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AUTHOR Ellis, Nick  
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ABSTRACT

Noting that proposed models of literacy development suggest that reading and writing mutually influence and grow from each other, this paper summarizes aspects of stage theories of literacy development and an integrative model, and considers how the model fared in empirical longitudinal tests. The paper begins with a summary of the modal aspects of stage theories of spelling development and reading development. The paper then discusses interactions in the development of reading and spelling as indicated in U. Frith's developmental model, which suggests that normal reading and spelling development proceed out of step and that the adoption and use of a strategy in one domain may serve as a pacemaker for development of that strategy in the other. The paper also discusses tests from longitudinal studies of development, including investigations of phonological awareness and alphabetic reading; alphabetic spelling, phonological awareness, and reading; and orthographic reading and orthographic spelling. The paper next discusses results of tests from training studies and longitudinal studies of single cases. The paper concludes that the studies reviewed give considerable support for several of the claims of Frith's model, but that further research is needed to properly examine the detailed cognitive interactions in the development of literacy. A figure illustrating Frith's model of reading and spelling acquisition and a figure illustrating a proposed longitudinal study are included. Contains 103 references. (RS)

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LONGITUDINAL STUDIES OF SPELLING DEVELOPMENT

ED 366 930

Nick Ellis

Department of Psychology,  
University of Wales,  
Bangor, Gwynedd, Wales

LL57 2DG

U.K.

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*N. Ellis*

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## INTRODUCTION

A number of models of the development of spelling have been progressively refined over the last fifteen years (Ehri, 1986; Gentry, 1978, 1982; Henderson & Beers, 1980; Morris, 1983). These share the following commonalities: (i) they are based on analyses of spelling errors when children attempt to spell novel words (invented spellings), (ii) they are stage theories, proposing that qualitatively different cognitive processes are involved in children's spelling at different points in development and that there is a characteristic progression from stage to stage, (iii) they emphasise that phonological awareness plays a crucial role in children's early spelling but also that children eventually acquire orthographic descriptions of words. These models have been developed in parallel with cognitive developmental stage theories of reading acquisition (e.g. Marsh and his colleagues, 1980, 1981), also based on error analysis, also holding that there are very different strategies of information processing used in reading at different stages of its development, and also emphasising the links between phonological awareness and reading development. Although synchronous, paradoxically these theoretical developments concerning reading and spelling were essentially independent until Ehri (1979, 1984) showed that the improvements in phonological awareness on which are based the acquisition of alphabetic reading are themselves a consequence of learning how sound segments in words are spelled conventionally, and hence Frith (1985) and Ehri (1986) proposed models of literacy development where reading and writing mutually influence and grow from each other.

The purpose of the current review chapter is to briefly summarise the modal aspects of stage theories of spelling development, reading development, and Frith's integrative model and then to see how well these theories have fared in empirical tests from several longitudinal studies of development which have been prosecuted in recent years.

## STAGES OF SPELLING DEVELOPMENT

The idea that children's misspellings reflect a developing sense of phonetic properties in words was pioneered by Read (1971, 1975, 1986) who found evidence that young inventive spellers used a system of grouping sounds together according to shared phonetic features. Thus they might represent a particular vowel sound in their spelling by substituting a letter

whose name shared a salient phonetic feature with the sound. Read's exhaustive studies of invented spellings demonstrated that children use processes of both speech production and perception to group sounds together and that these categorizations may not coincide with the classification system used by adults:

'We now value spellings for what they can tell us about psycholinguistic processes. Standard spellings are of less interest, not because they represent successful instruction, but because they do not indicate how a child arrived at them... Some non-standard spellings represent a more advanced conception of the task or the language than others.' (Read, 1986, p. 47; see also Wilde, 1988).

This idea that spelling errors provide an index of children's metalinguistic understanding of language has allowed subsequent researchers to categorize developmental strategies in spelling. Henderson and Beers (1980) analyzed samples of children's creative writing and assigned each error to a category according to the completeness of phonetic information mapped by the misspelling. On the basis of their work and that of Bissex (1980) and of Gentry (1978, 1982), it is now generally agreed that children move through five distinct stages of spelling, viz, PRECOMMUNICATIVE, SEMIPHONETIC, PHONETIC, TRANSITIONAL and CORRECT spelling. PRECOMMUNICATIVE spellings are characterized by the strategy of randomly selecting letter strings to represent words (e.g. spelling *monster* as BTRSS, or *chirp* as IMMPMPH). Although at this stage children can produce letters in writing, their spellings reflect a complete lack of letter-sound or letter-name knowledge. SEMIPHONETIC spellings contain a partial mapping of phonetic content. At this stage (i) the speller begins to conceptualise that letters have sounds that are used to represent the sounds in words, (ii) the letters used to represent words provide a partial but not total mapping of the phonetic representation of the word being spelled, and (iii) a letter name strategy is very much in evidence - where possible the speller represents words, sounds or syllables with letters that match their letter names (e.g. R for *are*; U for *you*; LEFT for *elephant*). At the PHONETIC stage, (i) phonological segmentation of spoken words is usually evident and as a result, (ii) spellings contain a complete description of the sequence of sounds in pronunciations, (iii) all of the surface sound features of the words are represented in the spelling, (iv) children systematically show particular spellings for certain

details of phonetic form such as tense vowels, lax vowels, preconsonantal nasals, syllabic sonorants, *-ed* endings, etc., but (v) letters are assigned strictly on the basis of sound without regard for acceptable letter sequence or other conventions of English orthography (e.g. IFU LEV AT THRD STRET IWEL KOM TO YOR HAWS THE ED for *If you live at Third Street I will come to your house. The End.* [Bissex, 1980, p. 13]). In the TRANSITIONAL stage the child begins to adhere to more basic conventions of English orthography: vowels appear in every syllable (e.g. EGUL instead of the phonetic EGL for *eagle*); nasals are represented before consonants (e.g. BANGK instead of the phonetic BAK for *bank*); both vowels and consonants are employed instead of a letter name strategy (e.g. EL rather than L for the first syllable of ELEFANT for *elephant*); common English letter sequences are used in spelling (e.g. YOUNITED for *united*), especially liberal use of vowel digraphs like *ai, ea, ay, ee*; silent *e* pattern becomes fixed as an alternative for spelling long vowel sounds (e.g. TIPE in place of the phonetic TIP for *type*), etc. TRANSITIONAL spellers present the first evidence of a new orthographic strategy, moving from phonological to morphological and orthographic spelling (e.g. EIGHTEE instead of the phonetic ATE for *eighty*), but they have not fully developed knowledge of environmental factors such as the graphemic environment of the unit, position in the word, stress, morpheme boundaries, and phonological influences. Acquisition of this knowledge, along with extended knowledge of word structure (e.g. prefixes, suffixes, contractions, and compound words), an increased accuracy in using silent consonants and in doubling consonants, and simply in knowing when word “just don’t look right” (i.e. in having a complete visual orthographic description of them), are elements which allow the mastery of CORRECT spelling.

