Why Spelling is More Difficult than Reading

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"Thinking is always limited by the quality of our metaphors, and this is no exception."

Robert James Waller (1988, p.116)

Before you read this chapter, please get a pen and write down the name of the Indian nationalist and spiritual leader who developed the practice of nonviolent resistance that forced Great Britain to grant independence to India. He is known as Mahatma ___________.

Campbell and Coltheart (1984) found that undergraduates of two London colleges, despite numerous exposures through ads and newspaper articles following the release of the famous movie "Ghandi"[1], were unable to spell the name of the man who showed the Indians the way to freedom. The chance that you spelled his name correctly is between 14% and 44%. An example from the Dutch language (the first author's native tongue) is the notorious misspelling of the word *Sperzieboon* (green bean). The majority of people, including greengrocers, misspell the word by writing a C instead of a Z (Spercieboon). This misspelling is phonetically accurate, but is rather unconventional. Thus, to be in a QUANDERY about the spelling of QUANDARY is not a problem restricted to children. Highly skilled writers often need a dictionary or the spell-checker of a word processor to verify a word's spelling. But for skilled readers, doubts about how to read a word are largely restricted to heterophonic homographs - English examples are, *Live*, *Tear*, and *Wind*; Dutch examples are *Kantelen* (topple/crenelation), *Regent* (rains/regent, and *Bedelen* (endow/beg for).

This asymmetry between spelling and reading is evident at all levels of literacy. Skilled readers read more words correctly than they can spell, and children's spelling and reading skills diverge soon after the onset of formal instruction (Mommers, 1987; Seymour & Porpodas, 1980). It is relatively easy to find children whose reading performance meets the required level, but whose performance on a spelling test is below average, whereas the opposite pattern is much rarer (Frith, 1980). Spelling problems of dyslexic readers also prove

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[1] Actually, the proper spelling is GANDHI. Campbell and Coltheart (1984) explained the high percentage of "Ghandi"-misspellings in English-speaking college students in terms of a high summed position-specific bigram frequency of this pattern as compared to that of the correct spelling pattern "Gandhi". However, a similar test with Dutch-speaking University students showed that they had the same tendency of spelling Gandhi's name as Ghandi (21 out of 24 misspellings); Dutch summed position-specific bigram frequency, however, favours the Gahndi-pattern (Klønhammer, 1990)

to be more persistent than reading problems (Frith, 1984, 1985; Nicolson & Fawcett, 1994; Thomson, 1984).

These observations raise many interesting questions, including the general question of how spelling and reading are related. Moderate to high correlations between scores on spelling and reading tests suggest a fairly tight relationship (Malmquist, 1958, in Frith, 1980). This leads some theorists to emphasise the similarities between the skills, and claim that the processes (Ehri, 1980; Gough, Juel, & Griffith, 1992) or representations (Perfetti, 1992) underlying spelling and reading are in fact the same. Others, however, stress the differences between spelling and reading processes, suggesting two separate mechanisms (Bryant & Bradley, 1980; Frith & Frith, 1980). Frith (1979) claimed that reading occurs by 'eye' and spelling by 'ear', to make the point that spelling is phonologically mediated, but reading is not. Read (1981) also argued that reading and spelling are not symmetrical, because children who attempt to write words or stories often cannot read their own 'invented' spellings (see also Treiman, 1993).

The most cited empirical evidence suggesting separate mechanisms for spelling and reading was provided by Bryant and Bradley (1980). Dyslexic and non-dyslexic beginning readers read words they had previously spelled. Generally, both groups read more words correctly than they were able to spell. In all groups, however, there were some words that children were able to spell, but unable to read (the percentage varied between 3% and 13%). Gough, Juel, and Griffith (1992) replicated the experiment with a group of non-dyslexic beginning readers. On four different occasions, their subjects read each word twice and spelled each word twice. As in the study of Bryant and Bradley, the children sometimes were able to spell words they were unable to read (on average 10%). Moreover, they sometimes were able to read words on one occasion, but not on the other (10%), and sometimes they spelled words incorrectly on one occasion and not on the other (11%). Thus, the inconsistency observed between spelling and reading also occurred within reading and within spelling, respectively. If the inconsistency between spelling and reading merely reflects performance variability across occasions, then this inconsistency no longer motivates separate mechanisms.

