מס. מערכת: 001224023

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כותר: [Beneath the surface of developmental dyslexia [offprint

טקסט מלא: Full-text

הערה: In: Patterson, K.E. & Marshall, J.C. (Eds.): Surface dyslexia; Neurological and cognitive studies of phonological readings. London; Erlbuam, 1985. ch. 13, pp. 301-314.

מרצה: אלטמן, כרמית (תדפיסים)

קורס: לקויות למידה-התערבויות ייעוציות - תשע"ב

Patterson, K.E., Marshall, J.C., & Coltheart, M. (Eds.) (1985). Surface dyslexia: Neurological and cognitive studies of phonological readings. London: Erlbaum. pp. 301-314.

122023

13 Beneath the Surface of Developmental Dyslexia

U. Frith

ARE COMPARISONS BETWEEN DEVELOPMENTAL AND ACQUIRED DISORDERS MEANINGFUL?

It seems straightforward to define developmental dyslexia as a disorder in which reading skills have never been gained and acquired dyslexia as a disorder in which reading skills have been lost. The questions that these particular definitions pose are whether the affected skills in the two disorders are comparable, and whether the remaining intact skills, as well as any compensatory strategies, are similar. It also seems straightforward to answer these questions empirically—without too much prior concern for the underlying nature of the skills that are being compared. However, the recent progress in our understanding of acquired dyslexia was due *not* to such collections of empirical data, but rather to the fruitful application of detailed information-processing models to reading failure. Just as it was necessary to make explicit certain theoretical assumptions about the *nature of skilled reading* in order to advance in the empirical study of acquired dyslexia, so it may well be necessary to make explicit assumptions about the *nature of reading development* in order to advance our understanding of developmental dyslexia.

A developmental model has certain requirements that are not met by a structural model of skilled reading. Above all, it needs to explain how the various strategies that are mastered by the skilled reader come into being. If one ignores the question of acquisition then one is forced to make some rather odd assumptions. Presumably one would have to believe that the skills that are seen as components of the end-state of reading mastery have always

תדפיס שנה: תשס"ד
שם המרצה: דר' גלטמן
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been there. For instance, one would have to believe that the brain is equipped from birth with a grapheme-to-phoneme converter. If there were an innate deficiency in the brain structure underlying a specific skill, one would then expect a particular type of reading failure. This would be directly comparable to acquired reading failure. At the price of faith in predestination this theory essentially dispenses with developmental factors. Thus, it ignores not only maturational processes and their complex interaction with the environment, but also social, cultural, and educational factors that influence the acquisition of literacy. Given the fact that the majority of the world's population do not read at all and that the majority of literate people read in non-alphabetic scripts, one might wish to view the acquisition of literacy by the English-speaking schoolchild in a more relative light.

Nevertheless, it is reasonable to assume that there are certain brain structures corresponding to basic cognitive processes that are necessary for literacy skills to develop. If these are impaired at an early age, then this would result in problems of literacy acquisition. On the other hand, it is theoretically possible that a defect exists that interferes with developmental processes, be they maturational or experiential, while the basic cognitive processes are intact. A third and perhaps most likely possibility is that there is an interaction with impairments in basic cognitive processes and developmental ones. If we take this possibility seriously then it is necessary to face some very complex issues that are intrinsic to developmental psychology in general: for instance, what *are* developmental factors, and how do they interact with basic cognitive processes?

The simplest model of developmental change is one of a steady and gradual improvement over time. Thus, a child might become faster and faster at decoding words phonemically until in the end the process is so fast that it seems to be instantaneous. Likewise, with time, the entries in the internal lexicon might become so numerous that every single word is present and can be "looked up." Unfortunately, this simple model has to be rejected because it cannot account for the phenomenon of "dips and drops" in development (Bever, 1981; Bower, 1974; Strauss, 1982). Also, it cannot account for differences in speed of acquisition, which range from sudden insight-type improvements to very slow changes and apparent plateaux. It is possible to explain these phenomena if we view the acquisition of skills as a sequence of steps. A step forward in the sequence is identified with the adoption of a new strategy. Thus sudden improvement is allowed for by the move from one step to the next higher (cf. Bryan & Harter, 1899). A fall-off in performance is also allowed for, because, by applying a new unpractised strategy in place of a well-practised old one, performance may initially drop. This model of developmental change seems applicable to reading acquisition: a child learning to read shows plateaux, sudden improvements, gradual increases, and drops in performance (Downing & Leong, 1982). We can therefore

assume that for reading there is a developmental sequence of steps, with new strategies introduced at different points in the sequence. At the same time it is reasonable to assume that there are connections, however complex, between earlier and later phases of acquisition. Clearly, the "outcome" of the developmental sequence is the skilled reader. Structural models of skilled reading are therefore helpful when considering developmental models and vice versa.

It must be emphasised that a developmental approach implies special awareness of the interaction of constitutional and environmental factors. This is not a notable feature of structural approaches. Perhaps environmental factors are less important when one is dealing with highly skilled readers. After all, at that stage automatic processes are operating, and these are by definition under rigid internal control. This is not the case with developing readers. Here, for example, the influence of school and home can plainly be seen in what, why, and how they read (Clark, 1976; Entwisle, 1979; Francis, 1982; Seitz, 1977).

Clearly, the use of a developmental model for the study of developmental dyslexia does not rule out a comparison with acquired dyslexia. Indeed, it is my contention that such a comparison can only become meaningful if the differences between structural and developmental approaches are made explicit, and their complementary nature is made apparent.

WHAT IS A DEVELOPMENTAL DISORDER?

In a major textbook on child psychology Rutter (1976) describes developmental disorders as "an important group of conditions in which there is a specific delay in the emergence of a biologically impaired function (p.695)." Developmental speech/language disorder is diagnosed "by a delay in the development which is out of keeping with the child's general level of intelligence, which is not associated with a gross hearing loss or any overt neurological condition, and which is associated with a normal social usage of the language available to the child (p.699)." This definition focuses on the discrepancy between expected and actual attainment. Useful as it is in initially establishing what kind of children one might be talking about, it has very limited explanatory value. The term "delay" is of rather questionable use here, as it is entirely unspecified. Thus, it is uncertain whether or not it should be contrasted with "deviance." Delay is commonly interpreted as a merely quantitative difference and deviance as a necessarily qualitative difference. However, it has not yet been established whether such a dichotomy is actually applicable. In any case, today's qualitative difference is often tomorrow's quantitative one, depending on theory and refinement of measuring instruments. In order not to prejudge this issue I would like to use

the term "delay" *when development is slow and eventually catches up* and "deviance" *when there is a life-long handicap*. Only in the latter case would it seem justified to talk of a developmental *disorder*.