These descriptive categories for this developmental sequence are quite fine grained. They can be more coarsely summarised as a shift from Stage I of early attempts (which may be PRECOMMUNICATIVE or be based on visual copying of whole word or symbol patterns [SYMBOLIC or LOGOGRAPHIC], or very rudimentary PREPHONETIC attempts representing perhaps just the first sound of a word), through Stage II reflecting varying degrees of mastery of the ALPHABETIC principle, through to Stage III of correct ORTHOGRAPHIC or MORPHEMIC spelling (Gentry, 1982; Ehri, 1986; Frith, 1985).

## STAGES OF READING DEVELOPMENT

Analyses of children's early reading errors (Biemiller, 1970; Torrey, 1979; Weber, 1970) led Marsh, Friedman, Welch and Desberg (1981) to propose that the first stage of reading could be characterised as one of LINGUISTIC SUBSTITUTION where the child uses a strategy of rote association between a simple unsynthesised visual stimulus and an unanalysed oral response. "The child typically centres on one aspect of the visual stimulus such as the first letter and associates that with the oral response ... Their natural strategy is congruent with the 'whole word' approach to teaching reading" (pp. 201-202). Frith (1985) calls this the LOGOGRAPHIC stage. If the child does not know the word she may guess on the basis of contextual cues.

Marsh et al. suggest that the child next progresses to DISCRIMINATION NET SUBSTITUTION where "the number of graphemic features a young child can process is limited initially to the first letter, and it is only later that additional features such as word length, final letter, etc. are added. The child at this stage appears to be operating according to a 'discrimination net' mechanism in which graphemic cues are processed only to the extent necessary to discriminate one printed word from another." (p. 203).

Marsh et al. call the next stage that of SEQUENTIAL DECODING, Frith terms it ALPHABETIC, Gough and Hillinger (1980) DECIPHERING, Harris and Coltheart (1986) PHONOLOGICAL-RECODING. In all of these models this is characterized by the use of individual graphemes and phonemes 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 novel and nonsense words" (Frith, 1985, p. 308).

Both models hold that the final stages of skilled reading takes place by the use of ORTHOGRAPHIC strategies. Marsh et al. characterize this as being an extension to the simple decoding strategy (which was based on one-to-one correspondence) where the child now learns more complex rules of orthographic structure - the units are letter groups, and higher order conditional rules (like the magic *e* rule) are used. Frith, however, suggests that skilled reading involves orthographic strategies where the words are instantly analysed 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." (Frith, 1985, p. 308). Both the models of Frith and Marsh et al. emphasize analysis of multiple letter orthographic units, but Frith is implying that practice at the analysis of orthographic sequences will eventually allow non-phonological whole-morpheme direct lexical access, with post-lexical phonological retrieval.

### INTERACTIONS IN THE DEVELOPMENT OF READING AND SPELLING

The importance of Frith's (1985) model is that it provides a theoretical framework within which spelling and reading interact to advance the learner towards increased proficiency in each ability. It is a developmental model where reading and spelling both progress through stages of logographic, then alphabetic, and finally orthographic strategies. But her model does more than this in that it suggests reasons for the move from one stage to the next. The crux of her argument is that *normal reading and spelling development proceed out of step* and that the adoption and use of a strategy in one domain may serve as a *pacemaker* for development of that strategy in the other. This is illustrated in Figure 1 which shows the points at which the domains are misaligned and the cross-domain influences that are suggested to occur.

Figure 1 about here

**CLAIM 1** Frith suggests that the beginnings of literacy lie in logographic reading whereby the child has a finite whole-word reading vocabulary and that the development of this means of reading results in its adoption as a strategy for spelling. Thus CLAIM 1 is that *logographic reading is the pacemaker for the use of a logographic strategy in spelling*. Evidence for a logographic stage of reading comes from Seymour and Elder (1986) who showed that five-year old beginning readers, who were taught by a predominantly 'look and say' method, were able to read aloud words that they had been taught but nevertheless possessed no usable procedures for pronouncing new words. However, evidence for this driving the development of a logographic strategy of spelling is more hard to come by. There is little doubt that children are

first brought to the importance of the written word by seeing them, but several investigators, most notably Goswami and Bryant (1990, chapter 3), seriously question the existence of a logographic stage of spelling.

**CLAIM 2** At some points of development, reading and spelling are paradoxically out of synchronisation. As Goswami and Bryant (1990, p. 148) put it: "It is still not clear why children are so willing to break up words into phonemes when they write, and yet are so reluctantly to think in terms of phonemes when they read. But there can be little doubt that at first children's reading and spelling are different and separate. The most dramatic demonstration of this separation is the fact that young children often cannot read some words that they know how to spell and also fail to spell some words which they can read." Perhaps the major tenet of Frith's model, like that of Ehri (1986), is that children first gain explicit insight into the alphabetic code through practice at spelling and that it is this which causes a shift from a logographic reading strategy to alphabetic approach. CLAIM 2 is therefore that *alphabetic spelling is the pacemaker for the use of an alphabetic strategy in reading*. This can be broken down into two components: CLAIM 2a is that *phonological awareness is much more related to early spelling than it is to early reading*, CLAIM 2b is that *this mutually supportive growth of phonological awareness and spelling acts as a pacemaker for the adoption of an alphabetic strategy of reading*.

