.... The confusion in the literature as to whether it is good or poor readers who rely more heavily upon phonological information in reading may be due in part to failing to distinguish between its pre- and postlexical functions. Poor readers may rely more upon this information, derived from spelling-sound knowledge, in word decoding, to their detriment; good readers may be more facile in using phonological information that is accessed postlexically, facilitating text comprehension" (p.131).

What the findings both of Backman, Bruck, Hebert, and Seidenberg (1984) and of Perfetti et al. (1979) emphasize is that in word recognition there is a developmental trend away from supplementing bottom-up processes of direct visual access with additional knowledge (spelling-sound correspondences and contextual expectancies). It appears that as reading skill develops, the word-recognition process during reading becomes increasingly modular (Fodor, 1983; Forster, 1979; Gough, 1983; Seidenberg, 1985a, 1985b; Seidenberg, Waters, Sanders, & Langer, 1984; Stanovich & West, 1983; Stanovich, Nathan, West, & Vala-Rossi, 1985). That is, word recognition via direct visual access occurs more autonomously, and other knowledge sources tend to interact only with the *outputs* of completed word recognition, not with the word-recognition process itself. When the task demands it, adults can utilize phonological mediation to name a stimulus (as in pseudoword naming), but ordinarily this mechanism is not used to support their ongoing processes of word recognition.

The hypothesis that adult differences in phonological coding are remnants of an earlier causal relationship suggests many questions that will require investigation. Even if the hypothesis is correct, the developmental change in the linkage between reading ability and individual differences in phonological coding skill will have to be fully traced. An intriguing possibility—already suggested by some research (Barron & Baron, 1977; Kimura & Bryant, 1983; Reitsma, 1983)—is that visual access for most words begins to develop very rapidly (e.g., after only a few exposures), rendering phonological coding differences noncausal relatively early in development. Finally, note that in the case of phonological recoding the term developmentally limited may be a slight mis-

nomer. Individual differences in this process may be less implicated in determining reading ability among older readers simply because fewer unknown words are encountered, but it may in fact be fully operative on those few occasions when such words occur.

Of course, phonological coding may be only one example of what might turn out to be a host of developmentally limited relationships. One intriguing candidate is individual differences in word-recognition efficiency itself. Although there is some evidence indicating that word-recognition efficiency is a causal determinant of reading skill (e.g., Biemiller, 1970; Blanchard, 1980; Herman, 1985; Lesgold, Resnick, & Hammond, 1985; Lomax, 1983), it has sometimes been difficult to demonstrate a causal connection, particularly in research employing adults and older children as subjects. For example, it has been surprisingly difficult to show that disrupting word-recognition processes diminishes comprehension (Levy, 1981; Masson & Sala, 1978; Wilkinson, Guminski, Stanovich, & West, 1981; but see Bowey, 1982) or that making word recognition more efficient results in better comprehension (Fleisher, Jenkins, & Pany, 1979; but see Blanchard, 1980; Blanchard & McNinch, 1980; Herman, 1985). Thus, the possibility that the causal link between individual differences in word-recognition efficiency and comprehension is developmentally limited deserves further investigation.

Some Variables Display Reciprocal Causation: Vocabulary

As mentioned in the introduction, one of the problems in conceptualizing the literature is that there are too many differences between good and poor readers. These differences lead to a plethora of explanations for reading failure, and in many cases the explanations are incompatible. Each investigator—emotionally wedded to his or her particular task(s)—likes to believe that his or her variable (and associated theory) is the key to understanding reading disability. The possibility that the difference observed is a consequence of the reading level or reading history is often not considered or, at most, is given a footnote or parenthetical comment. Of course, no one would wish to deny that individual differences in reading ability may be a function of the differential efficiency of many cognitive processes. However, the previous discussion was intended to suggest the possibility that the situation may have become overly confused through the indiscriminate application of the stricture "Reading ability is determined by variability in many different processes." In this review I have suggested that the literature on individual differences in reading could be considerably clarified if the number of potential causal relationships could be pared down by classifying some as consequences and some as having developmental limits.

Classifying relationships as either causes or consequences of reading ability of course does not exhaust the possibilities. Reading ability may be correlated with the efficiency of a certain cognitive process because both are linked to some third variable. For example, it is possible that a maturational lag in the general development of language abilities is what leads to the linkage between reading and phonological skills (Mann, 1984, 1986). Tallal (1980) has speculated on how a basic problem in processing rapidly presented information might serve to link low reading ability, speech disorders, and lack of phonological awareness.

Researchers investigating individual differences in reading have also become increasingly sensitized to the possibility that processes may be interlocked with reading in relationships of *reciprocal causation:* that individual differences in a particular process may cause differential reading efficiency, but that reading itself may in turn cause further individual differences in the process in question. There is mounting evidence that in the early acquisition stages this is precisely the status of phonological awareness and reading (Ehri, 1979, 1984, 1985; Perfetti, 1985, pp. 220-227; Perfetti, Beck, & Hughes, 1981). Individual differences in certain aspects of phonological awareness appear to be causally linked to variation in the ease of early reading

acquisition; but initial success at cracking the spelling-to-sound code further develops phonological awareness and provides the experiences necessary for the acquisition of increasingly differentiated phonological knowledge and the ability to access it consciously. Ehri (1979, 1984, 1985) has provided the most convincing evidence for the effects of orthographic representations on phonological awareness.

However, as hypothesized in the previous section, in the case of phonological awareness there is probably a developmental limit on the time course of the reciprocal relationship. If reading is progressing normally, children may move quickly into stages where direct visual access predominates (Barron & Baron, 1977; Kimura & Bryant, 1983; Reitsma, 1983) and variation in phonological awareness is no longer the primary causal determinant of differences in reading ability. This example illustrates that hypotheses involving the concept of reciprocal causation must be framed developmentally. For example, assume that individual differences in a certain process (call it *A*) both cause differences in reading acquisition and in turn are also affected by reading. However, suppose that at some point, variation in *A* no longer causes variation in reading ability. Then it is important to investigate whether the "kickback" from reading to *A* occurs early enough for the newly facilitated *A* to affect subsequent reading acquisition. The research question concerns whether the "bootstrapping" occurs early enough for a true reciprocal relationship to develop, or whether the facilitation of *A* occurs too late for its extra efficiency to cause further achievement differences in reading. In the case of phonological awareness, evidence from a longitudinal study by Perfetti et al. (1981) suggests that a true reciprocal relationship may be occurring.

Nevertheless, if the conclusion of the previous section is correct, then this bootstrapping involving phonological awareness has some inherent limits. There will be a point when the facilitation of phonological awareness by reading becomes much less important because the level of phonological awareness is no longer determining reading ability. A more powerful reciprocal relationship would be one that was operative throughout reading development. The motivational differences that are associated with variability in reading ability (e.g., Butkowsky & Willows, 1980; Oka & Paris, 1986) may be involved in relationships of this type. In this section we will explore what may be another example of such a potent reciprocal relationship: the association between vocabulary development and individual differences in reading ability.

The correlation between reading ability and vocabulary knowledge is sizeable throughout development (Anderson & Freebody, 1979; Mezynski, 1983; Stanovich, Cunningham, & Feeman, 1984a). Although, as in most areas of reading research, correlational evidence is much more plentiful than experimental evidence (Anderson & Freebody, 1979; Mezynski, 1983), there is a growing body of data indicating that variation in vocabulary knowledge is a causal determinant of differences in reading comprehension ability (Beck, Perfetti, & McKeown, 1982; McKeown, Beck, Omanson, & Perfetti, 1983; Stahl, 1983). It seems probable that like phonological awareness, vocabulary knowledge is involved in a reciprocal relationship with reading ability, but that—unlike the case of phonological awareness—the relationship is one that continues throughout reading development and remains in force for even the most fluent adult readers.

There is considerable agreement that much—probably most—vocabulary growth takes place through the inductive learning of the meanings of unknown words encountered in oral and written language. It appears that the bulk of vocabulary growth does not occur via direct instruction (Nagy & Anderson, 1984; Nagy, Herman, & Anderson, 1985; Jenkins & Dixon, 1983; Jenkins, Stein, & Wysocki, 1984; Sternberg, Powell, & Kaye, 1982; Sternberg, 1985). Also, there is substantial agreement among researchers that reading is a significant contributor to the growth of vocabulary. However, positions on this issue run from the conservative conclusion of Jenkins et al. (1984)—"Because we do not know how many words individuals know, we are seriously lim-

ited in accounting for changes in these totals. Whatever the totals, incidental learning from reading could account for some portion of the growth in vocabulary knowledge" (p. 785)—to the stronger position of Nagy and Anderson (1984)—"We judge that beginning in about the third grade, the major determinant of vocabulary growth is amount of free reading" (p. 327).