The lack of a clear concept of developmental disorders has not helped the still faintly burning controversy as to whether developmental dyslexia exists, although there are other reasons for the controversy as well (Frith, 1981). The discrepancy definition, as applied to reading failure by Rutter and Yule (1975) and Rutter (1978), is useful in order to distinguish specific and general deficits. But it is not without problems. Thus, it excludes children who, despite a specific deficit, manage to gain a normal score on a reading test by using effective compensatory strategies. Similarly, it can falsely include children who fail, for instance, because of erratic school attendance. While a discrepancy definition remains at best descriptive, it is possible to move towards a more explanatory definition by applying a developmental framework. In this framework *developmental disorder can simply be seen as a persistent failure to advance to the next step in the normal acquisition process.*

The contrast to a developmental disorder is a disorder acquired in childhood not resulting in developmental arrest. It seems highly likely that just as adults can acquire various forms of dyslexia through specific brain accidents, so can children. This should be an equally rare occurrence in both cases, and there is no reason to expect it to be differentially distributed as to sex, except insofar as sex differences may exist for brain accidents in childhood. Clearly, the relatively high frequency of developmental dyslexia (see Tansley & Panckhurst, 1981, for a review of prevalence studies) and also its highly asymmetrical sex ratio suggest a different category of disorder. In what way the categories of developmental disorders and childhood brain trauma should be distinguished in terms of intact, faulty or compensatory strategies is an empirical question; and, of course, whether or not identical trauma in adult and child will have identical psychological consequences is precisely the kind of question addressed by a developmental approach.

The new definition of developmental dyslexia as developmental arrest has some important implications. It allows the possibility that a child fails to advance normally from step 1 to 2, or from 2 to 3, and so on. Hence it is rational to expect that each point marks a particular type of dyslexia. We can postulate as many types of dyslexia as we postulate steps in acquisition. At the same time we rule out the possibility that skills higher in the normal developmental sequence are intact when earlier ones are missing or incomplete by the normal criteria. We do not rule out that the child is continuing to improve his reading skill. Indeed, *after the point of arrest in the normal sequence the child would be expected to go on to develop compensatory strategies.* These strategies may be teacher induced or spontaneously adopted ones. They might well mimic normally used strategies, but they would be different in the way they arose and in the way they are used. In practice,

differences might be demonstrated using measures of automaticity, for example latency and variability of responses. Thus, we have a new definition of developmental *deviance* in contrast to developmental *delay*. The child who shows delay is expected to develop strategies as they arise in the normal sequence, but at a slower pace. The child who shows deviance develops abnormal or compensatory strategies after the point of failure. At the same time any strategies he or she had acquired before the arrest will be available as normal. No such constraints exist for post-developmentally acquired disorders. Components of a previously completed system might become impaired independently of each other, and regardless of their order of acquisition.

In order to implement a developmental approach it is necessary to find a theory that would help us to envisage the sequence of normal reading acquisition. The value of such a theory is of course determined by its power to fit the known facts as well as to predict new ones. In the present context, however, the main requirement is that the theory should allow us to interpret facts already known about developmental reading disorders.

A THEORY OF READING ACQUISITION

There are few satisfactory theories of literacy acquisition, but Marsh and his colleagues (1977, 1980, 1981, 1983) have presented a cognitive developmental theory that is admirably suited for the present purpose. They postulate four stages in the development of reading in terms of four learning strategies with specific predictions for reading unknown words and reading known words in isolation and in context. Moreover, they provide empirical evidence for the existence of the four stages and their successive emergence over the school years. Briefly, *rote learning* is the first strategy for learning new words. This is complemented by so-called *linguistic guessing*, that is, a child often tries to predict a word from context. At stage 2, for the first time guesses are based on *visual letter cues* as well as linguistic context. At stage 3, *sequential decoding* in letter-by-letter and phoneme-by-phoneme fashion is introduced. At stage 4, *hierarchical decoding* appears, that is, the interpretation of each phoneme becomes dependent on its letter context (for example the pronunciation of *c*). Lastly, at this stage, the *analogy* strategy first appears, which from then on is used more and more for the successful reading of new words. Evidence from reading and spelling errors supports this model very well, as do observational studies of young readers (Biemiller, 1970; Francis, 1982; Soderbergh, 1971; Weber, 1970).

Marsh's cognitive developmental theory can be adapted so as to provide links to current models of skilled reading. My own preferences for the way this theory might be modified are expressed below. The development of

reading is divided into three phases identified with three strategies. Let us call these "logographic," "alphabetic," and "orthographic."

The Three Strategies

The terms "logographic" and "alphabetic" cover the same processes respectively as Marsh et al.'s rote learning and sequential decoding strategies. The term "orthographic" replaces their analogy strategies. Their hierarchical decoding can either be considered orthographic, or an advanced form of the alphabetic strategy.

Logographic skills refer to the instant recognition of familiar words. Salient graphic features may act as important cues in this process. Letter order is largely ignored and phonological factors are entirely secondary, in other words the child pronounces the word after he or she has recognised it. If the child does not know the word, he or she will refuse to respond. However, the child will often be prepared to guess on the basis of contextual or pragmatic cues.

Alphabetic skills refer to knowledge and use of individual phonemes and graphemes and their correspondences. It is an analytic skill involving a systematic approach, namely decoding grapheme by grapheme. Letter order and phonological factors play a crucial role. This strategy enables the reader to pronounce (not necessarily correctly) novel and nonsense words.

Orthographic skills refer to the instant analysis of words into orthographic units without phonological conversion. The orthographic units ideally coincide with morphemes. They are internally represented as abstract letter-by-letter strings. These units make up a limited set that—in loose analogy to a syllabary—can be used to create by recombination an almost unlimited number of words. The orthographic strategy is distinguished from the logographic one by being analytic in a systematic way and by being non-visual. It is distinguished from the alphabetic one by operating in bigger units and by being non-phonological.

The three strategies, defined in this way, can readily be related to components in current models of skilled reading (Morton & Patterson, 1980; Shallice, Warrington, & McCarthy, 1983). For example, word-form analysers might be derived from early logographic skills; grapheme-to-phoneme skills would need to have been constructed out of alphabetic knowledge; lastly, word-component analysers, as postulated by Shallice & McCarthy (Chapter 15 in this book) could be readily traced to orthographic skill acquisition.

The present model leaves open the possibilities of how the initially acquired strategies are continued in skilled reading. Thus, they may remain available at all times, such that in case of need a reader can "fall back" on earlier strategies. On the other hand, once the orthographic strategy has

become established, the previous strategies might be less accessible: it is possible that they cannot be used later without special retraining or in special (e.g. experimental) circumstances.

The Sequence

At present no more than a basic outline of a three-phase theory of reading acquisition can be provided. The aforementioned three strategies are hypothesised to follow each other in strict sequential order. Each new strategy is assumed to "capitalise" on the earlier ones. The logographic strategy might be thought of as capitalising on the basic (and impressive) memory skills that the child brings with him or her when starting to learn to read. Nevertheless, the child has to apply these basic skills to the written word. This is acknowledged by the "look-and-say" method. The logographic strategy is assumed to dominate the first phase of reading acquisition allowing a sizeable sight vocabulary to develop. This assumption is supported by evidence from many observational studies (see Torrey, 1979, for a review).