The flesh of the argument of CLAIM 2 is as follows. It assumes that phonological awareness is important in the development of alphabetic reading (Bradley and Bryant, 1983; Ellis and Large, 1987, 1988) but it is first when attempting to spell rather than to read that the child realises that a phonological strategy is useful in breaking up print-speech correspondences (Smith, 1973; Bryant and Bradley, 1980; Frith, 1981; Snowling and Perin, 1983). Early spelling practice typically involves dividing spoken words into phonemes and representing these phonemes with letters. In this way experience in spelling words affords the opportunity for making comparisons between the phonetic information in individual letters and sounds as they are embedded in the spoken word. Spelling practice helps to establish this abstract concept through two very concrete means - articulatory and kinesthetic rehearsal - and by cross-modal correspondences so that orthographic units guide parsing breaks and provide



labels for the sound chunks produced by the novice segmenter (indeed, when considering phonology, we cannot ignore our knowledge of orthography once acquired, as is evidenced by fourth-graders and above thinking that *pitch* has four phonemes but *rich* only three, whereas in both of these words a phonetic element corresponding to the extra letter *t* is present in articulation, Ehri & Wilce, 1980). Through repeated practice in spelling, the child may come to appreciate the subtle relationship between a symbol in the written word and its corresponding sound in the context of the spoken word. The discovery of this relationship is the key to alphabetic insight. The crux of the problem is 'knowing how to combine the letters into units appropriate for speech' (Liberman and Shankweiler, 1979, p. 141). As children struggle to decompose words into individual phonemic units, they commonly experiment with various articulatory rehearsals of word parts and they search for distinguishable articulatory units that correspond to letter-sound units. This process of their separating sounds in a word through consciously monitoring their own articulations may serve a dual purpose: it may both help the development of phonological awareness and enhance knowledge of the alphabetic principle. As children refine their ability to detect and isolate the sound content of spoken words through repeated practice in spelling, so they build a store of knowledge about the relationships among sounds, letters and pronunciations that can be applied to the task of reading (Chomsky, 1977; Ehri, 1986).

**CLAIM 3** Finally both Frith (1985) and Ehri (1986) suppose that considerable practice at reading by means of an alphabetic strategy encourages sufficient analysis of letter sequences in words to allow the reader to develop internal representations that are well-specified in terms of letter by letter detail. These orthographic representations acquired through reading would then be exact enough to be transferred to spelling and to there constitute the knowledge that allows the shift from PHONETIC through TRANSITIONAL to CORRECT spelling described above. Thus CLAIM 3 is that *reading is the pacemaker for the development of orthographic spelling.*

Frith's model is also important in that it explains different disorders of developmental literacy in terms of arrest at different stages of development. Since the present purpose is to assess it as an explanation of normal literacy development, these other claims will not be

addressed further here.

If we want to study development then we must do so directly. Only when the same persons are tested repeatedly over time does it become possible to identify developmental changes and processes of organization within the individual. Cross-sectional studies which compare different groups of people at different points of acquisition must always come a poor second when small but reliable changes with age are to be detected, where teaching methods and teachers change with time, and where we do not wish to make the artificial assumption that the abilities of a younger cross-section were present in the older cross-section at a previous time (Ellis & Large, 1987). For these reasons we will only weigh the model against the two types of research paradigm which allow some degree of causal interpretation: longitudinal studies and experimental investigations of the effects of training.

## TESTS FROM LONGITUDINAL STUDIES OF DEVELOPMENT

### 1) PHONOLOGICAL AWARENESS AND ALPHABETIC READING

There have now been a number of longitudinal demonstrations that early phonological awareness (PA) predicts later reading achievement even when prior IQ is controlled (Bradley & Bryant, 1985; Ellis & Large, 1987; Lunberg, Olofsson & Wall, 1980; Mann, 1984; Stanovich, Cunningham & Cramer, 1984; see Wagner & Torgesen, 1987 and Goswami & Bryant, 1990 for reviews). It is clear, therefore, that there is a causal developmental sequence whereby alphabetic reading capitalises on prior phonological abilities.

Reciprocal influences are also evident whereby, as metaphonological skills are made relevant and are practised in alphabetic reading, so they themselves are enriched (see Morais, Alegria & Content, 1987 for review). For example: (1) Portuguese adult illiterates who had never attended school for social reasons scored only 19% correct on tests of phoneme addition and deletion whereas matched subjects who had been taught to read and write in special classes in adulthood scored at over 70% levels. Thus Morais, Cary, Alegria and Bertelson (1979) concluded that the ability to deal explicitly with the segmental units of speech is not acquired spontaneously in the

course of cognitive growth, but demands some specific training, which, for most persons, is provided by learning to read and write. (2) Alegria, Pignot & Morais (1982) showed that 6-year-old children trained to read using phonic methods were much better (58%) at phonemic segmentation than whole-word trained readers (15%). (3) Chinese literates who were taught to read *pinyin*, an alphabetic script, scored 83% on a test of segmental analysis, whereas non-alphabetic literates who could read logographs only scored 21% (Read, Zhang, Nie & Ding, 1986). Thus phonological segmentation is to some considerable extent a consequence of *alphabetic* literacy. (4) In a longitudinal investigation of 40 children learning to read English (Ellis and Large, 1988), reading ability at 5 and 6 years old better predicted phoneme segmentation skill one year later than did phoneme segmentation predict later reading. (5) Perfetti, Beck, Bell and Hughes (1987) used time lag partial correlation analyses of first grade children's development to demonstrate that whereas phoneme blending predicted later reading ability, this in turn predicted later proficiency at phoneme segmentation. They suggested that young children come to possess a basic, primitive awareness of the sounds of language on which alphabetic reading capitalises. However, learning to read fosters attention to constituent principles of words and this results in the development of sophisticated segment analysis ability. As this is acquired so there are then further gains in reading itself.