The role hypothesized for vocabulary in this review will reveal a bias toward the stronger position of Nagy and Anderson (1984). The association between variation in vocabulary knowledge and reading achievement seems a good candidate for a strong reciprocal relationship. Much more evidence on the nature of both causal connections clearly is needed, but recent studies that are methodologically superior to earlier work have provided support for causal mechanisms operating in both directions. Also, some recent theoretical extrapolations support the plausibility of a reciprocal bootstrapping interaction between vocabulary and reading.

Although some earlier studies had failed to verify the relation, recent research has demonstrated a causal connection between vocabulary knowledge and reading comprehension (Beck et al., 1982; McKeown et al., 1983; Stahl, 1983). Regarding the reverse connection, there has also been some research progress. The most recent estimates of children's vocabulary sizes serve to emphasize the futility of expecting major proportions of vocabulary growth to occur via direct instruction; they also serve to reinforce the importance of learning word meanings from encountering words in different contexts during free reading (Nagy & Anderson, 1984). However, until quite recently the evidence for the assumption that much vocabulary growth occurs through inducing the meanings of unknown words from context during reading was virtually nonexistent. This is because, as many investigators have pointed out (e.g., Jenkins et al., 1984; Nagy et al., 1985), most previous studies have focused on the ability to *derive* meanings from context when that was the explicit task set, rather than on the extent to which meanings are naturally learned during reading. However, recent studies by Jenkins et al. (1984) and Nagy et al. (1985) have indicated that learning from context during reading does occur (but see Schatz & Baldwin, this issue). Furthermore, an analysis of the extent of the vocabulary learning in both studies, taken in conjunction with some reasonable estimates of children's reading volume and vocabulary growth, led Nagy et al. (1985) to conclude, "Despite the uncertainties, our analysis suggests that words learned incidentally from context are likely to constitute a substantial portion of children's vocabulary growth" (p. 250).

Matthew Effects in Reading: The Rich Get Richer

If the development of vocabulary knowledge substantially facilitates reading comprehension, and if reading itself is a major mechanism leading to vocabulary growth—which in turn will enable more efficient reading—then we truly have a reciprocal relationship that should continue to drive further growth in reading throughout a person's development. The critical mediating variable that turns this relationship into a strong bootstrapping mechanism that causes major individual differences in the development of reading skill is the volume of reading experience (Fielding, Wilson, & Anderson, 1986; Nagy et al., 1985).

As previously discussed, Biemiller (1977-1978) found large ability differences in exposure to print within the classroom as early as midway through the first-grade year. Convergent results were obtained by Allington (1984). In his first-grade sample, the total number of words read during a week of school reading-group sessions ranged from a low of 16 for one of the children in the less skilled group to a high of 1,933 for one of the children in the skilled reading group. The average skilled reader read approximately three times as many words in the group reading sessions as the average less skilled reader. Nagy and Anderson (1984) estimated that, as regards in-school reading, "the least motivated children in the middle grades might read 100,000 words a year while the average children at this level might read 1,000,000. The figure for the voracious middle grade reader might be 10,000,000 or even as

high as 50,000,000. If these guesses are anywhere near the mark, there are staggering individual differences in the volume of language experience, and therefore, opportunity to learn new words" (p. 328). There are also differences in the volume of reading outside of the classroom that are linked to reading ability (Fielding et al., 1986), and these probably become increasingly large as schooling progresses.

The effect of reading volume on vocabulary growth, combined with the large skill differences in reading volume, could mean that a "rich-get-richer" or cumulative advantage phenomenon is almost inextricably embedded within the developmental course of reading progress. The very children who are reading well and who have good vocabularies will read more, learn more word meanings, and hence read even better. Children with inadequate vocabularies—who read slowly and without enjoyment—read less, and as a result have slower development of vocabulary knowledge, which inhibits further growth in reading ability. Walberg (Walberg et al., 1984; Walberg & Tsai, 1983), following Merton (1968), has dubbed those educational sequences where early achievement spawns faster rates of subsequent achievement "Matthew effects," after the Gospel according to Matthew: "For unto every one that hath shall be given, and he shall have abundance: but from him that hath not shall be taken away even that which he hath" (XXV:29).

The concept of Matthew effects springs from findings that individuals who have advantageous early educational experiences are able to utilize new educational experiences more efficiently (Walberg & Tsai, 1983). Walberg et al. (1984) speculated that "those who did well at the start may have been more often, or more intensively, rewarded for their early accomplishments; early intellectual and motivational capital may grow for longer periods and at greater rates; and large funds and continuing high growth rates of information and motivation may be more intensely rewarded. Thus, rather than the one-way causal directionality usually assumed in educational research, reverberating or reciprocal states may cause self-fulfilling or self-reinforcing causal processes that are highly influential in determining educational and personal productivity" (p. 92). In short, Walberg et al. (1984) emphasized that reciprocally facilitating relationships, like the one between vocabulary and reading, can be major causes of large individual differences in educational achievement.

The facilitation of reading comprehension by vocabulary knowledge illustrates a principle that has been strongly emphasized in much recent research on cognitive development: the importance of the current knowledge base in acquiring new information (Bjorklund & Weiss, 1985; Chi, Glaser, & Rees, 1982; Keil, 1984; Larkin, McDermott, Simon, & Simon, 1980). Sternberg (1985) has articulated the point in the context of vocabulary: "Thus, vocabulary is not only affected by operations of components, [but] it affects their operations as well. If one grows up in a household that encourages exposure to words, then one's vocabulary may well be greater, which in turn may lead to a superior learning and performance on other kinds of tasks that require vocabulary" (p. 123). Thus, one mechanism leading to Matthew effects in education is the facilitation of further learning by a previously existing knowledge base that is rich and elaborated. A person with more expertise has a larger knowledge base, and the large knowledge base allows that person to acquire even greater expertise at a faster rate. An analogous Matthew effect in reading arises from the fact that it is the better readers who have the more developed vocabularies.

There are several factors contributing to Matthew effects in reading development. For example, the research cited above has pointed to reading exposure differences between individuals of different skill levels. This is an example of the important principal of *organism-environment correlation:* Different types of organisms are selectively exposed to different types of environments. Recently, theorists have emphasized the importance of understanding that there are important organism-environment correlations that result from the child's own behavior (Lerner & Busch-Rossnagel, 1981; Plomin, DeFries, & Loehlin, 1977; Scarr & McCartney, 1983; Sternberg, 1985; Wachs & Mariotto, 1978). Organisms not only are acted on by their environments; they also select, shape, and evoke their own environments. Particularly

later in development (see Scarr & McCartney, 1983), a person has partly selected and shaped his or her own environment (sometimes termed *active* organism-environment correlation) and has been affected by the environment's response to the particular type of organism (sometimes termed *evocative* organism-environment correlation).

The differences in volume of reading between readers of differing skill are partly due to these active and evocative organism-environment correlations. Children who become better readers have selected (e.g., by choosing friends who read or choosing reading as a leisure activity rather than sports or video games), shaped (e.g., by asking for books as presents when young), and evoked (e.g., the child's parents noticed that looking at books was enjoyed or perhaps just that it kept the child quiet) an environment that will be conducive to further growth in reading. Children who lag in reading achievement do not construct such an environment. Anbar (1986) noted the importance of these active and evocative organism-environment correlations in her studies of children who acquired reading before school: "Once the parents began to interact with their children around the reading activities, the children reciprocated with eagerness. The parents then intuitively seemed to follow the child's learning interests and curiosity, sensitively responding to requests for aid. One could say, therefore, that the parents facilitated the child's natural course of development" (p.77).