At the next phase the alphabetic strategy is adopted. Observational and some experimental evidence supports this assumption (Condry et al., 1979; Pick et al., 1978). It is generally agreed that a "*phonics*" stage in reading is of great importance and cannot simply be skipped (Chall, 1967). Here, at least some explicit instruction would seem to be necessary. This must be so if one accepts the notion that the alphabetic system is arbitrary and constitutes a relatively recent cultural invention (cf. Gleitman & Rozin, 1977). During this second phase conversion rules for sounds and letters are acquired; first simple rules, then so-called context-sensitive rules (soft *c* rule, silent *e*; Marsh et al., 1981).

Finally, the child will adopt the orthographic strategy. That this strategy can be differentiated from the logographic one, and also that it appears at a later stage of development, is consistent with findings by McCaughey et al. (1980). Abstract orthographic, as opposed to visual logographic and phonological alphabetic knowledge, was shown to exist by a reading age of 7 (Snowling & Frith, 1981). Whereas for the orthographic strategy there is no catchy label from teacher usage, it is clear that teachers in fact do employ methods to promote orthographic skills as defined in the present context. For instance, Stern and Gould (1965) emphasise the use of morphemes in teaching what they call "*structural reading.*" Similarly, the well-known Gillingham–Stillman method (1956) stresses the synthesis of phonemic elements into meaningful units and the knowledge of syllable structure.

For a long time there has been controversy over the developmental succession of visual and phonological reading strategies. This could be because differences between logographic and orthographic strategies have

been largely ignored and either one has been assumed to represent a visual strategy. The three-phase model offers potentially a reconciliation. Although in its present form the model does not incorporate mechanisms of change, a particular suggestion is presented later in this chapter, where the three-phase model is modified, and becomes a six-step model.

From 0 to Phase 1

Even before phase 1 is entered the child has in some sense started to learn to read. The earliest attempts at reading and writing, however, do not imply sufficient linguistic awareness to qualify to be called logographic skills. Perhaps they are better described as symbolic skills. During this phase a child has to acquire some understanding of such difficult metalinguistic terms as "word" and "sentence." Work in this area has been reviewed recently by De Goes and Martlew (1983). Metalinguistic awareness of written language cannot be taken for granted in beginners and develops in an orderly fashion. This is vividly documented by Ferreiro (1978).

Given that a child has mastered the symbolic pre-literacy phase, he or she is ready to enter the *logographic phase*. When this happens is very hard to predict and shows immense individual variation (Francis, 1982). Children often spontaneously acquire an impressive sight vocabulary. Soderbergh (1971), reports that her 3-year-old child acquired in this fashion 120 words within 3 months. This may be an exceptional case, but it may turn out that this sort of achievement is not uncommon among 4- and 5-year-olds (cf. Smith, 1971). Interestingly, adults often do not credit this skill as "reading." In common usage reading is often identified with decoding or recognising unfamiliar words. This, however, presupposes the next phase of reading acquisition.

From Phase 1 to Phase 2

It is popularly assumed that the look-and-say strategy is abandoned when the storage has reached a critical limit and visually similar words become confused. This contention is an example of the many *post-hoc* hypotheses that attempt to explain the mechanism of developmental change. One suggestion for the transition to phase 2 that needs to be taken seriously is the appearance of phoneme awareness (Gleitman & Rozin, 1977; Liberman et al., 1977). The work by these authors makes clear the radical nature of the change from logographic to alphabetic principles. A detailed discussion of this important work is beyond the scope of this Chapter.

From Phase 2 to Phase 3

The same principles are assumed to operate as with previous transitions. As with the introduction of the alphabetic strategy, the introduction of the orthographic strategy might result in apparent setbacks in performance.

Thus "good," phonetically plausible spellings may disappear and become "bad" errors. These would be bad only in the sense that they disregard phonology, but good in the sense that they apply orthographic units, even if an inappropriate one was chosen. The work of Smith (1983) and Sterling (1983) suggests that morphological knowledge, which may well be the hallmark of orthographic skill, can be clearly demonstrated in children's spellings.

Once the three phases have been passed through one could consider the essential period for literacy acquisition to be completed. However, at least a *Phase 4* is conceivable where the independence of written from spoken language is achieved and written language is handled as a system in its own right. Too little is known about this further development of functional literacy, but it need not concern us here, because not reaching a higher level of skill than Phase 3 is not usually regarded as failure.

The Principles of Change

Reading performance, assessed in terms of reading age, increases roughly as chronological age increases. Whereas this may be true for a group of children as a whole, an individual child would not be expected to show a smooth and gradual increase. Exactly when and how rapid spurts, decreases, plateaux, and slow gradual increases in performance occur is a matter of empirical investigation. The present theory aims to provide a framework for explaining these surface changes in terms of underlying step-wise improvements in skill. These step-wise changes of course are part of a complex developmental process about which we know hardly anything. I would like to suggest that we leave unexplained for the moment the maturational and educational factors, which we recognise as the necessary triggers of change, and instead focus on what it is that they trigger. It is clearly not enough to assume that at point one the logographic strategy is adopted by the child, at point two the alphabetic one, and so forth. If this was the case, then strategies would either replace each other, each starting again from zero, or be run in parallel. Neither of these possibilities allows for the type of change where there appears to be a sudden "breakthrough" in reading competence.

I would like to hypothesise that a breakthrough to the next phase of development would only occur if there is a merging of the old and new strategy. Certain components of the old strategy might be retained because they enhance the new strategy. Thus, it may be crucial that the "goal" of instant word recognition (which is established in the logographic phase) is preserved while the child gets to grips with grapheme-by-grapheme conversion. For the orthographic strategy it is easy to imagine that there must be a merging of instant recognition and piecemeal analytic skills, each of which is assumed to be predominant at an earlier phase. My hypothesis then requires

that what is triggered by developmental factors is a process of "merging." Vague as it is, this hypothesis would immediately explain why it is that children apparently "choose" their own time to apply taught knowledge. It seems that they have to wait until everything is right for the old and new to merge together. This is consistent with recent explanations of developmental change using the concept of "success" of earlier strategies (Karmiloff-Smith, 1979, 1984), or the notion of agreement between old and new strategies (Bryant, 1982). If this particular developmental process fails we would expect that the child would simply not move on to the next step in normal development. In no way could drill in the new strategy by itself reinstate the normal progress, and I think that this is exactly what we find with many well-tutored dyslexics. Thus we are not surprised that a teacher complains that "Johnny knows all the rules of phonics, but he doesn't apply them." Furthermore, the hypothesis would give a rationale for teaching compensatory strategies even though one would not expect them to be as efficient as normal strategies.

We now have to consider *how* a child might move from one step to the next. What provides the impetus for the adoption of the various strategies?