Ellis & Cataldo (1990) put a similar case concerning different aspects of phonological awareness and the differential interactions of these with developing reading. Whereas early research into the relationship between reading and phonological awareness did not discriminate between different types of phonemic awareness tasks (Lewkowicz, 1980; Bradley and Bryant, 1985), more recent work suggests that the level of phonemic awareness demanded by the phonological tasks influences the strength of the relationship between reading and phoneme awareness (Backman, 1983). Stanovich, Cunningham, and Cramer (1984) asked children to perform tasks involving the analysis of words for explicit sound content (nonrhyming tasks) and for the perception of overall similarity of sound content (rhyming tasks). They found that the nonrhyming, or analytic, and productive phonological tasks formed a cluster of related skills and that the rhyming tasks did not correlate strongly with the nonrhyming tasks. Snowling and Perin (1983) found that children's ability to perform a segmentation task was not significantly

different from their ability in spelling, the close connection between these skills indicating the necessity of explicit PA in spelling. Thus there seem to be two, developmentally different, measurable levels of PA. Children's first awareness of the sound properties of speech is implicit and perceptual. Spontaneous play with rhyming and nonsense words is thought to reflect an overall sensitivity to the sound content of words (Chukovsky, 1968; Slobin, 1978; Clark, 1977). At this point they are not yet able to consciously reflect on language (Shankweiler, Liberman and Savin, 1972; Andresen in Valtin, 1984). Valtin (1984) describes a three-stage model for the development of phonological awareness. Initially the child is not aware of the sound value of speech; s/he senses when, but not why, speech acts fail to be communicative. During the next stage, 'children become increasingly able to abstract the language from the action and the meaning context and to think about some of the properties of the form of language. Their knowledge of language units is still implicit, however, and related to psycholinguistic units of speech' (Valtin, 1984, p. 214). Once the child achieves conscious awareness, s/he demonstrates explicit phonological awareness and can reflect upon, produce and manipulate phonemic units within spoken words. MacLean, Bryant and Bradley (1987) demonstrated in a longitudinal study that children's early experience of nursery rhymes results in their gaining initial implicit phonological awareness, Bradley and Bryant (1983) and Ellis & Large (1987) that very early reading capitalises on this implicit phonological awareness, and the above studies, particularly Perfetti et al. (1987), that experience in alphabetic reading promotes more analytic and explicit phonological awareness at sub-syllabic levels.

Stanovich and his colleagues present a body of evidence which appears interestingly to contradict the above conclusions. They use tests of recognition of famous authors and titles to assess the amount to which individuals have been exposed to print and, by inference, the amount of reading that they have done. Although, as will be described below, print exposure is highly predictive of orthographic knowledge and vocabulary even when intelligence is controlled, it does not reliably predict phonological processing abilities (e.g. phoneme deletion or transposition) either in children (Cunningham & Stanovich, 1990, in press), or in adults (Stanovich & West, 1989). These disparate results do not seem attributable to measurement instruments since they used similar sorts of phoneme segmentation tasks to those in the above

studies. Cunningham and Stanovich (in press) invoke the twin studies of Olson, Wise, Conners, Rack, and Fuller (1989) which demonstrate that the variance in word recognition associated with orthographic processing had a much less heritability than did variance in word recognition associated with phonological processing and thus they suggest that phonological awareness of this type is less affected by experience afforded by print exposure. Another possibility is that amount of exposure to the written language per se is not the relevant variable - rather, in normal (as opposed dyslexic) children, refined explicit phonological awareness at the level of the phoneme is acquired as a result of alphabetic literacy skill which in turn is engendered by an introduction to grapheme-phoneme correspondences in spelling.

This leads us to the particular question of CLAIM 2 - what is the role of spelling in the coming together of phonological skills and reading?

## 2) ALPHABETIC SPELLING, PHONOLOGICAL AWARENESS, AND READING

There is now a useful collection of longitudinal studies which address the development of phonological awareness, reading and spelling. Unfortunately while they are all informative, they also all have their problems. This section will briefly describe some representative studies and weigh CLAIM 2 against their evidence.

(L1). *Lundberg, Olofsson and Wall (1980)* presented the first longitudinal study where phoneme segmentation and synthesis skills measured during kindergarten in 143 Swedish children were used as predictors of reading and spelling development at the end of grade 1 and the beginning of grade 2. There were highly significant correlations between the PA measures and later reading and spelling, demonstrating the extreme importance of PA in literacy acquisition. Unfortunately the study was marred by too easy a spelling test at grade 1 resulting in ceiling effects on this variable and lack of discrimination. It is difficult, therefore, to assess whether PA is more involved in early spelling than in reading (CLAIM 2a) and impossible to look at causal interactions between early spelling and later reading (CLAIM 2b).

(L2). *Tornéus (1984)* investigated the causal relationships between intelligence (IQ), general language development (L), phonological awareness (PA: sound blending and segmentation), reading (R), and spelling (S) in 46 dyslexic and 44 control Swedish children at the end of grade 1 (IQ1, L1, PA1, R1, S1) and at the beginning (IQ2, R2, S2) and middle of Grade 2 (S3).

A number of causal models of interactions in their development were tested using LISREL. There was a very strong causal path from PA1 to spelling, but only a slight influence of general linguistic and cognitive development on spelling. The causal model for reading was similar with the exception that it also included a direct causal path from cognitive development. Moreover, it was clear that the correlations between various aspects of PA and spelling at all grades measured (.51 - .73) were considerably higher than those between PA and reading (.33 - .53), a set of findings consistent with Frith's CLAIM 2a that phonological awareness is initially much more involved in spelling than in reading. Unfortunately there were no models which looked for interactions in affect from reading to spelling and vice versa, so it is difficult to assess Frith's CLAIM 2b about pacemakers from this study (the failure to obtain an R3 measure also limits these possibilities here). Tornéus does provide tests of reciprocal models whereby PA could affect S (or R) and S (R) could in turn affect PA. These suggested much more of a causal role in development from PA to reading and spelling than the reverse. However, there are grave problems with these analyses: (i) solutions to such reciprocal path models are notoriously unstable in causal path analysis, (ii) PA was measured at time 1 only, the composite S variable was measured at times 1, 2, and 3, the composite R variable at times 1 and 2, and therefore the models fitted were looking for causal affects of, e.g., spelling mid grade 2 on grade 1 PA. Since neither time nor development run backwards it is not surprising that there were low beta-weights on these paths. Contra Tornéus' claims, therefore, these models are not fair tests of, for example, Ehri's (1979) claim that phonological awareness arises from acquaintance with orthography gained from practice in spelling.