In this chapter we eventually present a framework for spelling and reading which does not require independent components to explain the asymmetry between spelling and reading performance.

SPELLING AND PHONOLOGY

Since Read's publications on children's invented spellings (1971, 1981, 1986), it has generally been acknowledged that beginning (and skilled) spellers rely heavily on phonology. All theories of spelling acquisition include a dominant role for phonology (Frith, 1980, 1985; Henderson & Beers, 1980; Marsh, Friedman, Welch, & Desberg, 1980; Read, 1986; Snowling, 1994). Empirical evidence for phonology's role in spelling comes from two sources. First, phonological awareness and spelling skill are highly correlated (van Bon & Duighuisen, 1995; Bruck & Treiman, 1990; Duighuisen & van Bon, 1992; Holligan & Johnston, 1991; Lundberg, Frost & Peterson, 1988; Marcel, 1980; Stuart & Masterson, 1992; uit de Haag, 1994). Second, spelling errors are predominantly phonetically accurate.

One common definition of phonetically accurate spelling errors is that the error pattern can be pronounced identically to the intended word using grapheme-to-phoneme correspondence rules (e.g., Bosman, 1994; Bruck, 1988; Holmes & Ng, 1993; Treiman, 1993). For instance, the spelling pattern KLINTON is phonetically correct as an attempt to spell the name *Clinton*. Sounding out KLINTON by applying grapheme-to-phoneme correspondence rules will sound just like an American president's last name. A similar example in Dutch, sounding out the incorrect graphemic pattern VAN GOCH produces *van Gogh* - a phonetically correct representation of a famous Dutch painter's last name. The spelling pattern PLINTON, in an attempt to spell *Clinton,* is considered phonetically incorrect because no grapheme-phoneme correspondence rule seems to be able to produce the intended word. This definition of phonetic accuracy has been applied to the spellings of skilled adult spellers (Bosman, 1994; Campbell & Coltheart, 1984; Gompel, Tromp, de Vries, & Bosman, 1990; Holmes & Ng, 1993; Sloboda, 1980), normal beginning spellers (Bosman & de Groot, 1991; Bosman & van Leerdam, 1993; Bosman, de Groot, & van Leerdam, 1995; Brown & Ellis, 1994; Manrique & Signorini, 1994; Porpodas, 1987; Waters, Bruck, & Seidenberg, 1985); children with spelling (and reading) difficulties (Bruck, 1988; Bruck & Waters, 1988; Frith 1984; Nelson, 1980; Valtin, 1987), prelingual deaf children and adults (Campbell, 1994; Dodd, 1980; Gibson, Shurcliff, & Yonas, 1970), language-disordered children (Cromer, 1980), an adult with an acquired spelling disorder (Hatfield & Patterson, 1983), and a hyperlexic child, whose spelling and reading skills were extraordinary, but who performed below average on intelligence and language tests (Siegel, 1994). In all these cases, the vast majority of spelling errors were phonetically acceptable.

The occurrence of phonetically correct errors is traditionally explained by a phonological spelling route, that is, phonemes are recoded into graphemes by means of grapheme-to-phoneme rules. However, there are inherent limits on a phoneme-grapheme converter. A large number of phonemes map onto more than one grapheme (for example, the phoneme [i:] has two possible spellings as in H*ea*p and as in D*ee*p). Also spellers do make errors that do not qualify as phonologically correct by the previous criterion. These facts seemed to necessitate a second *lexical* spelling mechanism. The lexical spelling route reads out whole-word spellings. "Non-phonetic" errors occur when something goes wrong in the read-out process (Ehri, 1980; Holmes & Ng, 1993; Kreiner & Gough, 1990). These two routes from lexicon to print in 'the dual-route model of spelling production' (see Barry, 1994) are the mirror images of the two routes in the dual-route model for reading (Coltheart, 1978).