FROM THREE-PHASE TO SIX-STEP MODEL

In the basic outline of the three-phase model a general literacy skill, for example reading age, was the target variable. Clearly this is not satisfactory, and instead a number of specific variables that are all performance aspects of literacy could be considered. In particular, there is *the* major division of literacy skills into input and output components, word recognition (reading), and word production (writing). It is this division that I would like to use in order to redesign the basic model. I have argued previously (Frith, 1979, 1980) that writing and reading skills will sometimes show dissociations in development. The hypothesis I would like to put forward now is simply that *normal reading and writing development proceeds out of step*. This hypothesis results in a noticeable modification of the acquisition model, as shown in Table 13.1. Table 13.1 shows that each phase is divided into two steps with either reading or writing as the pacemaker of the strategy that identifies the phase. The division into steps also allows a differentiation in terms of level of skill in a particular strategy, here symbolised by number subscripts. Level 1 would imply that the skill is present in very basic form only; level 2, that it is more advanced, and so on. Thus one might postulate that only when logographic skill has reached level 2 in reading is it ready to be adopted for writing.

The alphabetic strategy is first adopted for writing, whereas the logographic strategy is continued to be used for reading, perhaps at an even more

TABLE 13.1
The Six-step Model of Skills in Reading and Writing Acquisition

Step	*Reading*	*Writing*
1a	*logographic*$_1$	(symbolic)
1b	logographic$_2$ →	logographic$_2$
2a	logographic$_3$	*alphabetic*$_1$
2b	alphabetic$_2$ ←	alphabetic$_2$
3a	*orthographic*$_1$	alphabetic$_3$
3b	orthographic$_2$ →	orthographic$_2$

advanced level 3. Only when the alphabetic strategy reaches level 2 will it be adopted for reading. The rationale for the antecedence of writing here is provided by the idea that the alphabet is tailor-made for writing rather than for reading (Frith & Frith, 1980). Thus it is easy to learn to write using the relatively small set of letters. At the same time the limited number of symbols creates ambiguities when translation into sound is required. Although observational and experimental evidence needs to be collected to test this feature of the present model, it would provide an explanation for the finding (see Part I Introduction) that in acquired disorders phonological (i.e. alphabetic) reading is always accompanied by phonological spelling, but not vice versa.

Phase 3 again shows reading as the pacemaker resulting in step 3a. Orthographic knowledge at level 1 is presumed to be weak—sufficient to be used in recognising words, but not to be used in guiding the writing of words. Level 2 would imply that orthographic representations are now precise enough to be useful for spelling. It is plausible to assume that they would then be "transferred" to the spelling output system. The highly skilled reader/speller requires internal representations that are exact in terms of letter-by-letter detail.

In summary, the theory now states that at each phase there is a first step involving a divergence between strategies used for reading and writing, then a step involving convergence. Developmental progress is envisaged as an alternating shift of balance between reading and writing. Reading is the pacemaker for the logographic strategy, writing for the alphabetic strategy, and reading again for the orthographic one.

While this model is as yet purely speculative, it suggests numerous experiments that may either change or disprove it.

SOME TESTABLE PREDICTIONS

The internal representation of words acquired during the logographic phase might well resemble memory images for other types of graphic stimuli. Because there is as yet no proper guiding principle for the analysis of a written word, it is reasonable to suppose that the child selects the graphic features that are salient to him and uses them as critical identifiers. Thus, the x in Alex, the exclamation mark after the word bang! may be of special significance to a child. This child might say "Alex" when seeing the word Max and "bang" when seeing the word big! In attempts at writing the child would be expected to preserve the x and the ! and to omit those features that are not salient to him or her. Matching to sample or sorting techniques would be useful for investigating salient features. Stimuli would have to be prepared with systematic graphic variations. Presumably, the child would class together stimuli that seem similar, that is, share the same internal representation. Certain changes of graphic features, for example letter type, may signal changes of word identity, even if the orthographic sequence remains intact. On the other hand, changes in orthographic sequence would be readily tolerated, because there is no commitment to sequential order. (The opposite would be predicted for children at the orthographic phase.)

It would be possible to test the hypothesis that at first the most important cues might come not from the written stimulus but from the situational context. It remains to be seen to what extent semantic or episodic context support is crucial in this process and exactly what it contributes to word recognition. Clearly, the more a child relies on cues from the word rather than context, the more efficient, and of course, situationally independent, his word recognition should become. One very important cue in this respect is the first letter of a word. It is known that sounding out the first letter acts as a powerful cue for recognition, so that the remaining letters in the word need not be sounded out at all (Marsh et al., 1981). This is one way through which the logographic strategy might become viable for quite advanced reading.

The suggestion that spelling practice will be more important to the acquisition of the alphabetic principle than reading practice can be readily tested. It is conceivable that it is the orderly sequential production of letters when writing which might be "copied," even unnecessarily, for word recognition. Thus, the piecemeal left-to-right decoding of a word might first make sense to a child as a deliberate reflection of the first-to-last writing process. This then would become the guiding principle of analysis that was missing before. When a child has learned to spell a word (oral or written spelling) then he or she may realise that what is important is temporal order rather than salient graphic features. The first letter of a word is both prominent in the spelling sequence and graphically salient. This may be an example of a merging of components of two strategies.

The orthographic strategy is postulated to differ from the logographic strategy, being based on segmentation into letter-by-letter units. This claim is also amenable to experimental investigation. The theory would predict, perhaps counterintuitively, that a child at phase 1 could not recognise words embedded in words. Thus words inside the word *scared*, such as *car*, *care*, *red*, *scar*, *ed*, *are*, some of which are likely to be highly familiar, would not be "seen" unless the irrelevant letters are actually blocked out. The process involved in seeing the embedded word *car* might at this stage be similar to seeing *ear* in *scared*, because commitment to fixed letter order is lacking. In contrast, a child at phase 3 should see *car* more readily than *ear*. Furthermore, this child would automatically give prominence to morphologically salient units, for example he or she might be quicker at finding *scare-* and *-d* compared to *car-* and *-red*. Perhaps these latter solutions might occur more readily to the child using an alphabetic strategy. This child might always specially attend to the first two or three letters, regardless of their morphological relevance, because they come first in the left-to-right sequential decoding process.

Predictions can also be made for the different strategies in spelling a completely unfamiliar word. Use of the logographic strategy would mean that the word cannot be written at all. Use of the alphabetic strategy in basic form would mean that individual phonemes are converted into individual graphemes and strung together ("frend" for *friend*, "gust" for *just*). When this strategy is more advanced, then context-sensitive rules are used, and errors such as "gust" for *just* would no longer be made. Use of the orthographic strategy would mean that instantly segmented units are matched with internally represented units. Hence an unfamiliar word will be spelled by using components of familiar words ("inteligents" for *intelligence*). As a result a good speller can spell nonsense words apparently "in analogy" with existing words, regardless of whether a so-called regular or irregular spelling is present (Campbell, 1983). Different types of otherwise phonetically acceptable spelling errors would therefore be predicted to occur at the different phases of acquisition. For example, the unfamiliar word *traction* might be spelled "trackshen," or "trackshun" at phase 2. At phase 3, however, instant segmentation would take place, which entails that the first segment of the word can be spelled with regard to an existing unit, say *track*, and the ending can be spelled as a known morpheme such as "sion" or "tion." A misspelling might thus be "tracksion." Similarly, if the target word is *generally*, then it might well be misspelled as "genralee" at phase 2, and as "genraly" at phase 3. The classification of spelling errors according to the extent to which they preserve morphemes or small orthographic units (ght, ou, or, etc.) would thus be of interest. Longitudinal studies of individual children would certainly provide tests of the usefulness of the present model.