(L3). *Juel, Griffith and Gough (1986)* assessed a well motivated range of variables including IQ, listening comprehension, PA (phoneme segmentation and phoneme substitution), exposure to print, non-word reading, spelling recognition and production, reading comprehension and writing in over a hundred children over the first two grades of their schooling in Texas. Unfortunately they analysed the data with a series of cross-sectional rather than time-lag models and re-analysis is impossible as they do not provide time-lag correlations. Their cross-sectional data do replicate high correlations between PA and both reading and spelling. However these correlations were of similar magnitude in both grades (Table 3) and there is thus

no evidence from their study that explicit PA is more related to grade 1 spelling than to reading (CLAIM 2a). The lack of cross-lagged correlations precludes a test of CLAIM 2b.

(L4). *Mommers (1987; Mommers, van Leeuwe, Oud, & Janssens, 1986)* describe a longitudinal investigation of the first three years of development of PA, reading and spelling in approximately 500 Dutch children. The study is admirable in that (i) word identification, spelling, and reading comprehension were measured in parallel at least 5 points in development and (ii) the investigators analyse the results with proper longitudinal causal path models. Unfortunately (i) PA was only measured at the first point and so reciprocal effects of reading and spelling on PA growth cannot be assessed, (ii) as in many of the above studies the reading and spelling tests included both words regular and irregular in terms of grapheme-phoneme correspondence and so we cannot disentangle alphabetic and orthographic strategies, (iii) such a complex data set limits the authors to reporting only the final models resulting from many iterative stages of model refinement. Even so there is some tentative support for aspects of Frith's model. In the first place there were strong effects of initial PA on immediately subsequent single word reading and spelling abilities, although there was no evidence of a greater contribution on spelling (CLAIM 2a). In the course of model refinement the investigators found it necessary to fit a path at the second point of measurement (4 months after the start of formal reading instruction) between spelling ability and word reading (SPo to DSo in their Figure 5), "a much stronger one than in the reverse direction" (Mommers, 1987, p. 136). In that this influence of spelling on reading is unique to this early stage of literacy development this finding is highly supportive of Frith's suggestion of the influence of spelling on alphabetic reading (CLAIM 2b). At all subsequent stages the best-fitting causal models had significant, although not large, influences in the reverse direction, i.e. from word reading to spelling: "There also exists an influence of decoding skill on spelling. In both decoding skill and spelling, orthographic representations stored in the lexicon play a part. .. The repeated reading of words can only to some extent improve the quality of the orthographic representations." (Mommers, 1987, p. 140). These paths, although small, are supportive of CLAIM 3.

(L5). *Cataldo and Ellis (1988; Ellis & Cataldo, 1990)* charted the development of reading,

spelling and phonological awareness in a group of 28 children during their first three years in school. During this time the children were tested at four intervals in reading and spelling real and nonsense words, phoneme segmentation and auditory categorization. The Wechsler Preschool Primary Scale of Intelligence was included in the set of initial assessments. A test of phoneme segmentation was given as a measure of explicit phonemic awareness and a test of auditory categorization was taken as a measure of implicit phonological awareness. The majority of the sample had only begun to attend school when the initial assessments were taken at the beginning of the school year when their mean age was 4 years 6 months. The children were retested at the end of their first school year, at the beginning of the second year and finally at the beginning of the third school year. Exploratory (LISREL) causal path analyses were used to investigate the contribution of each ability to the subsequent growth of skill in word recognition, spelling and phonological awareness over three measured phases of development. Phase One spanned the children's first year in school. Phase Two charted the development from spring of the first school year to autumn of the second year. Phase Three looked at development from the beginning of the second year in school to the beginning of the third year. The Phase One pathweights from spelling to reading real words (0.31) and nonsense words (0.23) identified spelling as an important contributor to the early formation of reading. This pattern of influence was repeated in the second phase (spelling to reading real words 0.64 and nonsense words 0.60). The pronounced influence of spelling on reading contrasted with the meagre contributions of reading to spelling (Phase 1: 0.10 real words, 0.06 nonsense; Phase 2: 0.14 real, 0.00 nonsense) thus confirming CLAIM 2b. Implicit PA initially predicted early attempts to read (0.36, 0.41) as well as to spell (0.38, 0.31) but lost its influence on both reading and spelling in the following two phases. In contrast to the diminishing predictive power of implicit PA, explicit PA consistently predicted spelling in all three phases (confirming CLAIM 2a), this influence increasing with phase. Explicit PA only emerged as a strong predictor of reading in Phase Three. To summarize the Ellis & Cataldo results, the early flow of information between reading and spelling appeared to be asymmetrical: knowledge gleaned from spelling contributed to reading. Similarly, both implicit and explicit PA affected spelling development with explicit PA increasing its influence as the contribution of implicit PA



diminished. Only later in the developmental sequence did explicit PA begin to contribute directly to reading.

(L6). *Berninger, Abbott and Shurtleff (1990)* tracked visual language processes (1 second delayed visual recognition memory for a word or for a letter in a word), oral language processes (vocabulary and phoneme segmentation and deletion), reading (word naming and lexical decision), and spelling (written reproduction subsequent to seeing the word) in 42 children during their first grade of school in the U.S. Written and oral language abilities at end of kindergarten predicted reading and spelling at the beginning of first grade. PA skills at this first measurement interval correlated .63 with whole word presentation (WW) reading (lexical decision) but somewhat more so with WW spelling (.74) and WW reading for naming (.77). At the end of first grade the concurrent correlations with PA followed the same patterns with lexical decision reading (.47) lower than spelling (.57) lower than reading for naming (.74). It seems therefore that PA is initially more involved in spelling than in lexical access for reading (although it is involved in reading for naming). This accords with but qualifies CLAIM 2a. Visual word recognition memory abilities at end of kindergarten correlated .55 with WW lexical decision reading, .63 with WW spelling and .63 with WW naming reading but these dropped dramatically in the concurrent correlations at the end of first grade to .26, .04, and .28 respectively. The fact that there are these visual correlates of both reading and spelling at the start of grade 1 but not at the end does lend some support to CLAIM 1 that early reading and spelling are visual or logographic in nature and that there is then a shift from this to alphabetic processing.

(L7). *Goulandris (1991)* reports a small longitudinal study of 27 British children to assess CLAIM 2b. Verbal intelligence (vocabulary), nonword spelling, reading and spelling were used to predict reading and spelling one year later. Even when verbal intelligence, reading age and spelling age were partialled out, non-word spelling still predicted reading and spelling one year later, clearly demonstrating that a child's ability to generate phonetic spellings is the precursor of the eventual acquisition of alphabetic reading (CLAIM 2b).