Next, we question whether spelling errors can be reliably classified in two distinct categories. In doing so we question the empirical justification for two spelling routes.

SPELLING ERRORS REASSESSED

The previous definition of phonetically acceptable errors is based on applying spelling-to-sound rules to a spelling pattern. But, both Read (1971, 1981, 1986) and Treiman (1993) have shown that an evaluation of spelling errors solely based on spelling-to-sound rules seriously underestimates the phonetic complexity of children's invented spellings and the spellings of beginning readers/spellers (see also Moats, 1993). We will not address this issue in full; excellent treatments are provided by Treiman and Read. An illustration by means of examples will suffice.

Take, for instance, the letter string DIK in an attempt to spell the word *Dike*. According to spelling-to-sound rules this is a phonetically inaccurate spelling pattern. However, if we extend the definition and assess phonetic accuracy using the sound-to-spelling relation in the other direction, this pattern becomes phonetically correct. The phoneme [a^i] covaries with the grapheme I*e, as in *Stripe*, *Hive,* and *Agile*, but also with I as in *Pint*, *Find*, *Bind*, *Kind*, and *Mind*. A speller who spelled DIK on the basis of the second set of words has shown sophisticated knowledge of a sound-to-spelling relation. The same applies in Dutch. The letter string AMSTERDAMERS in an attempt to spell the word *Amsterdammers* (people from Amsterdam), is a phonetically incorrect spelling pattern, given standard spelling-to-sound relations, but sound-to-spelling rules render it a perfect representation of the word *Amsterdammers*. The majority of Dutch first-graders make this mistake initially.

Assessing spelling errors on the basis of both spelling-to-sound and sound-to-spelling appears to reveal more of the phonetic structure in children's (and probably also in adults') spelling attempts than just on the basis of spelling-to-sound rules. Thus, a more liberal assessment of phonetic accuracy appears reasonable. However, both the restricted and the liberal definition of phonetic accuracy assume a categorical distinction between phonetically correct and phonetically inaccurate spelling errors. The following examples show the difficulty (if not impossibility) of precisely specifying these categories. A child's misspellings in the words, KELL (for *Bell*), KALL (for *Ball*), KUG (for *Bug*), and KIT (for *Bit*) appear phonetically inaccurate in terms of spelling-to-sound rules and sound-to-spelling rules. But are these spelling attempts void of phonetic knowledge? The most likely interpretation of the error pattern of this child is that she misremembered the physical shape of the letter B. After all, the (phonetic) structure in the incorrect spelling patterns is identical to the structure in the correct patterns. (These English examples are made up to illustrate patterns observed by the first author in Dutch children's spelling.).

Another example illustrates why it is often necessary (and revealing) to know what a child wanted to spell to fully appreciate its phonetic complexity. For example, the letter string CINPYEUTER is an attempt by Read's son at the age of 6, to spell the word *Computer* (Read, 1981, p. 118). To establish that a spelling error *was not* mediated by phonology, it is necessary to fully recover the intention of the speller (see also Moats, 1993), whereas establishing that a spelling error *was* mediated by phonology appears uncontroversial. This practical impossibility of sorting errors into two distinct categories bears on theoretical issues because this distinction is the sole basis for proposing two spelling mechanisms.

The previous examples do not imply that meaningful assessment of spelling errors is impossible. A less theoretically driven evaluation of spelling errors might be how well they represent the sounds of words according to the conventions of the orthography in question. Spelling errors of less advanced spellers and of disabled spellers are usually less consistent and more idiosyncratic than those of skilled spellers (Bosman, 1994; Bosman & de Groot, 1991; Bruck, 1988; Bruck & Waters, 1988; Lennox & Siegel, 1993; Waters, Bruck, & Seidenberg, 1985). But, there is no basis for the assumption that phonology plays a less important role in less advanced and disabled spellers (cf., Holligan & Johnston, 1991). In fact, it is highly likely that the phonologic properties of words overwhelm the less able speller (compare the exaggerated phonologic effects in dyslexic readers compared to normal readers; cf., Van Orden & Goldinger, 1995; Van Orden, Pennington, & Stone, 1990).