An Explanation of Reading–Spelling Dissociations

Apart from a number of testable predictions the model can neatly account for the three types of reading/spelling dissociations that have been described in normal schoolchildren. These are Read's (1971, 1980) pre-school orthographers, Bryant and Bradley's (1980; Bradley & Bryant, 1979) first-year readers, and Frith's (1980) type-B spellers of secondary-school age.

Read's (1971, 1980) pre-school orthographers show the beginning of an alphabetic writing strategy, without having yet applied this strategy to reading (phase 2a). Thus, they cannot read back later what they themselves have written. Although in these studies there is no documentation either way as regards logographic word recognition skills, it would have to be assumed that such children were able to recognise at least some words by sight. For the reasons already mentioned such skill, if it existed, may well have been disregarded as not proper reading.

Bradley and Bryant's (1979) and Bryant and Bradley's (1980) beginning readers showed that they were able to recognise some words. This is likely to have been a result of applying a logographic strategy. Some of the words they recognised were highly irregular (*school, light*) and could thus not have been tackled by alphabetic strategies. On the other hand, the same children were able to spell correctly some words that showed simple phoneme–grapheme relationships (*bun, mat*) presumably by applying an alphabetic strategy, and these they were not necessarily able to recognise. This pattern fits perfectly with phase 2a. However, Bryant and Bradley's work also extends to phase 2b. They demonstrated that the children could be given a "set" to use the alphabetic strategy for reading, and then were able to read such words as *bun, mat, leg*, on which they previously failed. In view of the model's claim for the antecedence of the alphabetic strategy in writing, it is important supportive evidence that the children succeeded with the alphabetic strategy in reading certain words—only if they were also able to succeed in writing these words. Exactly this would be expected in phase 2b.

Frith's (1980) type-B spellers belong to phase 3a, whereas type-A spellers would belong to phase 3b. Type-B spellers can use an alphabetic strategy as shown by their phonetically acceptable spelling errors. However, when reading, their strategy seems to be orthographic. This dissociation is shown strikingly by their ability to distinguish correctly between homophones (e.g. *their–there*) in recognition, an ability which they seem to lack when writing these words. Type-B spellers are characterised by persistent difficulties. However, even a very cursory glance at the reading and spelling performance of normal children in the later years of primary school suggests that there are differences in strategies for these two activities. It is typical, for example, at that stage (presumably phase 3a) that a child often has to construct a word from laborious phoneme-to-grapheme rules when writing, but effortlessly recognises the word in question when reading.

POSSIBLE OUTCOMES OF DEVELOPMENTAL READING FAILURE

Although both the basic and modified version of the theory are only rough sketches and would need to be elaborated in more detail, they do provide a guide for looking at developmental reading disorders.

Given our previous definition of developmental reading disorder, it is clear that we can theoretically distinguish at least between arrest at phase 1 and arrest at phase 2. Obviously we cannot decide what the arrest is due to, because we are far from penetrating into the complexities of maturational and environmental causes of change. It would, however, already be useful to establish whether it is possible to accommodate some of what is known about developmental dyslexia within the present framework.

Failure of the Logographic Principle

It is theoretically possible that a child fails to acquire any sight vocabulary, but in practice such cases are conspicuously rare. What is striking is the ability to acquire a respectable sight vocabulary even when there is severe mental retardation (O'Connor & Hermelin, 1963) and at very young ages (Doman, 1965). From this it seems that it is unlikely to be a major factor in accounting for developmental dyslexia. If such cases occur they should be especially evident with logographic scripts, and this would be interesting to establish.

Boder's (1973) dyseidetics might perhaps be cases in point. These are rare children who are said to show some knowledge of letter–sound correspondences but little ability to recognise words instantly, and who apparently cannot rely on good memory images when spelling words. However, this pattern does not necessarily implicate logographic failure. Even with intact logographic skills, relatively poor spelling is only to be expected, because of the absence of sequential order as a guiding principle. Evidence for logographic failure in reading would be, for instance, that words with striking visual features are recognised no more readily than those with unremarkable ones.

Failure of the Alphabetic Principle

Suppose a child fails to advance from phase 1 to phase 2. Of course, this child will not, therefore, be at a standstill. He or she will continue to improve in logographic skills and the child's reading age will still increase, if slowly. Difficulty in grasping and applying the alphabetic principle will mainly be obvious in the child's unsuccessful attempts at writing, and at sounding out and "blending" letters in reading (decoding) unfamiliar words. Unfortuna-

tely, this sort of difficulty often attracts the verdict "unable to read," because logographic skills are frequently not given any credit. Rozin, Poritsky, and Sotsky (1971) have shown that young children in socially adverse circumstances, who failed to learn to read in the normal school environment, were able to learn a set of 30 Chinese symbols with only 2–5 hours' tutoring. From this success we must infer that a logographic strategy was available. Why then was it not used in their reading of English words? The children experienced continuous failure in trying to grasp the alphabetic strategy. Here they may have been so poorly motivated in normal reading tasks that they would not even use the strategy that they were able to master. In the case of these children there may have been delay rather than deviance. What happens, however, when the alphabetic strategy presents an insurmountable barrier to normal progress?

The hypothesis I would like to propose here is that a developmental "arrest" at phase 1 characterises classic developmental dyslexia. From then on the sequence of literacy development would be abnormal. Usually when a child fails to progress there is intervention. Ideally, everything possible is done to promote advance to the next phase, namely the alphabetic one. With drill in "phonics" certainly a resemblance of alphabetic skills can be achieved. These skills, however, would never become automatic enough to be applied effortlessly. On the other hand, other compensatory strategies might be developed; perhaps there is also extended use of logographic skills. A further prediction from the model is that the normal effortless mastery of the orthographic strategy should be just as impossible as effortless mastery of the alphabetic strategy. Yet, again a resemblance of this skill might be found with specific training in orthographic segmentation. This is suggested by the work of Scheerer-Neumann (1981), who showed that a striking poverty in the utilisation of intra-word structure could be overcome by placing gaps between segments and by specific training in syllable segmentation.

Miles' (1982) study of 300 cases leaves no doubt that it is perfectly possible for a developmental dyslexic to become, on the surface, a good reader. It would be predicted that such a person used strategies that differ from those acquired in normal development. From the sparse evidence so far one can quote two pertinent observations: on "bad days" the painfully acquired reading competence can be seemingly lost again (Simpson, 1980); a variety of cognitive dysfunctions (involving phonological coding, see later) can still be uncovered by sensitive tests (Ellis & Miles, 1981; Miles & Ellis, 1981). The first observation implies that the skills are not automatic, the second, that improvement in reading is due to "symptomatic" treatment, but does imply that the underlying deficit has not been removed.