However, the vocabulary superiority of the better reader is due to more than just the differential exposure to written language that is the result of active and evocative organism-environment correlations. As Sternberg (1985, pp. 306-308) has emphasized, although the amount of practice and extent of the knowledge base are important factors in acquiring expertise, the sheer amount of experience is less than perfectly correlated with the level of skill attained in a particular domain. This point applies to reading and vocabulary. Although better readers are indeed exposed to more written language, they are also superior at deriving the meanings of unknown words from a passage when differences in the knowledge base are controlled. Sternberg (1985; Sternberg & Powell, 1983; Sternberg, Powell, & Kaye, 1982) found that the ability to derive the meanings of unknown words from unfamiliar passages displayed a correlation of .65 with reading comprehension ability. Interestingly, in the two best controlled studies of learning word meanings from natural reading (Nagy et al., 1985; Jenkins et al., 1984), there was also a tendency for the better readers to learn more word meanings. Thus, there appears to be evidence for several different mechanisms involving vocabulary and reading that operate to create rich-get-richer effects. Better readers are exposed to more written language than poorer readers; the expanded knowledge base that they thus acquire probably facilitates the induction of new word meanings; and finally, better readers appear to learn new words from context with a greater efficiency than do less able readers even when differences in the knowledge base are controlled.

Matthew Effects and the Less Skilled Reader

Because Matthew, or rich-get-richer, effects have been shown to be an important source of achievement variance in many areas of schooling, researchers need to explore more fully the operation of such effects in the domain of reading. Also, of course, the other side of the coin, poor-get-poorer effects, may help to explain certain aspects of reading failure. For example, Matthew effects may arise from conditions other than those described above. In addition to the achievement differences that will occur as a result of the information processing efficiency of the better reader (e.g., Sternberg, 1985) and the exposure differences resulting from active and evocative organism-environment correlations (e.g., Nagy & Anderson, 1984), there are also *passive* organism-environment correlations that contribute to rich-get-richer and poor-get-poorer effects. A passive organism-environment correlation is a relationship between the type of organism and environmental quality that is not due to the organism's active selection and shaping of the environ-

ment. Some of these passive organism-environment effects are unavoidable, such as the passive genotype/environment effects discussed by Scarr and McCartney (1983): The genotypes of a child's parents partially determine both the home environment of the child and the child's genotype. Other passive organism-environment correlations are a function of social structures: Less healthy organisms grow up in impoverished environments. Biologically unlucky individuals are provided with inferior social and educational environments, and the winners of the biological lottery are provided better environments (Rutter & Madge, 1976).

An example of a passive organism-environment correlation that contributes to Matthew effects is provided by the literature on the influence of a school's ability composition on academic achievement. The evidence, as summarized by Rutter (1983), indicates that "quite apart from the individual benefits of above-average intellectual ability, a child of any level of ability is likely to make better progress if taught in a school with a relatively high concentration of pupils with good cognitive performance" (p. 19). But of course a child of above-average ability is much more likely to reside in a school with a "concentration of pupils with good cognitive performance" (Jencks, 1972). Such a child is an advantaged organism because of the superior environment and genotype provided by the child's parents. The parents, similarly environmentally and genetically advantaged, are more likely to reside in a community which provides the "concentration of pupils" that, via the independent effects of school composition, will bootstrap the child to further educational advantages. Conversely, disadvantaged children are most often exposed to inferior ability composition in the schools that they attend. Thus, these children are the victims of a particularly perverse "double whammy."

Recently, Share et al. (1984) uncovered some fascinating ability-composition effects that illustrate how passive organism-environment correlations contribute to Matthew effects in the area of reading achievement. They investigated the relationship of 39 cognitive and home environment variables measured at kindergarten entry to reading achievement at the end of kindergarten and of Grade 1. (In Australia, the country of these subjects, formal reading instruction begins in kindergarten.) Share et al. (1984) tested over 500 subjects in many different classrooms located in several different schools. Their ability-composition analysis focused on phoneme segmentation ability because it was the single best predictor of reading achievement. Each child was assigned three phoneme segmentation scores. One was the child's own score on the phoneme segmentation test. Next, the mean score of each classroom was calculated and assigned to each child in that room. Finally, the mean score for each school was calculated and assigned to each child in that school. The zero-order correlations confirmed for phonological awareness—a critical determinant of the ease of initial reading acquisition—what is observed for ability in general: Higher ability students are surrounded by higher ability peers. The correlation between individual and classroom phoneme segmentation ability was .59, and the correlation between individual and school phoneme segmentation ability was .45.

But does being surrounded by better phoneme segmenters make a difference in early reading? Apparently it does. The child's own phoneme segmentation ability at kindergarten entry correlated .65 with that year's reading achievement (correlations were similar for Grade 1 reading achievement); the correlations involving the classroom and school means were .64 and .68. After *all 39* cognitive and home background variables had been entered into a regression equation predicting end-of-kindergarten reading ability (the results were similar when Grade 1 ability was the criterion variable), the school ability mean accounted for a statistically significant additional 9% of the variance. After the individual variables were entered, classroom mean accounted for an additional 5% of the variance in individual kindergarten achievement (again, statistically significant). Note that the 39 variables entered first include the child's *own* phoneme segmentation ability!

Although Share et al. (1984) have speculated on the reasons for these ability-composi-

tion effects (teacher responsiveness to ability differences, language interactions among the children, etc.), the issue of the precise mechanism involved is beyond the scope of this review. For the present purpose, the importance of the Share et al. findings is in the demonstration of an ability-composition effect—a passive organism-environment correlation that contributes to poor-get-poorer effects in achievement—in the domain of phonological awareness and reading. Unlike some of the unavoidable organism-environment correlations discussed by Scarr and McCartney (1983), this one is partially a function of social policy. It is controllable, perhaps unlike many such correlations that contribute to Matthew effects in education. Rutter (1983) emphasized this point in his conclusion: "Nevertheless, the implication is that there are considerable disadvantages in an educational system that allows such an uneven distribution of children that some schools have intakes with a heavy preponderance of the intellectually less able. There can be no dodging the need to ensure a reasonable balance of intakes among schools, but the best way to do this is not obvious" (p. 20). This example illustrates the importance of research aimed at uncovering the existence and causes of Matthew effects in reading, because a thorough understanding of the causes is a necessary prerequisite to sound social policy in education.

Reconceptualizing the Reading Disability Literature in Terms of Reciprocal Causation and Matthew Effects

A thorough exploration of the possible influence of reciprocal relationships and Matthew effects on observed performance profiles might help to clarify some problematic issues in the area of individual differences in reading ability. For example, reading disabilities would be better understood if some of the observed individual differences could be differentiated as cases of consequences of reading level or history, or as cases of reciprocal causation. Indeed, I will argue in this section that a consideration of the relationships between reading and other cognitive skills in terms of the concepts outlined above can help to resolve some recurrent problems in the area of reading disabilities (or dyslexia; these terms are used interchangeably in the following discussion). Some of these conceptual problems are so serious that they threaten to undermine the entire field if they are not soon resolved. For example, one assumption that is essential to all definitions of reading disability is the "assumption of specificity" (Hall & Humphreys, 1982; Stanovich, 1986). This assumption underlies all discussions of the concept, even if it is not stated explicitly. Simply put, it is the idea that a child with this type of learning disability has a brain/cognitive deficit that is reasonably specific to the reading task. That is, the concept of a specific reading disability requires that the deficits displayed by such children not extend too far into other domains of cognitive functioning. If they did, there would already exist research and educational designations for such children (low intelligence, "slow learner," etc.), and the concept of reading disability would be superfluous.

The assumption of specificity is contained within virtually all psychometric and legal definitions of reading disability, and it is also quite salient in media portrayals of dyslexia. The typical "media dyslexic" is a bright, capable individual with a specific problem in the area of reading (the quintessential example of the white-collar worker who through dictation, secretaries, and various office maneuvers, covers up the fact that he cannot read). In terms of the concepts I have developed in this review, such individuals have remained immune to the negative cascade of interacting skill deficits and Matthew effects surrounding reading. For example, their vocabularies and other language abilities have continued to develop without the benefit of reading, and they have (to some degree) avoided the negative motivational consequences of reading failure. It will be argued here that the number of such individuals—those who truly escape the snowballing consequences of reading failure—is much smaller than is commonly presumed.