To summarise, we believe that spelling errors cannot be reliably classified into two categories, which renders an explanation in terms of two independent spelling routes superfluous. In the next section, we show how a "single process" framework developed to explain word perception also explains spelling performance. Word perception models usually do not incorporate spelling (Coltheart, Curtis, Atkins, & Haller, 1993; McClelland & Rumelhart, 1981; Seidenberg & McClelland, 1989), and spelling models do not include word perception (Brown & Loosemore, 1994; Houghton, Glasspool, & Shallice, 1994; Olson & Caramazza, 1994). The following proposal is an attempt to incorporate both in a common framework.

Bosman, A. M. T., & Van Orden, G. C. (1997). Why spelling is more difficult than reading. In C. A. Perfetti, L. Rieben, & M. Fayol, (Eds.), *Learning to spell: Research, theory, and practice across languages* (pp. 173-194). Hillsdale, NJ: Lawrence Erlbaum Associates.

A DYNAMIC SYSTEMS FRAMEWORK FOR SPELLING AND READING

Our proposal derives from a new framework for word perception (Stone & Van Orden, 1994; Van Orden & Goldinger, 1994; Van Orden et al., 1990). This framework is rooted in dynamical systems theory, which supplies a new metaphor for cognitive systems (e.g., Thelen & Smith, 1994). Space requires a severely abridged version of this account; interested readers are referred to the original papers. Figure 1 depicts the macro-dynamic of word perception described in Van Orden and Goldinger (1994).[2] Three families of fully interdependent subsymbols[3] (nodes) are assumed for a recurrent network model. Dynamics between nodes are sufficient to mimic performance attendant on word perception.

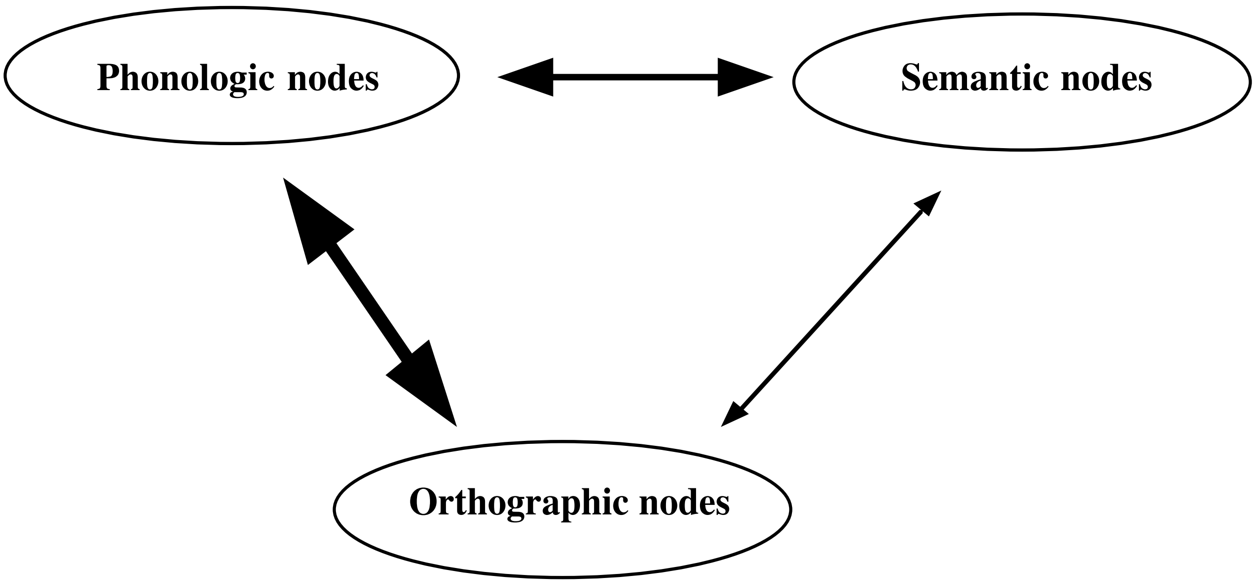

Figure 1. An illustration of the macro-dynamic that describes reading and spelling performance in a recurrent network. The boldness of the arrows indicates the overall strength (self-consistency) of the relations between the respective node families.