Sensitive test material is provided by non-words. It is strongly predicted that, even in "ex"-dyslexics, word-recognition skill in terms of speed and accuracy will be way ahead of non-word skills. Although logographic

recognition shows improvement, and reading age as measured by such word recognition tests as the Schonell, goes up, performance with non-words shows very little improvement with reading age (Snowling, 1981). Baddeley et al. (1982) found that older, well-tutored dyslexic boys with a reading age of 10 years read fewer non-words correctly than controls of the same reading age. The significance of this result in the light of related work has been discussed by Snowling (1983). Seymour and MacGregor (1984) have found poor non-word skills relative to word skills in almost all their individually studied adolescent and adult dyslexic readers. Naidoo (1972), in her extensive description of 98 dyslexic boys, found that their main problems were those of sounding out and blending letters, typical alphabetic skills. The finding that dyslexic children with good word-recognition skills showed no spelling-regularity effect and a hugely increased word–non-word effect (Frith & Snowling, 1983) would be consistent with the notion that words are not recognised by phonological piecemeal analysis, but by logographic strategies.

Some important confirmation for the developmental sequence of strategies and the effect of arrest comes from a study of children with serious speech problems by Snowling and Stackhouse (1983). These children were able to acquire a considerable sight-word vocabulary, but, when compared with normal children from the same school who had a similar sight vocabulary, showed a greatly impaired phonetic spelling strategy. Relevant to this question is the often-quoted (Makita, 1968) absence of classic developmental dyslexia in Japan. This could readily be explained by the fact that the Japanese script involves logographic and syllabic but not alphabetic skills.

The Phonological Dysfunction Hypothesis and Classic Developmental Dyslexia

If we accept the identification of developmental arrest at phase 1 with classic developmental dyslexia, it is tempting to speculate on a reason for this arrest. It seems to me that at this stage the attractively simple hypothesis of a basic phonological dysfunction deserves the most serious consideration. Independent authors with very different experimental approaches have provided evidence that seems to converge on this possibility. As far as the three-phase model is concerned, it is clear that phase 2 is the only one where a connection to phonological processes is required. If there is a basic cognitive deficit in this area this would be most detrimental at the point of transition to phase 2, and may well go unnoticed.

The hypothesis assumes that the problem exists in speech regardless of whether reading is acquired or not. Reading failure would be seen as an artefact of alphabetic writing systems. Thus it is crucial to demonstrate that developmental dyslexics show specific impairments on non-reading tasks

involving phonological processing. Some such demonstrations are now listed:

1. Retrospective reports of delayed speech acquisition (Fundudis et al., 1979; Ingram, 1962, 1969; Ingram et al., 1970; Mason, 1967; Naidoo, 1972; Rutter et al., 1970).
2. Prospective studies relating poor sound categorisation skills (rhyming, alliteration) to later reading backwardness (Bradley & Bryant, 1983).
3. Difficulties in orally repeating unfamiliar words (Godfrey et al., 1981; Miles, 1974, 1982; Snowling, 1981).
4. Phonological inaccuracies in paired associate learning with nonsense words (Done, 1982).
5. Slowness in picture naming (Denckla & Rudel, 1976).
6. Slowness in name-code as opposed to physical-code matching (Ellis, 1981).
7. Poor awareness of position of articulatory organs during phoneme production (Montgomery, 1981).
8. Poor speech acoustic-cue discrimination abilities (Tallal, 1980; Tallal & Stark, 1981).

These examples implicate a large variety of so-called auditory-verbal dysfunctions. In contrast, so-called visual-perceptual dysfunctions, another "old favourite" among causal explanations of dyslexia, have not fared very well in recent years (Bradley & Bryant, 1981; Hulme, 1981; Vellutino, 1979). Vellutino (1979) in particular has made a strong case for a verbal-processing dysfunction in dyslexia. Certainly among the most reliable findings in this area are deficits in the recall of phonologically structured lists, such as digits, multiplication tables, the alphabet, months of the year, etc. (Ellis & Miles, 1981). Apart from evidence from outside the reading task, there is also some evidence from reading and spelling errors that would support the hypothesis of a phonological dysfunction. Nelson and Warrington (1974) and Frith (1980) found that misspellings in dyslexic children betray phonological problems. For instance, dyslexic children fail, more often than controls, to preserve the number of syllables let alone phonemes (Farnham-Diggory & Nelson, 1983).

Despite the support that can be derived from recent studies the phonological dysfunction hypothesis is of rather limited use in its present form. It still remains to be specified how phonological skills affect the acquisition of alphabetic skills, and what aspect is the most critical, be it phonemic segmentation, phonological assembly, articulatory programmes, or metalinguistic skills.

Failure of the Orthographic Principle

The theory states that phase 2, identified by the adoption of alphabetic strategies, is only an intermediate step towards phase 3. It was hypothesised that a merging of instant recognition and analytic sequential skills would result in the breakthrough to this last phase, where orthographic units are employed in reading rather than salient graphic features or grapheme–phoneme correspondences. Again, we have to consider what the failure to achieve this particular transition might mean: we would expect pronounced reliance on the alphabetic principle together with a lack of orthographic skills, whereas logographic skills should be intact. If over-reliance on alphabetic strategies is the hallmark of acquired surface dyslexia, then this failure constitutes a developmental analogue. However, there might be differences in terms of intactness and accessibility of logographic skills. As a preliminary term for developmental arrest at phase 2 I would suggest "developmental dysgraphia." This distinguishes it from "dyslexia," which was defined as arrest at phase 1, and further points to a striking problem associated with this condition, namely *spelling* so-called irregular words. These words would always tend to be regularised according to phoneme–grapheme rules. On the other hand, *reading* irregular words would only be a problem if the logographic strategy has been discouraged (which does happen). Regular words, by definition, would be spelled and read correctly, simply by application of the alphabetic strategy. Compensatory strategies would again be expected.

Children arrested at phase 2 are probably those that Naidoo (1972) and Nelson and Warrington (1974) identified and described as spelling-only retardates. These children were separable from classic dyslexic children on a number of tests. Their reading skill was generally more advanced and they made significantly fewer phonetically inaccurate errors. Also, unlike dyslexics, they showed no impairments on any language tests. The present theory-imposed categorisation into two types of developmental reading disorder accords well with the main findings from these two studies. In both studies large groups of children diagnosed as reading retarded were scrutinised with the purpose of finding distinct subgroups. Interestingly, both studies turned up only two subtypes, and the same ones, although this was *not* specifically predicted in either case. The frequent failure to find evidence for a large variety of subtypes in developmental dyslexia cannot be ignored and constitutes a glaring difference to studies in acquired dyslexia.