A major problem in the area of reading disabilities research is that the literature on individual differences in the cognitive processes related to reading has undermined the assumption of specificity. When researchers went looking for cognitive differences between reading disabled and nondisabled children, they found them virtually everywhere. The plethora of cognitive differences that have been uncovered threatens to undermine the concept of a reading disability because the existence of such differences calls into question the assumption of specificity and instead suggests that dyslexic children exhibit rather generalized cognitive deficits.

Consider the concatenation of processes that have been found to differentiate disabled from nondisabled readers. Not surprisingly, phonemic awareness and associated spelling-to-sound decoding skills are markedly deficient in disabled readers (Bradley & Bryant, 1978; Gough & Tunmer, 1986; Snowling, 1980, 1981). However, more general aspects of speech perception have been implicated by the findings of Brady, Shankweiler, and Mann (1983) that poor readers make more perceptual errors when listening to speech in noise, and the findings of Godfrey, Syrdal-Lasky, Millay, and Knox (1981) that disabled and nondisabled readers differ in the categorical perception of certain speech contrasts. Briggs and Underwood (1982) have presented evidence of a deficit in the speech code that is closer to articulatory in level, and Tallal (1980) has even uncovered processing deficits with nonspeech auditory stimuli. Of course, naming deficits have also long been associated with reading failure (Denckla & Rudel, 1976; Spring & Capps, 1974; Wolf, 1984). Thus, indications are that the speech and auditory processing problems of the disabled reader are multiple and pervasive.

Moreover, language processing differences have turned up at other levels. Syntactic knowledge and awareness seem to be deficient in disabled readers (Bowey, 1986; Byrne, 1981; Hallahan & Bryan, 1981; McClure, Kalk, & Keenan, 1980; Menyuk & Flood, 1981; Newcomer & Magee, 1977; Semel & Wiig, 1975; Siegel & Ryan, 1984; Stein, Cairns, & Zurif, 1984; Vellutino, 1979; Vogel, 1974). Their performance is relatively low on tests of general listening comprehension and general linguistic awareness (Berger, 1978; Downing, 1980; Kotsonis & Patterson, 1980; Menyuk & Flood, 1981; Newcomer & Magee, 1977; Siegel & Ryan, 1984; Smiley, Oakley, Worthen, Campione, & Brown, 1977). Comprehension strategies that are very general seem to be deficient. Concatenating these findings with those on phonological awareness and speech cited previously, we seem to be uncovering a deficiency in a "specific" area that can only be labeled "language—in all its conceivable aspects." This is not the type of "specific" psychological disability that the originators of the idea of dyslexia had in mind.

Work on short-term memory as a psychological locus of the processing difficulties of disabled readers was originally motivated by the desire to uncover a specific "site" that was the source of reading problems. Although some proportion of the performance difference between normal and disabled readers on short-term memory tasks is almost certainly due to the specific phonological coding problems experienced by the latter (R.L. Cohen, 1982; Jorm, 1983; Torgesen & Houck, 1980), research on individual differences in memory performance soon pushed the mediating cognitive mechanisms far beyond an explanation purely in terms of phonological coding. Cognitive and developmental psychologists have linked many processing strategies to memory performance, and research has shown reading disabled children to be deficient in their ability and/or willingness to employ virtually every one of these strategies (Bauer, 1977, 1979, 1982; Foster & Gavelek, 1983; Newman & Hagen, 1981; Tarver, Hallahan, Kauffman, & Ball, 1976; Torgesen, 1977a, 1977b, 1978-1979; Torgesen & Goldman, 1977; Wong, Wong, & Foth, 1977). These findings have led to characterizations of the underlying cognitive deficit of learning disabled children that are strikingly general. For example, Torgesen's (1977a, 1977b) early work on memory functioning led him to characterize the learning-disabled child as an inactive

learner, one who fails to apply even cognitive strategies that are within his or her capabilities.

Torgesen's notion is of course similar to currently popular ideas regarding the importance of metacognitive or executive functioning. Indeed, recent work on the performance of reading disabled children has reinforced Torgesen's earlier position and explicitly tied his ideas in with recent views on metacognitive functioning (Baker, 1982; Bos & Filip, 1982; Foster & Gavelek, 1983; Hagen, Barclay, & Newman, 1982; Hallahan & Bryan, 1981; Wong, 1984). However, the tendency to link deficiencies in metacognitive functioning with reading disability will undermine the assumption of specificity. Recent conceptualizations (e.g., Baron, 1978; Campione & Brown, 1978; Sternberg, 1980, 1982, 1985) have stressed that metacognitive awareness of available strategies is a critical aspect of *intelligence!* Thus, further developments along these lines will surely evolve a paradoxical conclusion: that reading disabled children are deficient in a generalized ability to deal with cognitive tasks of all types (i.e., that they lack metacognitive awareness: a critical aspect of intelligence). This, of course, would be the death knell for the assumption of specificity, and hence the entire rationale for the concept of dyslexia would be undermined.

Escaping the Paradox: Subject Selection

There are at least three ways to escape the dilemma posed by the fact that the literature on individual differences in the cognitive processes of reading threatens to erode the fundamental assumption upon which the concept of dyslexia rests. One is to question the nature of the subject samples employed in the research. It may be that the less skilled children were not sufficiently disabled: that many studies contained substantial numbers of children who were experiencing only a moderate degree of reading difficulty and whose cognitive performance profiles—unlike those of the truly disabled reader—were characterized by mild but pervasive deficits. To the extent that some investigators have employed primarily school labeling as the criterion for forming subject groups—rather than scores on their own self-administered tests and strictly applied psychometric criteria—this criticism is appropriate.

Since the advent of the concept of a reading disability, it has repeatedly been pointed out that schools do not identify reading-disabled children in accord with the actual definitions of dyslexia prevailing in the professional literature (Ames, 1968; Bryan, 1974; Kirk & Elkins, 1975; Miller & Davis, 1982; Norman & Zigmond, 1980). We have come to think of a reading-disabled child—in the view that is certainly the one promoted by parent groups and the media—as a child with normal intelligence. But surveys of school-labeled reading disabled children have consistently shown that even on nonverbal and performance intelligence tests, the mean score of the children does not approximate 100, but is usually closer to 90 (Anderson, Kaufman, & Kaufman, 1976; Gajar, 1979; Hallahan & Kauffman, 1977; Kirk & Elkins, 1975; Klinge, Rennick, Lennox, & Hart, 1977; Leinhardt, Seewald, & Zigmond, 1982; McLeskey & Rieth, 1982; Norman & Zigmond, 1980; Satz & Friel, 1974; Shepard, Smith, & Vojir, 1983; Smith, Coleman, Dokecki, & Davis, 1977; Tarver, 1982; Valtin, 1978-1979).

Thus, to the extent that school-labeled samples have been used, researchers have been comparing less skilled readers with mild IQ deficits to the normal control groups, and it is perhaps not surprising that a large number of performance differences have appeared. This problem extends even to research where an attempt has been made to match (or restrict the range of) the reading-disabled and control groups on other environmental variables (Fletcher, Satz, & Scholes, 1981; Hallahan & Kauffman, 1977; Klinge et al., 1977). For example, from a group of 108 learning-disabled children, Klinge et al. (1977) selected 30 children to match 30 controls on sex, race, age, socioeconomic status, and geographic community. Despite the matching, the mean performance intelligence test score of the learning-disabled group (94) was 9 points lower than that of the control group (103).

The problem is pervasive even in research studies that have attempted to match subjects on

intelligence test scores. Although these procedures often ensure that the intelligence test scores of the reading-disabled sample approximate 100 and are not significantly different from those of the control group, it is almost invariably the case that the IQs of the disabled group turn out to be lower (Hall & Humphreys, 1982; Stanovich, 1986; Torgesen, 1985). In a formal survey of the research literature, Torgesen and Dice (1980) found that the mean intelligence test scores of the learning-disabled groups averaged 6 points lower than those of the control groups. Wolford and Fowler (1984), in their survey, came to similar conclusions.