In a model, the presentation of a printed word activates letter nodes which, in turn, activate phoneme and semantic nodes. Following initial activation, recurrent feedback dynamics begin between all these node families. The assumed dynamics are similar to those of the Interactive-Activation model of McClelland and Rumelhart (1981; see Stone & Van Orden, 1994). Behaviourally meaningful structure emerges in positive feedback loops between the

[2]We use macro and micro as relative terms. What is macro for word perception could be micro for discourse processing. Likewise what is micro for word perception could be macro for letter perception (cf., Ziegler & Jacobs, 1995).

[3]The term subsymbol does not refer to a lower level symbol in the sense used in representational theory. Subsymbols are simply pragmatic notations for the purposes of modelling or illustration. They are not to be taken as psychologically real or as fundamental units of cognition (see for an in-depth discussion of this issue, see Van Orden & Goldinger, 1994; see also Putnam, 1981).

three sets of nodes. The order in which feedback loops cohere is determined by the history of bi-directional correlations between words' printed forms and their linguistic functions (cf., Varela, Thompson, & Rosch, 1987).

At the macro-level of description, node families differ in overall strength and consistency of relations with other node families, as illustrated by the relative boldness of arrows in Figure 1. Overall, the relations between letters and phonemes in alphabetic languages support the most powerful bi-directional correlations. The same letters and phonemes occur together in very many words. Phoneme-semantic relations and letter-semantic relations are less strongly correlated. Phonemes and semantic features, and letters and semantic features covary much less systematically. However, phoneme-semantic relations support stronger correlations than letter-semantic relations. This is true because, essentially, we speak before and more often than we read.

Once in place, this asymmetry is self-perpetuating. Reading strengthens phoneme-semantic connections, because phonology functions in every instance of printed word perception. Thus, even the exceptional condition of a person who reads more than he speaks would support phoneme-semantic connections that are at least as strong as letter-semantic connections. Also, in principle, if a coherent positive feedback loop forms between phoneme and semantic nodes, before the feedback loop between letter and semantic nodes, then printed or spoken discourse may proceed without settling the feedback loop between letter and semantic nodes. The absence of coherence in the latter feedback loop may preclude strengthening the connections between letter and semantic nodes (cf. Grossberg & Stone, 1986).

The relative strength of the relations between letter and phoneme nodes illustrates why phonology supplies such powerful constraints on word perception. Stated differently, it explains why phonologic mediation is fundamental to reading (and spelling). Strong bi-directional connections between nodes yield powerful feedback loops that cohere very early in a model's dynamics. Abundant empirical evidence agrees with this claim (Berent & Perfetti, 1995; Bosman & de Groot, 1995, in press; Carello, Turvey, & Lukatela, 1992; Perfetti, Zhang, & Berent, 1992; Van Orden et al., 1990).

In Figure 2, we zoom in on the micro-dynamics of "fine-grain" letter-phoneme relations. In Figure 2a, the presentation of the word *Hi* has activated the letter nodes H_1 and I_2, which activate the phoneme nodes [h_1] and [$a^I{}_2$], but also competing correlated nodes such as [i] (as in *Hit)* which must be inhibited. Figure 2b shows how, in turn, phoneme nodes feed back activation to letter nodes (illustrated for the phoneme nodes [h_1] and [$a^I{}_2$]). [$a^I{}_2$] activates the correct letter nodes H_1 and I_2 and also competing letter nodes. For example, [$a^I{}_2$] activates the letter node Y_2 as in *My* or *By*. Dynamics from this point on select a "correct" combination through inhibition of competing nodes.

Reliable performance emerges if the overall bi-directional configuration of connections between the letter nodes H_1 and I_2 and the phoneme nodes [h_1] and [$a^I{}_2$] favours coactivation of these four nodes. This advantage grows over time as the "strong grow stronger", and the "weak grow weaker" (cf., McClelland & Rumelhart, 1981). This is illustrated in Figure 2c, which combines the flow of activation from letter nodes to phoneme nodes and from phoneme nodes back to letter nodes, as assumed in a recurrent network.