(L8). Finally and most recently there are the studies of *Wimmer, Landerl, Linortner and Hummer (1991)*. The importance of these studies are that the initial testing was done on

children within one month of joining school in Salzburg before any reading instruction had taken place. In the first study of fifty children, vowel substitution (their measure of PA) was a significant predictor of end of first grade spelling ( $r=.49$ ) and reading ( $r=.45$ ), and these effects were significant even after IQ, initial letter knowledge, and initial nonword reading abilities were partialled out. Study 2 investigated 42 children and the degree to which initial PA and rudimentary logographic (identification of ubiquitous logos such as *Coca Cola*, *Milky Way*) and alphabetic (the reading of logos printed in upper case to distort their original distinctive whole word shape) reading skills predicted later reading of familiar words and nonwords and alphabetic and orthographic spelling. PA predicted later alphabetic spelling (.31), reading accuracy (.30), but not orthographic spelling (.15). Logographic reading did not predict later reading (.08), but alphabetic reading did more so (.19), suggesting a change of reading strategy over this first year from logographic to alphabetic strategies. Logographic reading did, however, predict later orthographic spelling (.42). Most striking was the finding that PA skill at the end of the year was only moderately predicted by prior PA skill (.31), but was highly correlated with reading accuracy at that time (.53) and even more so with nonword spelling (.66). In other words, over the course of the children's first year of entry into literacy, PA and spelling became strongly enmeshed abilities as a result of a symbiotic developmental relationship. Wimmer et al. summarise their article in the title "The relationship of phonemic awareness to reading acquisition: More consequence than cause but still important" and conclude that in most children quite limited exposure to reading and spelling instruction is sufficient to induce explicit awareness of phonemic segments of words..

These findings will be compared and brought together with the findings of training studies in the conclusions of this chapter.

### 3) ORTHOGRAPHIC READING AND ORTHOGRAPHIC SPELLING

We have already described Mommers' (1987) finding of causal paths from word reading skill to spelling at later stages of development. Though not strictly longitudinal studies, Stanovich and his co-workers have produced a number of group studies that give further confirmation to CLAIM 3. Stanovich and Cunningham (1992) argue that when reading,

“whatever cognitive processes are engaged over word or word-group units (phonological coding, semantic activation, parsing, induction of new vocabulary items) are being exercised hundreds of times a day. It is surely to be expected that this amount of cognitive muscle-flexing will have some specific effects.” They demonstrate in multiple regression analyses that adults who read a lot (who have ‘high print exposure’ as measured on Author and Magazine Recognition Tests) are better spellers even when non-verbal intelligence is controlled. The same is true for third and fourth grade children - Cunningham and Stanovich (1990) found that even after partialling out IQ, memory ability, and phonological processing abilities, print exposure (the amount of reading the child did) accounted for significant variance in orthographic knowledge. This result is clear confirmation of CLAIM 3 - that the move to an orthographic strategy of spelling was driven by reading at later stages of development. However, Cunningham and Stanovich (in press) also show that it is true in the case of first grade children. They demonstrate that 6 to 7 year old children’s ability to spell phonologically irregular words like *red*, *talk*, *mouse*, *rough* which require consultation of an orthographic lexicon for conventional rather than phonetic spelling, was a separable component of variance in word recognition from phonological awareness. Furthermore, even at these young ages significant variance in the ability to perform correct orthographic spelling was accounted for by print exposure after phonological processing skill had been partialled out.

Thus there does seem to be clear evidence for CLAIM 3 - that exposure to the letter sequences of words in reading allows the child to develop orthographic representations that can then be used in spelling. However, these results qualify the claim in one important aspect - it seems that in normal children this is happening from quite early on in the development of literacy (Grade 1) rather than being solely an aspect of a later third stage of reading and spelling development.

### TESTS FROM TRAINING STUDIES

Studies involving training children in PA are fairly consistent in supporting CLAIM 2a of Frith’s model whereby phonological awareness is more involved in early spelling than in early reading - training in PA has its first effect on children’s spelling:

(T1). *Bradley and Bryant (1983)* taught metaphonological skills to 4- and 5-year old children who could not read and who were at least two standard deviations below average in sound categorisation ability. Some children were trained in categorising common beginning (*hen, hat*), middle (*hen, pet*), and end (*hen, man*) sounds, others received this training and, with the help of plastic letters, how each common sound was represented by a letter of the alphabet. The training had a positive effect on both reading and spelling measured over the next four years, and Bradley and Bryant concluded that “although others have suggested a link between phonological awareness and reading, our study is the first adequate empirical evidence that the link is causal”. But there is more in their study than this. In the first place there was much greater benefit from training sound categorisation in conjunction with plastic letters which labelled the sounds, confirming the emphases of Ehri and Frith that phonological awareness is more readily acquired when it is related to orthography. In the second place, this training had more effect on later spelling (17 months gain) than it did on later reading (8.5 months gain).

(T2). *Tornéus (1984)* reports a training intervention whereby 38 1st graders were assigned to either phonological awareness training or to a general language activity control for eight weeks. They were pre- and posttested on reading, spelling, sound blending, and segmentation. Training of phonological skills was effective and among the children with the lowest phonological awareness pretest performance, specific phonological training improved spelling performance more than did general language activities. Phonological training did not, however, directly affect reading.

(T3). Experimental evidence for CLAIM 2b is provided by *Ehri and Wilce (1987)* who taught kindergarten children to spell words by attending to constituent letter-sound sequences, and when necessary, to phonetic, phonemic and articulatory cues. These children learned to read words better than children who were taught isolated letter-sound relationships. Thus children trained in *spelling* were superior to the controls in their ability to use phonetic cues and letter-sound constituents when learning to *read*.

(T4). *Lundberg, Frost and Peterson (1988)* trained over 200 Danish preschool children who had as yet no reading instruction in phonemic awareness and assessed the later effects on reading and spelling in first and second grades. Training had a small effect on rhyming and

syllable manipulation abilities, and a dramatic effect on phoneme segmentation abilities. These improvements in turn had a large facilitative effect on grade 1 spelling ( $p < .001$ ) but only a marginal immediate effect on grade 1 reading ( $p < .10$ ). By the end of grade 2, however, the effect of training on spelling persisted ( $p < .001$ ) and by now had a knock-on effect on reading ( $p < .01$ ).