A discussion of the IQ matching problem leads naturally to a consideration of some of the statistical problems surrounding the concept of reading disability—statistical complications often unknown to the teachers and practitioners who are using the concept. For example, it is well known that performance on intelligence tests correlates with reading achievement. This correlation is usually in the range of .3 to .5 in the early elementary grades, but rises to the range of .6 to .75 in adult samples (see Stanovich, Cunningham, & Feeman, 1984a). An individual with a reading disability is by definition a person for whom this performance linkage does not hold, or at least for whom it is severely attenuated. Such a person has severely depressed performance on one variable (reading) but virtually normal performance on the other (intelligence test score). These individuals are statistical outliers, defined by their deviation from the regression line in a scatterplot of reading achievement scores against intelligence test scores. It is important to realize that because part of the outlier status of this group *must* be the result of measurement error, on a retesting (due to statistical regression) they will score lower on the IQ test (or highly related cognitive measure) and somewhat higher on the reading test (Crowder, 1984; Hall & Humphreys, 1982). Defining reading-disabled children on the basis of a single testing will conceal this fact and thus artificially magnify their outlier status (Shepard, 1980). A reading-disabled classification that partially reflects measurement error will contribute to the plethora of deficits obtained, because whatever cognitive tasks are administered become the "second testing" on which these subjects will regress to performance levels below those of their IQ-matched, nondisabled controls.

When we combine the purely statistical artifact of regression with the empirical fact, reviewed above, that the reading-disabled children in the schools and in research reports have mild IQ deficits, we may have a large part of the explanation for the tendency of the research literature to undermine the assumption of specificity. To some extent, the children in these samples *should* have small but pervasive cognitive deficits, because on one omnibus index of cognitive functioning (an intelligence test) they show a small deficit. They are not the extreme statistical outliers that the definitions of reading disability imply. Secondly, the moderate outlier pattern that they do display is, in part, measurement artifact.

The solutions to these statistical problems have clear implications for research and practice. Both practitioners and researchers should adopt a much stricter psychometric criterion for defining a child as reading-disabled. A second testing to insure that the bulk of the performance discrepancy is not measurement artifact is essential for accurate classification (see Shepard, 1980). It is only by isolating the true outliers that researchers can hope to obtain the evidence for specificity that the dyslexia concept requires if it is to be of scientific and practical utility. The parent groups who have pushed for ever-more-inclusive definitions of dyslexia (estimates from such groups often claim that anywhere from 10% to 30% of the school population should be so labeled) are indirectly undermining the concept. The wider the net that is cast, the greater will be the difficulties in distinguishing dyslexia from other educational designations (e.g., borderline retardation, EMR). Lack of restraint in applying the label is in part responsible for the failure of researchers to demonstrate consistently that the performance profiles of disabled subjects differ reliably from those of other poor readers (Algozzine & Ysseldyke, 1983; Bloom, Wagner, Reskin, & Bergman, 1980; Coles, 1978; Gottesman,

Croen, & Rotkin, 1982; Taylor, Satz, & Friel, 1979), and it is one of the main reasons why the diagnostic utility of the concept of dyslexia continues to be questioned (Arter & Jenkins, 1979; S. Cohen, 1976; Coles, 1978; Gross & Gottlieb, 1982; Miller & Davis, 1982; Ysseldyke & Algozzine, 1979).

The best existing evidence in favor of demarcating reading disability as a qualitatively distinguishable behavioral concept comes from the epidemiological Isle of Wight study reported by Rutter and Yule (1975; Rutter, 1978; Yule, 1973). Their study contrasts with many others that have failed to distinguish reading-disabled children from other poor readers (Bloom et al., 1980; Coles, 1978; Taylor et al., 1979), and two of its critical features deserve attention. One was the use of regression procedures to define outliers (Horn & O'Donnell, 1984; Shepard, 1980; Wilson & Cone, 1984). But probably most important was their use of a conservative criterion for classifying a case as an outlier; as a result, only 3.7% of the subjects in their sample were classified as "specifics." A conservative criterion like that employed by Rutter and Yule (1975) is probably essential in forming samples that stand a chance of providing evidence consistent with the assumption of specificity. It seems reasonable to speculate that only studies that classify less than 5% of the sampled population as reading-disabled will stand a chance of uncovering evidence for specificity. When the proportion gets much above 5%, one will probably observe more generalized deficits.

Escaping the Paradox: Subtypes

A second way of putting the assumption of specificity on a firmer footing—and one that by no means excludes the previous recommendation of a conservative criterion—is suggested by the "subtypes" argument. This is the argument that there may be many subtypes of reading disability, and that if a research sample comprises several subtypes (each with a distinct, but different, single-factor deficit), the overall results from the sample will mistakenly seem to indicate multiple deficits. Although this is a logical possibility, the subtyping literature itself remains confusing (Jorm, 1983; Lundberg, 1985; R. Olson, Kliegl, Davidson, & Foltz, 1985; Perfetti, 1985; Stanovich, 1986; Vellutino, 1979), and has produced no strong evidence implicating subtypes in the wide variety of deficits that have been observed. In fact, most researchers would probably find themselves having to agree that no "tight" subgroupings have been identified (Stanovich, 1986) and to accept Jorm's (1983) statement that "there is no agreed-upon taxonomy of subtypes" (p. 312). However, newer research methodologies for evaluating the subtype hypothesis are just beginning to be evaluated (Doehring, Trites, Patel, & Fiedorowicz, 1981; Lovett, 1984; Torgesen, 1982). Pursuing the subtype hypothesis, in conjunction with using a conservative definition of reading disability, might establish a firmer empirical foundation for the assumption of specificity.

Escaping the Paradox: A Developmental Version of the Specificity Hypothesis

There is, however, a third alternative—again, not exclusive of searching for subtypes and using a conservative criterion—which may be theoretically the most interesting. This alternative is to hypothesize developmental change in the cognitive specificity of the deficits displayed by reading-disabled children; change that is in part a consequence of individual differences in reading acquisition and the reciprocal relationships between reading, other cognitive skills, and motivational factors. This hypothesis follows from the tentative causal model presented earlier.

According to this hypothesis, the performance of reading disabled children *is* characterized by a relatively high degree of specificity upon entering school (see Jorm, Share, Maclean, & Matthews, 1986). The obvious candidate for the critically deficient process is phonological awareness. Thus, it is hypothesized that due to several incompletely determined—but undoubtedly complex and interacting—genetic and environmental causes (Chall, 1983; S. Cohen, Glass, & Singer, 1973; Duane, 1983; Feitelson & Goldstein, 1986; Guthrie, 1981; Rutter et al., 1974; Stevenson et al., 1985), children who will later be candidates for the label of reading-disabled enter school with markedly underdeveloped phonological awareness, but with either mild deficits in other cogni-

tive skills or none at all. Deficient phonological awareness makes it difficult for the child to understand the alphabetic principle and delays the breaking of the spelling-to-sound code. The differences in in-school exposure to text chronicled by Allington (1980, 1983, 1984) and Biemiller (1977-1978) begin to build up by the middle of the first-grade year. These exposure differences compound any out-of-school differences already present and leave reading-disabled children farther behind their peers in the development of the rapid, automatic processes of direct visual recognition. These processes enable the type of reading for comprehension that is more enjoyable than that encumbered by the cognitively demanding conscious process of "sounding out." The resulting motivational differences lead to further increases in the exposure differences between good and poor readers that are then exacerbated by further developments such as the introduction of more difficult reading materials.

Of course, the exact timing of this developmental sequence and of its feedback effects remains to be worked out. What is critical for the present discussion is the hypothesis that at some point, slower progress at reading acquisition begins to have more *generalized* effects: effects on processes that underlie a broader range of tasks and skills than just reading. That is, the initial specific problem may evolve into a more generalized deficit due to the behavioral/cognitive/motivational spinoffs from failure at such a crucial educational task as reading. For example, at some point reading exposure differences begin to result in marked divergences in the vocabularies of skilled and less skilled readers, and those vocabulary differences have implications for other aspects of language use. The same is probably true of syntactic knowledge and world knowledge.