The key to how one might apply this model to spelling is that all connections are bi-directional which means that activation flows in both directions. Thus, activation arising in semantic or phoneme nodes may generate a coherent pattern of activity across letter nodes.

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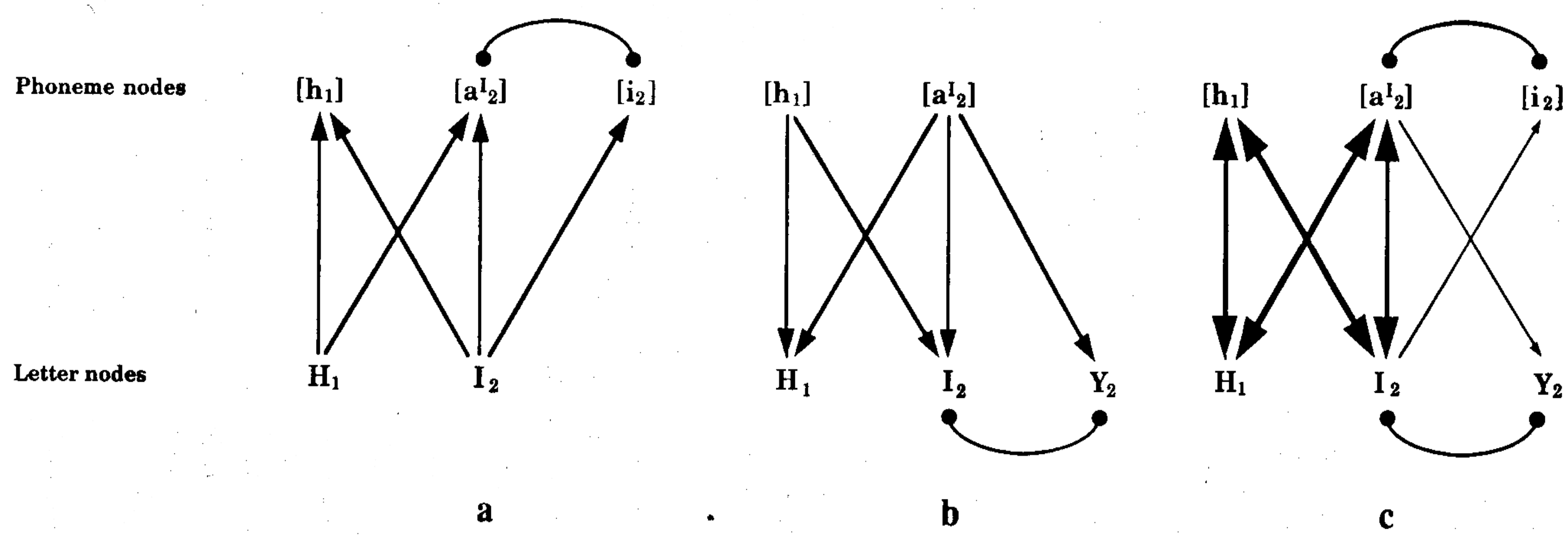

FIG. 10.2. A highly simplified illustration of micro dynamics that describe reading and spelling performance for the word *Hi*. The indices refer to the positions of the letters or phonemes in the word *Hi*. A recurrent network model presented with the written word *Hi* sends feed forward activation from letter nodes to phoneme nodes (Fig. 2a) and, in turn, feeds back activation from phoneme nodes to letter nodes (Fig. 2b). Figure 2c illustrates a resonance that emerges between letter and phoneme nodes corresponding to *Hi*.

This characteristic of recurrent models has important implications for word perception as well. It predicts that word perception should be affected by the relative consistency of phoneme-letter relations. In other words, not only does it matter for visual word perception that a word's spelling may have more than one *pronunciation* (e.g., Gibbs & Van Orden, 1995), it also matters that a word's pronunciation may have more than one *spelling*.