(T5). *Lie (1991)* assessed the effects on later reading and spelling of the training of metaphonological skills in approximately 100 first grade Norwegian children. Both training in phoneme identification and in phoneme segmentation and blending had a facilitative effect on later Grade 1 and 2 reading and spelling, but again the initial effect on spelling was somewhat greater than that on reading. At the end of grade 1, students who had been trained in sequential phoneme segmentation scored significantly higher in spelling than students who had received positional (phoneme isolation) training, a result which stresses that it is important to phonologically analyse a word sequentially in order to spell it.

The results of T1, T2, T4 and T5 are all consistent with both CLAIM 2a, that phonological awareness is much more involved in early spelling than in early reading. The findings of T3 and T4 moreover support pacemaker CLAIM 2b that the acquisition of phonological awareness in spelling drives the development of alphabetic reading.

### LONGITUDINAL STUDIES OF SINGLE CASES

No chapter on longitudinal tests of developmental models would be complete without describing one other essential source of evidence, that of detailed longitudinal clinical investigations of single cases. Unfortunately there simply is not the space to do justice to this body of research and so while this small subsection may allow an assertion of formal completeness, it is readily acknowledged that this chapter is far from satisfactory in this respect.

Just one study will be used to illustrate the power of this approach, particularly with respect Frith's claims about developmental arrest. The reader is referred to chapters by \*\*\*\*\* (this volume) for other examples and to exemplary studies by Temple (1988), Seymour and Elder (1985), Seymour and Evans (1992), and Snowling, Hulme, Wells and Goulandris (1992).

(SC1). *Seymour and Evans' (1988)* study is relevant to CLAIM 1. They analyzed reading and spelling processes in a case (AT) of developmental disability associated Klinefelter XXXY syndrome. Between the ages of seven and eleven years old this boy's reading was almost entirely logographic - he had a sight vocabulary of perhaps over 500 words that he had been taught but was unable to do any sounding and blending, with error rates on nonwords between 95 and 99%. He could spell around 170 words but only managed 1/200 nonwords correctly. Thus AT showed an almost complete absence of alphabetic functions, i.e. his development was arrested at a logographic stage.

## CONCLUSIONS

### 1) FRITH'S MODEL

The longitudinal studies reviewed above give considerable support for several of the claims of Frith's model. There is some evidence of a logographic first stage of reading (L6 and SC1), although no study can be found which provides corroboration for this driving a logographic stage of spelling [CLAIM 1]. Phonological awareness does seem more related in early development to spelling than to reading (L2 and L8, but compare L3 and L4), and training in PA first affects the development of spelling rather than reading (T1, T2, T4, T5) [CLAIM 2a]. The acquisition of PA through spelling engenders developments of an alphabetic strategy of reading (L4, L5, L7, T3, T4) [CLAIM 2b - see Ellis & Cataldo, 1990 for the pedagogical implications of this]. The acquisition of orthographic knowledge through reading promotes orthographic spelling (L4 and Stanovich & Cunningham, 1992) [CLAIM 3].

But these data also suggest some additions and qualifications. In the first place they very clearly show that there are different facets of PA, an early implicit awareness of syllables and rhyme and a later sophisticated explicit ability at segmentation at the level of phonemes. Even very early reading seems to capitalise on this implicit phonological awareness which plays a role in the logographic reading otherwise characterised as being primarily visual in nature. The above studies also demonstrate that experience in alphabetic spelling and reading promotes the more analytic and explicit phonological awareness at sub-syllabic levels. In normal children this

is acquired very quickly, and, although it remains to be determined by just how much, it seems likely that this comes more from alphabetic spelling instruction than from practice in alphabetic reading. Finally, although experience with reading allows the child to abstract knowledge of orthographic sequences which can then be applied in spelling, it seems that this is happening not just with mature readers who are solidly at an orthographic stage of reading, but also even with first grade children at the beginnings of literacy. Frith's model, literally interpreted, is a strong stage model suggesting three very different strategies of reading and spelling at three discrete stages of development. Although this is probably true as a broad characterisation, it seems that there are mutual influences between the alphabetic and orthographic aspects of reading and spelling at all stages of development.

A new skill invariably initially builds on whatever relevant abilities are already present, then, as it is used, it may well legitimize and make more relevant (Istomina 1975) those prior skills and so in turn cause their further development. Stanovich has persuasively argued the case for reciprocal relationships and bootstrapping effects: "In short, many things that facilitate further growth in reading comprehension ability - general knowledge, vocabulary, syntactic knowledge - are developed by reading itself" (Stanovich 1986, 364), "interrelationships between the various subskills of reading and intelligence increase with age, *probably due to mutual facilitation*" (Stanovich, Cunningham & Feeman 1984, 278, my emphasis). What is true of reading and intelligence also applies to the symbiotic development of spelling, reading and PA: they interact reciprocally over time. Finer grained studies are now needed to further determine the contributions from one to the other, the representations of the mutual exchanges (visual, phonological, orthographic), and their particular content at each point in the acquisition of literacy. That being said, as a general description of literacy development, Frith's model holds many truths.

## 2) SUGGESTIONS FOR FURTHER RESEARCH

The longitudinal studies that are available to date are informative but all have their flaws. We have now reached a position of sufficient theoretical and methodological development to

design a longitudinal investigation that will properly inform us of the detailed cognitive interactions in the development of literacy and which will help us answer some of the remaining questions concerning reciprocal skill interactions: continuities or critical stages, the identity of the partners, and the gifts they exchange. Future studies would benefit from adopting the following recommendations, some of which are illustrated in Figure 2.

Figure 2 about here

Models of literacy development emphasise interactions between reading and spelling - one moment spelling is the pacemaker, the next reading. But they say more than this: spelling is the pacemaker of *alphabetic* reading, reading the pacemaker of *orthographic* spelling, etc. Therefore future studies should be clear to assess the three different strategies of reading and spelling separately. For example, logographic reading strategies can be measured by comparing the reading of logos or known children's names in their normal whole-word form with that under mixed font or other visually distorted presentations as in the work of Wimmer et al. (1991) and Seymour; alphabetic reading can be hygienically assessed by nonword reading as in Ellis & Cataldo (1990); orthographic reading by the reading of words which are irregular or unusual in their grapheme-phoneme correspondences. Similar moves must be taken for the assessment of different aspects of spelling so that not two but six different aspects of literacy are assessed at each time-point as is illustrated in Figure 2. Only when these steps are taken can we identify if there are concurrent influences whereby, e.g., orthographic spelling ability might be growing as a result of the acquisition of orthographic representations from reading *at the same time as* alphabetic reading is developing as a result of the acquisition of phonological segmentation ability and letter-sound correspondences from spelling practice.