Nevertheless, it is generally acknowledged that children with developmental reading disorders are anything but a homogeneous group. The present theory attributes some heterogeneity to the underlying deficits, but most of it to the development of abnormal or compensatory strategies. These would be expected to be very diverse indeed. Classification according to development

subsequent to the point of arrest in the normal developmental sequence would of course also be possible, but this is another matter and needs to be kept separate.

Having identified just two points of developmental arrest, one at phase 1, the other at phase 2, it remains to be seen if it would be possible to identify arrest within phases, namely at steps 1a, 1b, 2a, 2b, etc. This would imply that each of the three basic strategies might be applied to reading/or writing exclusively without transfer from one activity to the other. This one might consider very unlikely. However, just such a case may be presented by the type-B speller.

A Selective Failure of the Orthographic Strategy and Type-B Spellers

Type-B spellers were previously described as poor spellers who are at the same time good readers. It was shown (Frith, 1979, 1980, 1982) that spelling errors in these cases were such that good alphabetic skills must be presupposed. Of course, the alphabetic strategy is never very efficient for reading, and when the children were forced to use it, for instance when reading nonsense words, or reading phonetically rendered text, then they were much less successful than when they could read using orthographic skills. However, whereas orthographic skills seemed strong in reading (e.g. correct identification of homophones) they seemed weak in spelling (confusion of homophones). Thus, type-B spellers could read their own misspelled words rather less well than type-A spellers could read theirs. Exactly this pattern of results would be expected for developmental arrest at step 3a and is different from arrest at step 2b, as in dysgraphia.

What failure can we suppose to underlie this persistent reading/spelling dissociation? Clearly, a hypothesis is required that allows the orthographic principle to be grasped fully and applied with consummate skill for reading, yet explains why this principle fails for spelling. Although the notion of separate orthographic output logogens (Morton, 1980) fits extremely well with this phenomenon, the puzzle remains of how faulty output logogens came about in the first place.

It has already been argued that the power of orthographic strategies for spelling eventually depends on the precision of the internal representation of the hypothesised orthographic units. At step 3a, representations may still be imprecise (level 1). This is not necessarily detrimental to reading, but very much so for spelling. For this reason spelling will still have to rely on alphabetic strategies, and lag behind reading.

I previously put forward the hypothesis that precise orthographic representations (whether or not they are separated for purposes of input and output) are acquired as the result of a reading strategy that gives equal attention to all letters in a word. This was supported by some experiments

(Frith, 1980, 1983). Such a strategy would therefore involve more work than was just necessary and sufficient for word recognition. It is conceivable that individual differences exist in terms of willingness/capacity to adopt such a wastefully inelegant strategy, and this would provide an explanation for arrest at this point in the sequence.

AN *e*-CANCELLATION EXPERIMENT WITH TYPE-B SPELLERS

To inquire further into this attention-to-detail hypothesis Dolores Perin and I carried out an *e*-cancellation experiment. We chose *e*-cancellation as just the sort of task to discriminate people who did and did not habitually pay attention to letter-by-letter detail. We hoped that the type of *e* that was missed would give us clues as to exactly which detail was likely to be *not* represented in imprecise internal orthographic images. Previously (Frith, 1979) I found it useful to distinguish important and unimportant *e*s in words on the basis of whether they are necessary for identification of a word. For instance, *lift.d* can be identified as "lifted" without the missing letter *e*; *l.ft* cannot be identified as "left", unless there is an *e*, otherwise, it could be "lift" or "loft." Whether or not an *e* is important can be easily established by this guessing technique. Important *e*s are usually in stressed syllables, mostly at the beginning or in the middle of a word and are clearly pronounced. Unimportant *e*s are usually in unstressed syllables, often near the end, and are usually schwa sounds or completely silent. I found that normal adults tend to miss more of the unimportant than the important *e*s in an *e*-cancellation task.

The distinction between important and unimportant *e*s makes sense insofar as it helps us to hypothesise what detail in a word may be skipped without penalty. This can be called "reading by partial cues." With an orthographic reading strategy that is just sufficient for recognition (but not for building up precise representations and hence *not* sufficient for word production) one could afford to skip unimportant *e*s but not important ones. This may be then what type-B spellers do. Certainly, in spelling it is precisely with schwa sounds that type-B spellers have particular trouble. They often do not know if it is *independent* or *independant*; *existance* or *existence*. Perhaps this difficulty stems from a relative neglect of these letters. Further, if these letters are neglected, then they are not internally represented. If they are not represented, then they might not be noticed during the cancellation task. The strong prediction can therefore be made that type-B spellers, who are equal to type-A spellers when cancelling important *e*s, should show more misses than type-A spellers for unimportant *e*s.

We used a sample of fourth-formers (aged 14) from five Inner London schools. All spoke English as a first language and all were assessed on the

Spar Reading Test which involves sentence completion with multiple choice (jet planes fly *fairy–farm–finish–fast*...) and a dictation test based on 30 regular and irregular words from Schonell's lists (1942). We initially selected 14 type-A spellers. These showed ceiling performance on both the reading and spelling test. There were also 12 type-B spellers who performed at ceiling (95–100% correct) when reading and much less well (42–65%) when spelling. The final selection of the subjects was based on their *e*-cancellation performance.

We presented two ordinary typed A4 pages each with 170 words, containing the letter *e* just once, intermixed with 130 words without any letter *e*. On one page, *e*-words had mainly important *e*s, on the other page, mainly unimportant ones. The order of presentation was balanced, each subject receiving both pages.

The two groups were matched in terms of the number of misses of important *e*s. The range was from 4 to 15 misses in this category. This matching procedure left nine subjects in each group. The results are shown in Table 13.2. They bear out the prediction that type-B spellers miss more unimportant *e*s than type-A spellers, even though they miss just as few important *e*s as type-A spellers ($z = 1.90$, $p = .023$). This supports the hypothesis that habitual attention to letter-by-letter detail in type-A spellers is superior compared to that in type-B spellers. Furthermore, it suggests quite concretely that neglect of schwa vowels may be a feature of imprecise orthographic images. If equal attention to all letters including schwa vowels is an essential requirement for skilled use of the orthographic strategy in spelling, then this aspect of skill seems to be inadequate in type-B spellers.

We still have the problem of explaining the persistent use of imprecise orthographic representations in spelling but not in reading. It seems reasonable to assume that type-B spellers who become truly excellent readers in the end do manage to build up precise orthographic input representations. Indeed, this must be so if they do not confuse homophones. Why then do they not use these excellent input-specific representations to modify their poor output-specific ones? One possibility is that modification is very

TABLE 13.2
Results of *e*-Cancellation Task: Number of *e*s Missed (out of 170)

	Important es		*Unimportant es*	
	Mean	*SD*	*Mean*	*SD*
A (N = 9)	7.44	(2.55)	12.56	(7.55)
B (N = 9)	7.11	(3.30)	17.56	(12.69)

difficult once automatic output programmes have been established. Their output programmes may have been established prematurely, that is, at a point before the input representations have reached the critical level 2. In normal development the trigger for moving forward from step 3a to step 3b would be the time when level 2 orthographic representations are available. A type-B child, on the other hand, might not reach this critical level for a very long time, and hence—perhaps in the way of compensation—will use level 1 orthographic representations, imprecise as they are, as the basis for spelling output programmes.