Perhaps just as important as the cognitive consequences of reading failure are the motivational side effects. These are receiving increasing attention from researchers. Butkowsky and Willows (1980) manipulated success and failure in a reading and a nonreading task. The poor readers in the fifth-grade sample were less likely to attribute success to ability, and more likely to attribute it to luck or to the easiness of the task, than were the better readers. Following failure, however, they were more likely to attribute their performance to ability and less likely to attribute it to luck or task difficulty. The poorer readers also displayed less task persistence than the better readers. Their behavioral and attributional patterns displayed characteristics consistent with the concept of academic learned helplessness, which has been studied in several areas of educational achievement (Diener & Dweck, 1978; Fowler & Peterson, 1981; Johnston & Winograd, 1985; Licht & Dweck, 1984; Torgesen & Licht, 1983). Interestingly, the same behavioral and attributional patterns were displayed on the nonreading task as on the reading task, indicating that by this age, achievement-thwarting motivational and behavioral tendencies were being exhibited on tasks other than reading, even though the disabled group was constituted solely on the basis of lagging reading achievement. Thus, the learned helplessness that may have been the result of reading failure was beginning to influence performance on other cognitive tasks, perhaps eventually leading to an increasingly generalized inability to deal with academic and cognitive tasks of all types. Thus, not only the negative cognitive effects but also the motivational spinoffs of reading failure can lead to increasingly global performance deficits.

Butkowsky and Willows (1980) point to the possibility of a negative Matthew effect in their paper—"These data provide convincing evidence in support of the notion that children with reading difficulties may display an eroding motivation in achievement situations that increases the probability of future failure" (p. 419)—and they suggest one mechanism contributing to this effect. They note that the lower persistence that is part of the learned helplessness pattern is self-defeating: "Children who give up easily in the face of difficulty may never persist long enough at a task to discover that success may, in fact, be possible. Such children may never spontaneously discover that they do possess the capacity to achieve outcomes that exceed their expectations" (p. 419).

Perfetti (1985) has explicated these proliferating Matthew effects and the related motiva-

tional problems using the framework of his verbal efficiency theory:

> The low-achieving reader starts out behind in terms of some of the linguistic knowledge on which this verbal processing system gets built. He falls farther behind as his reading experiences fail to build the rich and redundant network that the high-achieving reader has. By the time a fifth-grade student is targeted for remediation, the inefficiency (and ineffectiveness) of his (or her) verbal coding system has had a significant history. To expect this to be remedied by a few lessons in decoding practice is like expecting a baseball player of mediocre talent to suddenly become a good hitter following a few days of batting practice. This problem, the need for extended practice, is unfortunately coupled with the problem of motivation. (p. 248)

Evaluating a Developmental Version of the Specificity Hypothesis

The hypothesis entertained here is that there is a developmental trend in the specificity of the disability: A specific cognitive deficit prevents the early acquisition of reading skill. Slow reading acquisition has cognitive, behavioral, and motivational consequences that slow the development of other cognitive skills and inhibit performance on many academic tasks. In short, as reading develops, other cognitive processes linked to it track the level of reading skill. Knowledge bases that are in reciprocal relationships with reading are also inhibited from further development. The longer this developmental sequence is allowed to continue, the more generalized the deficits will become, seeping into more and more areas of cognition and behavior. Or, to put it more simply—and more sadly—in the words of a tearful nine-year-old, already falling frustratingly behind his peers in reading progress, "Reading affects everything you do" (Morris, 1984, p. 19).

The presence of a developmental trend in the specificity of the disability may in part account for why the literature has failed to uncover strong evidence for specificity and instead has augmented the number of possible cognitive deficits: The subjects in many of the studies may have been so developmentally advanced that generalized cognitive deficiencies had begun to appear. This account is certainly true of studies of cognitive differences among adult readers of varying skill.

At present, there is little direct evidence with which to evaluate this developmental variant of the specificity hypothesis. Clearly, we need longitudinal research designs to obtain the most diagnostic data. Also, such a developmental trend may be difficult to detect because the period during which specificity might be observed could be quite short. Perhaps it is only in the very earliest stages of reading acquisition—when the seriously disabled readers may be harder to identify—that considerable cognitive specificity occurs. Again, the need for longitudinal data is obvious.

There are many other methodological, conceptual, and statistical problems in evaluating some of the predictions that follow from the hypothesis. One such prediction is that reading and the cognitive skills related to it should become more interrelated with development. Unfortunately, this predicted trend will probably be confounded with the fact that more complex cognitive processes are engaged mainly at the more advanced levels of reading (Chall, 1983). For example, the more complex types of inferencing skills are necessary only when the material being read attains a certain level of difficulty. Thus, the correlation between reading and these cognitive skills will increase not only because of the consequences of differential reading experience, but also because the *task* of reading is changing (Chall, 1983). Separating the operation of these two mechanisms could be extremely difficult.

Additionally, researchers who attempt to evaluate the hypothesis during the developmental stages that are critical—the very earliest reading acquisition stages—will encounter some statistical complications. For example, the reliability of some tasks may increase during this period, necessarily leading to changes in correlations. It is not surprising, given these difficulties, that there is currently little evidence

to permit a strong test of the developmental version of the specificity hypothesis. Nevertheless, there are some suggestive trends in the literature that should at least motivate more definitive tests. The hypothesis is worth pursuing because—like the subtypes hypothesis, for which there is arguably little more evidence—it may provide a way of preserving the assumption of specificity (and the concept of dyslexia) in the face of the mounting body of data indicating pervasive cognitive deficiencies.

Developmental studies of multivariate relationships between reading-related cognitive processes have yielded suggestive evidence that the intercorrelation of subskills increases with age. In one study, we (Stanovich, Cunningham, and Feeman, 1984a) found that at the end of first grade, measures of phonological awareness, decoding speed, vocabulary, listening comprehension, and abstract problem-solving were only weakly correlated; but by the fifth grade, performance on these tasks was highly correlated. In the first grade the mean correlation between tasks tapping different cognitive skills was .24, whereas this correlation rose to .59 in the fifth grade. A similar trend runs through the correlations reported by Curtis (1980). Comparisons of other multivariate studies of reading-related skills in the early grades (e.g., Stevenson, Parker, Wilkinson, Hegion, & Fish, 1976) with adult studies (e.g., M. Jackson & McClelland, 1975, 1979) suggest a similar pattern.

In a test of several components of memory functioning, Brainerd, Kingma, and Howe (1986) found that second-grade learning-disabled children displayed deficits primarily in poststorage-retrieval learning, whereas in the sixth grade, deficits appeared there as well as in storage and in prestorage-retrieval aspects of performance. These results suggest that the memory problems of learning-disabled children become more pervasive as they grow older. R.L. Cohen (1982) presented results suggesting a similar pattern operating at an even earlier stage in development. He found that performance in nonstrategic serial memory tasks measured in kindergarten was related to first-grade reading ability, but that performance on a strategic memory task was not. However, when assessed in the first grade, both types of memory tasks were related to reading ability. In an argument similar to the one being developed in this section, R.L. Cohen (1982) speculated that deficits on the nonstrategic and strategic memory (STM) tasks were of two different types, "the former being one manifestation of their basic deficit and the latter being an acquired deficit" because "following academic experience that comprises practice in ineffective reading, these children will not develop the strategies required for successful performance in other STM tasks." (p. 51)

Bishop and Butterworth (1980) have reported one of the few longitudinal studies within the relevant age range, and their data are quite suggestive. They found that performance and verbal IQs assessed at age 4 were equally good predictors ($r = .36$) of reading ability at age 8; however, when assessed concurrently with reading ability at age 8, verbal IQ displayed a stronger relationship. Furthermore, the children in their sample who had reading problems at age 8 appeared to have lower verbal than performance IQ scores at age 8, but did not at age 4. These trends are consistent with the idea that success or failure at the initial stages of reading acquisition has effects on more general aspects of verbal intelligence.

Studies of reading-related cognitive skills in the early grades have consistently indicated that the different cognitive processes are only weakly interrelated. Our (Stanovich, Cunningham, & Feeman, 1984a) mean correlation of .24 is similar to that reported by other researchers, as follows: Blachman (1984), .30; Curtis (1980), .32, .27; Evans and Carr (1985), .39, .18; Share et al. (1984), .38; and Stevenson et al. (1976), .14, .26, .09, and .32. Although low reliabilities may be attenuating some of these correlations, these results do suggest the interesting possibility of considerable dissociation between the cognitive subskills related to reading when a child enters school. Such a relatively loose linkage between cognitive skills in the early grades would allow greater cognitive specificity among younger poor readers.