It is now clear that there are different levels of phonological awareness and that rhyming or implicit PA seem more involved in facilitating early reading acquisition whereas explicit phoneme-level PA seems to be more involved in, and more a consequence of, the acquisition of alphabetic spelling. At least these different aspects of PA need to be assessed, and the study could also usefully investigate the child's abilities of interim levels of PA at the onset-rime level



(Goswami & Bryant, 1990). We also need to consider potential early precursors of PA, for example, in early rhyming experience (MacLean et al., 1987; Bryant et al. 1989, 1990).

Given the ubiquitous influence of general ability it is essential to control for relevant aspects of environmental and genetic advantage using different aspects of IQ as index variables (Ellis & Large, 1987).

These measures need to be taken early. There are persuasive reasons to believe that in normal children there are massive developments in PA as a consequence of the very beginnings of introduction to print. Thus the whole range of tests must be administered before this. They should also be closely spaced thereafter since developments move quickly, especially during the first two years, and otherwise influences are going to be missed.

The data should be analysed with a proper longitudinal causal path model. It is not enough to generate composite variables over several time periods as was common in early studies, nor simply to report best-fitting models within each cross-section. Furthermore, with so many variables, 'tuned' models where a subset of paths are freed rest too much on the iterative steps of model building. It is therefore better to use causal path analysis in a descriptive fashion akin to factor analysis, using low-constraint time series models as in Cataldo & Ellis (1988) and Ellis (1990). In these models *any* ability at the prior testing point is free to affect *any* ability at the subsequent time, thus allowing the determination of causal paths whilst controlling for indirect effects and common causes. It is also advisable to free all possible covariation within each time-period thus allowing for unexplained covariation resultant from unknown causes operating between time-periods and avoiding over-estimation/inflation of the specified between-time-period effects in the model. To avoid clutter in Figure 2 we show only some of these paths, however it must be stressed that a proper statistical analysis of such a longitudinal study will involve all paths from each ability at a prior testing point to each ability at the next.

Our concern is literacy development rather than chronological development. Thus although the data are more easily analysed in terms of chronological time-slices (and they should so be analysed), so also it would be advantageous to reorganise the children, putting them into waves of comparable literacy development rather than chronological age. Then we would really have a chance to assess a stage rather than age model of reading and spelling

acquisition.

Unlike spoken language, literacy rarely comes naturally. Its acquisition is heavily determined by instruction and we need to determine how much of the course of development is a result of instruction. The most basic comparison would entail two groups of children, one exposed to more 'whole-word' methods and the other more 'phonic' approaches.

Finally, for reliable estimation of these causal interactions the sample sizes need to be large, at least in units of hundreds rather than tens.

It is no small enterprise but nonetheless it is a necessary one.

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Figure 1:  
 Frith's (1985) model of reading and spelling acquisition  
 (Strategies acting as 'pacemakers' at each step are italicised.)

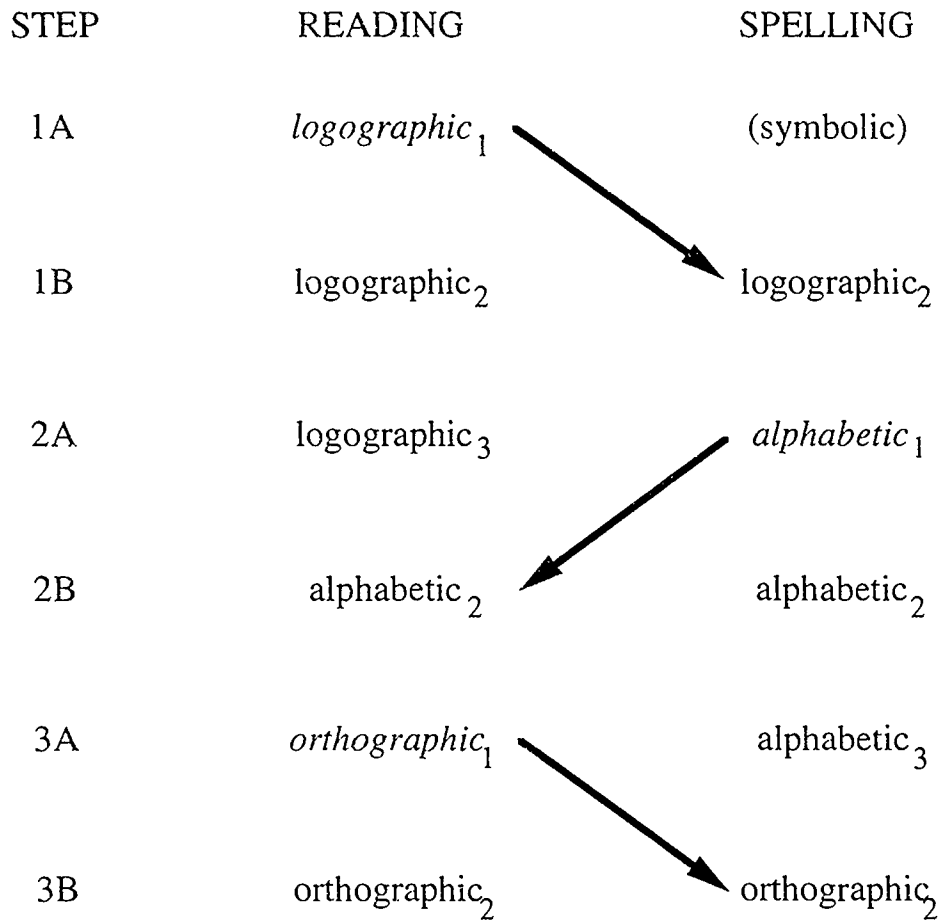


Figure 2: The Awaited Longitudinal Study