This hypothesis would derive support if it could be shown that spelling errors in type-B individuals exhibited undeniable orthographic elements (besides the already demonstrated alphabetic ones), such as morpheme preservation, or graphemic elaboration that is superfluous to the phonetic rendering of the word (*wright* for "write").

SUBTYPES OF DEVELOPMENTAL AND ACQUIRED READING AND WRITING DISORDERS

Developmental disorder was defined as a failure to advance normally from one phase to another. This contrasts with post-developmental disorder where there can be a loss of skill at whatever phase it was acquired. With a simple framework of three phases of literacy acquisition we can therefore distinguish two types of developmental but six types of post-developmental disorder. These are illustrated in Table 13.3. Types 1 and 2 are the only ones that should be quite closely comparable for both groups. A type 0 is conceivable where even the logographic principle fails. This, however, I

TABLE 13.3
Schematic Representation of Subtypes of Dyslexia According to Strategy Available (+) or Not Available (−)

	Subtypes of Developmental Disorder		*Subtypes of Post-developmental Disorder*					
	1	*2*	*1*	*2*	*3*	*4*	*5*	*6*
Logographic strategy	+	+	+	+	+	−	−	−
Alphabetic strategy	−	+	−	+	−	+	−	+
Orthographic strategy	−	−	−	−	+	−	+	+

would consider to be likely only in the context of severe subnormality or severe brain damage.

Patterson (1981) has used a similar format for the schematic representation of different types of acquired dyslexia. Her dimensions of classification, however, were expressed in terms of reading performance rather than in terms of underlying skills. It is very easy to draw the two together. The logographic strategy would be characterised in terms of a strong word/nonword effect, a content/function effect, and imageability/concreteness effect. The last two effects could both be considered to reflect an underlying age of acquisition effect. Thus, content words and concrete words are acquired earlier and are therefore likely to have been part of the early logographic representations. Deep dyslexic patients, given the present classification, would correspond to type 3. Type 1 may conceivably be another variant of deep dyslexia where orthographic skills are severely impaired in addition to alphabetic ones. The word length and the spelling regularity effect are characteristic of alphabetic skills, and if these are intact, as in types 2, 4, and 6, we can speak of variants of surface dyslexia.

If the present definition of developmental disorder is accepted, then there will always be more types of acquired disorder, however much one refines the theory of acquisition and however many subtypes of developmental failure one might identify.

SUMMARY AND CONCLUSIONS

The subtypes of developmental reading and writing failure that are suggested by the present theory can now be summarised.

Classic developmental dyslexia is the failure of alphabetic skills. It corresponds to arrest at phase 1 in the normal developmental sequence. One explanation of the failure that is favoured by a number of recent studies is in terms of a disorder of the phonological system. The theory predicts that dyslexic children are able to use logographic skills. This strategy is assumed to be characteristic of phase 1 in the young beginning reader. Nevertheless, dyslexic children do not necessarily resemble beginners because they also develop compensatory strategies. With time they can gradually improve in the use of logographic skills way beyond the level reached by young children and can build up a good sight vocabulary. Second, we know that dyslexic children are often especially drilled in "phonics" with the result that they do acquire alphabetic skills to a certain extent. This is not akin to normal developmental breakthrough, however, as they always have to spend more effort using this strategy than normal children. Typically, they are slower, more variable, and cannot always maintain the effort under stress. In contrast, the effortless automatic use of the skill is typical of normal readers.

Developmental dysgraphia is the failure of orthographic skills and corresponds to arrest at phase 2. If children find it difficult to handle these particular skills, then they are expected to continue to rely on alphabetic (and, if encouraged, logographic) skills. This is characteristic of phase 2b in normal literacy acquisition, and probably also of some cases of acquired surface dyslexia. Again, it needs to be added that compensatory strategies can lead to a reasonable degree of competence. Dysgraphic children (sometimes called spelling-only retardates) are not as severely handicapped as dyslexic children, because their developmental failure occurs later in the developmental sequence.

A variant of developmental dysgraphia at a more advanced phase of acquisition (phase 3a), and therefore a still milder handicap, is found in the *type-B speller*. This disorder implies a failure of the orthographic principle for spelling but not for reading, and results in the initially surprising combination of excellent reading and atrocious spelling. In the case of type-B spellers, orthographic representations for spelling production may have been established prematurely on the basis of still imprecise orthographic representations for word recognition. An experiment using *e*-cancellation illustrated that attention to letter-by-letter detail, which may be crucial for increasing the precision of representations, can be taken for granted in type-A spellers, but not in type-B spellers.

It would be paradoxical if the developmental approach to developmental disorders ignored developmental processes subsequent to the point of arrest in the *normal* sequence. Indeed it needs to be emphasised that we *expect* at least some improvement in literacy skills after such arrest. There is likely to be progress in earlier strategies that have been mastered normally. There may also be compensatory strategies. Hence, the present theory has no provision for "stagnation." Following arrest, therefore, we would not expect to find exactly the same picture in a dyslexic or dysgraphic child as in a normal child who is at that phase of acquisition where the arrest occurred.

The present framework may allow a fresh approach to comparisons between developmental and acquired reading disorders. It seems important to acknowledge that developmental disorders are not simply disorders occurring in childhood. The aetiology of developmental disorders must be located in the developmental process whereas brain trauma can occur at any time. In order to contrast these two types of problems it was suggested that a developmental disorder is defined as arrest at a particular phase in the developmental sequence. With an acquired disorder, a loss of a strategy may occur regardless of the order of acquisition. The patient may still retain a strategy that previously had been built up on the one he or she lost. A developmental disorder rules out such a case.

One major aim for research is to discover what it is that actually goes wrong when there is an arrest in development. There is the possibility that a

defect in underlying factors, for example, a phonological dysfunction, may prevent normal progress. There is the possibility that strategies fail to be merged together. As was briefly suggested earlier, one outstanding feature of normal development is the ability to pool strategies belonging to different phases. Thus, an arrest in the normal sequence can be seen perhaps as an inability to merge strategies rather than as an inability to acquire new ones.

Although much has still to be worked out to make the present model credible, it may have served a purpose in alerting us to the fallacy that developmental and acquired disorders are one and the same. Perhaps it has made the point that the already existing *structural model*, useful as it is in describing the skilled reading process, needs to be complemented by a *developmental model* in order to make sense of the varieties of developmental dyslexia.

ACKNOWLEDGEMENTS

While making extensive revisions to this chapter I have been greatly helped by the editors' questions and criticisms. I am especially grateful, for their many helpful suggestions and clarifications, to John Morton, Maggie Snowling, Lindsay Evett, Alan Leslie, and Chris Frith.

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