A similar pattern of relative dissociation appears when one examines the correlations between reading ability and scores on various intelligence tests. Although these correlations cluster in the ranges of .45 to .65 in the middle grades and .60 to .75 among adults, they are more commonly between .30 and .50 in the early elementary grades (see Stanovich, Cunningham, & Feeman, 1984a). Of particular interest is the finding that performance on phonological awareness tasks in kindergarten and first grade often predicts subsequent reading achievement better than intelligence tests that tap a variety of cognitive processes (Bradley & Bryant, 1983, 1985; Goldstein, 1976; Mann, 1984; Share et al., 1984; Stanovich, Cunningham, & Cramer, 1984; Stanovich, Cunningham, & Feeman, 1984a; Torneus, 1984; Tunmer & Nesdale, 1985; Zifcak, 1981). (Of course, it has long been known that letter knowledge prior to entering school is a better predictor of initial reading acquisition than IQ: Chall, 1967; Richek, 1977-1978; Stevenson et al., 1976.)

Additionally, several studies have demonstrated that phonological awareness accounts for a statistically significant and sizeable portion of variance in reading ability after the variance associated with standardized intelligence measures has been partialled out (Bradley & Bryant, 1983, 1985; Goldstein, 1976; Stanovich, Cunningham, & Feeman, 1984a; Tunmer & Nesdale, 1985). In short, some suggestive evidence does exist to indicate that, at school entry, phonological awareness is dissociated from other cognitive skills to such an extent that it could be the source of a specific reading disability: one that—according to the hypothesis outlined above—develops into a more generalized cognitive deficit.

Breaking the Cycle of Interacting Skill Deficits

The discussion in several previous sections, emphasizing as it did the cycle of negative Matthew effects set in motion by reading failure, invites speculation on how the cycle is to be broken. Although this discussion has highlighted the importance of breaking the cycle, it has also hinted at the difficulty of doing so. One of the reasons that the cycle will be difficult for educators to break is that some of the Matthew effects are linked to events in the child's out-of-school environment. Also, as a result, certain interpretive problems are often encountered when one is attempting to evaluate the effects of interventions to facilitate reading achievement. In order to better understand these issues we may find it instructive to consider the interpretive problems in an area with analogous problems—research on schooling effects.

Findings on the effects of schooling on achievement appeared confusing and inconsistent until reseachers generally recognized the importance of differentiating those factors that explain the variance in academic performance from those that determine the absolute level of performance (see McCall, 1981; Rutter, 1983). Rutter (1983) illustrated this point by pointing to Tizard's (1975) discussion of the fact that in the last 50-60 years, the average height of London children aged 7-12 has increased by nine centimeters—probably due to better nutrition—yet there has been no change in the variation in height among the children. Current variation is probably just as strongly determined by genetic factors as it always was, even though nutritional changes have raised the overall height of the population.

Understanding the effects of schooling on achievement requires that we understand the distinction drawn in the Tizard example. Although school variables explain very little of the *variance* in achievement (family background being the dominant factor), the *absolute level* of academic achievement is linked to a number of school variables (Rutter, 1983). This distinction provides a context for understanding Matthew effects in education. Raising the population's mean level of performance will not eliminate individual differences. In fact, raising absolute levels of performance might well *increase* performance variance, because high achievers will make better use of the new learning opportunities.

One might think that if overall performance levels rise, the lowest readers will eventually reach an acceptable level of achievement, one

where they would no longer be considered "disabled." Unfortunately, ever-escalating absolute levels of performance will not necessarily be a panacea for the low-achieving student. Rising absolute levels of performance more often result in increased societal expectations, marketplace adjustments, and higher criteria of acceptable performance on the part of the public and employers (Levine, 1982; Resnick & Resnick, 1977).

In this context, note that researchers and educators who are focusing on the problem of reading disability are in effect aspiring to reduce the variance in reading ability (i.e., to bring up the lowest readers to some reasonable standard). The existence of negative Matthew effects that go beyond the school, and the history of research on the attempts to decrease achievement variability, suggest that educational interventions that represent a "more-of-the-same" approach will probably not be successful. The cycle of escalating achievement deficits must be broken in a more specific way to short-circuit the cascade of negative spinoffs. This suggests that the remedy for the problem must be more of a "surgical strike" (to use a military analogy).

The field of learning disabilities has always implicitly recognized this logic, for its underlying motivation and associated techniques are of specific remediation rather than generalized enrichment. This logic pervades the whole area of perceptual process training in learning disabilities. Although process training is now discredited (Allington, 1982; Arter & Jenkins, 1979; Kavale & Mattson, 1983), it is important to appreciate the reasons why it has fallen into disfavor. Some of these I have outlined previously with regard to reading disability. First, there is the definitional problem. The children studied may not have been identified using a criterion that was stringent enough to select only those with specific deficits. Second, the "processes" that were trained may simply have been the wrong ones. With the hindsight of current research we now know that in some cases this was most certainly true (e.g., the fiasco of poor readers subjected to balance beams and eye movement training). Third, the training may have begun too late, perhaps after the specific deficit had turned into a more generalized learning difficulty. Thus, perhaps the idea that animated the process training attempts was correct, but it was inadequately carried out.

The conclusions drawn in this review will suggest what optimal specific remediation might be. I have hypothesized that if there is a specific cause of reading disability at all, it resides in the area of phonological awareness. Slow development in this area delays early code-breaking progress and initiates the cascade of interacting achievement failures and motivational problems. Fortunately, developmental delays in this ability can be detected fairly early. Several of the tasks used to assess this ability have been employed with preschool and kindergarten children (Bradley & Bryant, 1983; Fox & Routh, 1975; Stanovich, Cunningham, & Cramer, 1984; Williams, 1984). Recently, several studies have reported attempts to facilitate the development of phonological awareness and thus affect the speed of early reading acquisition. The most influential has been the study of Bradley and Bryant (1983, 1985), in which a group of five- to six-year-old children who had scored two standard deviations below the mean on a phonological awareness task were given 40 sessions of training in sound categorization stretching over a two-year period. A group matched on IQ and phonological ability received equivalent training in conceptual classification. The results indicated that the sound categorization training group was 4 months advanced in reading ability when assessed at age 8 (a group taught sound categorization with the aid of letters displayed a striking 8-month gain). This study provides strong evidence that early identification and subsequent training in phonological awareness can partially overcome the reading deficits displayed by many children whose phonological skills develop slowly.

A critic of the Bradley and Bryant (1983, 1985) study might argue that the achievement difference between the experimental and control groups appeared to be fairly small in magnitude (e.g., Yaden, 1984). However, one inference that follows from the argument presented here is that small achievement differences that appear early can be the genesis of large differences later in development. When viewed in

light of possible Matthew effects and reciprocal relationships involving reading, the achievement differences observed by Bradley and Bryant (1983, 1985) can hardly be deemed unimportant. A longitudinal study by Jorm, Share, Maclean, and Matthews (1984) illustrates how phonological skills may generate individual differences in reading acquisition that multiply with development. They formed two groups of kindergarten children who differed on phonological recoding skill but were matched on verbal intelligence and sight word-reading, By the first grade the group superior in phonological recoding skill was 4 months advanced in reading achievement. Importantly, the two groups tended to diverge with time: The performance difference increased to 9 months by the second grade.

The Bradley and Bryant (1983, 1985) study illustrates an ideal way to attack the problem of snowballing achievement deficits in reading: Identify early, remedy early, and focus on phonological awareness. But what is to be done at later points in development, when negative reciprocal relationships have already begun to depress further achievement? One answer is to aim an attack at a major bootstrapping mechanism: reading practice. A computer-aided reading system developed by McConkie and Zola (1985) exemplifies this approach (a similar system has been developed by R. Olson, Foltz, & Wise, 1986). They explicitly acknowledge that thwarting Matthew effects was one of the motivations for developing their system: "Since there are probably many aspects of reading skill that develop primarily through extended involvement in reading, these people (with reading difficulties) have been essentially blocked from this further development" (p. 9). The logic behind the system rests on some simple facts about individual differences in reading ability. One is that—particularly in the early stages of reading acquisition—poor readers have trouble identifying words (Perfetti, 1985), and this appears to be the primary causal mechanism behind their reading problems. Without efficient mechanisms of word identification, reading is difficult and unsatisfying because comprehension cannot proceed when word meanings are not efficiently extracted (Perfetti, 1985). Reading becomes less and less pleasurable as the poorer reader spends an increasing amount of time in materials beyond his or her capability. He or she avoids reading, and the resultant lack of practice relative to his or her peers widens achievement deficits.

The computer-aided reading system of McConkie and Zola (1985; see also R. Olson, Foltz, & Wise, 1986) is designed to partially eliminate the word processing problems of the poorer reader. The subject reads text on a color monitor attached to a computer. When the reader encounters a word that cannot be decoded, he or she touches the word on the screen with a light pen. In less than a second the word is "spoken" by an audio unit interfaced with the computer. Preliminary tests of the device indicate that with it children can read material that would have been beyond their capability without the word-identification support provided by the computer. In short, the system prevents the numerous comprehension breakdowns that poor readers experience due to their inefficient word-identification processes. It allows the poor reader to read material appropriate to his or her age level, thus circumventing a problem that increases as schooling proceeds: The poor reader becomes less and less able to read age-appropriate material, an additional factor contributing to the distastefulness of reading.

The computer-aided reading system has at least two major advantages over natural reading, where the child must guess at an unknown word. First, it provides the word faster than does conscious guessing, thus leading to fewer comprehension breakdowns. Secondly, it provides a positive learning trial (Jorm & Share, 1983) for the child to amalgamate a visual/orthographic representation of the word with its meaning and pronunciation (Ehri, 1984). Initial tests of the system have indicated that for many problem readers it was their first experience of reading without a struggle. Some mentally retarded students and children with severe reading disabilities read passages where they had to touch almost every word, yet they comprehended the passage to some extent and were enjoyably engaged in the activity. The system thus

has the potential to address at least partially the problem of the differential reading practice received by readers of differing skill.

The purpose of this section was not to survey techniques for remedying or preventing reading failure, but to illustrate two research programs with particular relevance to the model of the development of individual differences in reading ability that has been outlined here. The studies of Bradley and Bryant (1983, 1985) and of McConkie and Zola (1985) represent two ways of attacking the problem of early reading deficits that spiral the child into a pattern of ever-increasing scholastic achievement problems. The work of the former investigators represents the strategy of prevention; that of the latter represents the strategy of intervention to attenuate one of the most pervasive causes of Matthew effects on achievement: differential practice.

Conclusions, Speculations, and Caveats

In the foregoing, I have sketched the type of conceptualization of individual differences in reading and related cognitive processes that results from a consideration of the cognitive consequences of reading, reciprocal causation, organism-environment correlation, and developmental change. The review is not so much a complete model of the development of individual differences as an outline to be filled in by future research. It is hoped that this framework might help to clarify aspects of the existing research literature and to focus future experimental efforts. For example, the statement that reading ability is multiply-determined has become a cliche. But the number of causal mechanisms may not be as large as is commonly believed. Some of the differences in cognitive processes that are linked with reading ability may actually be the effects of reading efficiency itself. Similarly, some of the individual differences in cognitive processes that are associated with reading ability in the adult (M. Jackson & McClelland, 1979; Palmer et al., 1985) may be remnants of the reading histories of the subjects. This would be especially true if the processes responsible for reading ability variation change several times during development, leaving behind differences in cognitive processes that were causal at earlier stages.

The framework I have outlined may also help to clarify thinking about other issues in reading research. Consider two examples. A moderately popular genre of individual differences research has been the attempt to identify readers who have similar ability but different cognitive profiles. Often researchers have implicitly assumed that when such qualitatively different patterns have been observed among less skilled readers, they represent differing etiologies of reading failure. This conclusion is a consequence of the "many different types of reading failure" assumption that guides most research. But perhaps more attention should be directed to the possibility that the qualitatively different processing patterns represent alternative ways of *coping* with a reading deficit that had a common cause. This alternative explanation looms larger when older subjects are the focus of the investigation.

A second example is provided by the recent flurry of exciting research on comprehension strategies and cognitive monitoring during reading (e.g., August, Flavell, & Clift, 1984). It is often assumed that what is being investigated is a set of cognitive abilities separate from those linked with word-recognition skill. However, as Perfetti (1984, p.56; 1985, p. 244; see also Lovett, 1984) has noted, few such studies have included a comprehensive evaluation of decoding skill. This leaves open the possibility that the reading skill differences in comprehension strategies that are observed may be consequences of differing overall reading levels. The better readers could be decoding words more efficiently and thus have more cognitive resources available to allocate to comprehension. As Underwood (1985) has noted, "It is partly as a consequence of having automatic processes available that reading can be flexible" (p. 173). No doubt this is not the whole story. It is more likely that the comprehension strategy differences observed represent a combination of cognitive monitoring differences and the differ-

ential resource availability due to decoding skill variation. The point is that it is important—both practically and theoretically—to separate out the part of the relationship that is a consequence of reading level.

An emphasis on the importance of Matthew effects and reciprocal relationships will also help to highlight the necessity of providing some explanation of the massive individual differences in levels of acquired reading skill. Recall that Allington (1984) observed some skilled first-grade groups to be reading three times as many words a week as some less skilled groups. The differences among an adult population can be even more startling. Perfetti (1985, p. 10) has emphasized this point by noting that even among a self-selected and range-restricted group of college students, threefold differences in reading speed occur with regularity. If these large differences are indeed the result of Matthew effects, then research must begin to move beyond the mere chronicling of the achievement differences, and begin to specify and evaluate the mechanisms that produce the Matthew effects. Some of the progress already made on this problem has been outlined above. However, one important possible mediator of Matthew effects has so far been omitted because it deserves extended discussion beyond the scope of this review: instruction.

Despite some disagreement, researchers are increasingly uncovering support for Gough and Hillinger's (1980) provocative characterization of reading as an "unnatural act" (Barron, 1986; Byrne, 1984, 1986; Calfee, 1982, 1983; Donaldson, 1984; Donaldson & Reid, 1982; Ehri & Wilce, 1985; Masonheimer, Drum, & Ehri, 1984). Although it is popular for authors to cite examples of children who have acquired reading on their own—or, more often, have been able to identify some boxtop labels via paired-associate learning or guessing from context (Masonheimer et al., 1984)—for the vast majority of children the initial stages of reading must be traversed with the aid of some type of guided instruction from a teacher (who in the case of early readers may well be a parent; see Anbar, 1986; Durkin, 1982). Thus, because instruction must mediate the initial stages of reading acquisition, it could well interact with the child's initial level of cognitive skill to cause Matthew effects. Some of these effects will result from passive organism-environment correlations: Biologically disadvantaged children must learn in instructional environments (composed of teachers, schools, parents, etc.) that are inferior to those experienced by advantaged children (Rutter & Madge, 1976). Again, some part of this correlation is the result of social structures and is potentially manipulable, and some part of it is not.

Other Matthew effects may arise from evocative organism-environment correlations involving instruction. If Allington (1983) is correct that the reading instruction provided to less skilled readers is suboptimal in many ways, then a Matthew effect is being created whereby a child who is—for whatever reason—poorly equipped to acquire reading skill may evoke an instructional environment that will further inhibit learning to read. Certainly this was true of many of the ineffective visual training programs, which had the effect of removing from conventional reading instruction the very children who needed practice at actual reading. Calfee (1983) has previously speculated on such a mechanism's operating to cause reading disabilities: "It is true that dyslexia is associated with many correlates of the individual—being a boy, poor preparation for school, language deficiencies, among others.... A plausible hypothesis, which cannot be rejected from the available data is that these characteristics serve as markers about what to expect of the child in school and which thereby determine the instructional program in which he or she is placed" (pp. 77-78). If Matthew effects of this type are an appreciable source of ability variance, it will indeed be fortunate, because they are controllable.

In short, a major problem for future research will be to determine whether instructional differences are a factor in generating Matthew effects. In addition, it will be interesting to investigate whether any of the important consequences of the ease of initial reading acquisition arise indirectly from instructional differences determined by reading ability. Some progress has been made on these problems, as there is an increasing amount of good research

appearing on the effects of instructional variations on cognitive processes and achievement (Alegria, Pignot, & Morais, 1982; Anderson, Hiebert, Scott, & Wilkinson, 1985; Anderson, Mason, & Shirey, 1984; Barr, 1974-1975; Duffy, Roehler, & Mason, 1984; Evans & Carr, 1985; Hiebert, 1983; Hoffman & Rutherford, 1984). Several other fruitful research programs would probably arise from attempts to specify the mechanisms that mediate the cognitive consequences of individual differences in reading acquisition.

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Footnotes

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