Stone, Vanhoy, and Van Orden (1995) tested this hypothesis using a grain size of spelling-to-phonology that was larger than letters and phonemes, namely, onsets and rhymes (or bodies). The onset of one-syllable words is the initial consonant cluster (STR in *Str*eet), and the rhyme or body is the vowel and the final consonant(s) (EET in Str*eet*). Although letter-phoneme correlations are tracked at the grain-size of letters and phonemes, the overall pattern of weights will reflect correlational structure at any larger grain-size. It turns out that, for English, correlations at the grain-size of onsets and rhymes are highly predictive (Treiman, Mullennix, Bijeljac-Babic, & Richmond-Welty, in press).

Stone et al. (1995) used four sets of words in a 2 x 2 design. Bi-directionally consistent words were consistent in both spelling-to-phonology and phonology-to-spelling. An example is the word *Lust*. Its spelling body _UST is only pronounced one way in the various words that share this spelling body, and its pronunciation body /_ust/ is only spelled one way in the words that share this pronunciation body. A second set of words were bi-directionally inconsistent. For example, the spelling body _EAK in *Bleak* has multiple pronunciations, as in *Break* and *Leak*, and the pronunciation body /_eak/ has multiple spellings, as in *Freak,* and *Creek*. The third and fourth sets of words were consistent in one direction but inconsistent in the other. The example *Heap* has a spelling body _EAP that is always pronounced the same, but the pronunciation body /_eap/ can be spelled multiple ways, as in *Creep* and *Leap*. The contrasting example *Hull* has a pronunciation body /_ull/ that can only be spelled one way, but a spelling body _ULL that can be pronounced multiple ways, as in *Dull* and *Pull*.

In a lexical decision task, words that were consistent in both directions yielded faster correct “yes” response times than words which were inconsistent in either direction. Recently, Patrice Gibbs (personal communication, May 1995) found similar effects in a naming task. Thus, the fact that a pattern of phonology can be spelled more than one way even affects performance in simple reading tasks. These empirical findings agree with our suggestion that spelling and reading are fundamentally related.

Returning to Figure 2c, reading the word *Hi* not only activates the phonemes [h_1] and [$a^I{}_2$], and the letters H_1 and I_2, but also all multiple possible alternative spellings of the phoneme [$a^I{}_2$]. Thus, reading a word correctly requires that incorrect letter nodes are inhibited, just as spelling a word correctly would require that incorrect letter nodes are inhibited. In the case of reading, however, the letters are presented to the model, so phoneme-letter inconsistency is less likely to yield an incorrect pattern of activation across letter nodes. The match between letters presented to the model and pattern of letter activation fed back from phoneme and semantic nodes actually accelerates the formation of correct feedback loops (as illustrated by the bold arrows in Figure 2c). In spelling, however, a model must generate this pattern from phonology and semantic activation alone. There is no environmental support for correct letter nodes. Activation of letter nodes is determined by micro relations between phonemes and letters and macro-relations between phonology, semantics and spelling.

In the English orthography, there are generally more possible spellings for a particular word than possible readings; for example, the phoneme [i:] has the following possible spellings: Y as in *Entry*, EY as in *Key*, EE as in *Deep,* EA as in *Leaf*, and IE as in *Chief*.

Another example is the 36 possible spellings of the word *She* (see Simon & Simon, 1973).[4] This is the "micro-basis" for the asymmetry between spelling and reading (Barry, 1994; Stone et al., 1995; Waters et al., 1985). Stone et al. (1995) estimated that 69% of low-frequency English one-syllable words are letter-to-phoneme consistent (at the grain-size of onsets and rhymes), but that 72% of this sample are phoneme-to-letter inconsistent (at that same grain-size). Another estimate indicated that 72% of all letter-to-phoneme consistent one-syllable words were phoneme-to-letter inconsistent, which suggests that phoneme-to-letter inconsistency is the rule for English. This characteristic is not restricted to English, however. Alphabetic orthographies like, Dutch, French, German, and Spanish are also more inconsistent in their phoneme-to-letter relations than in their letter-to-phoneme relations (the exceptions being unpointed Arabic and unpointed Hebrew, see Berent, Frost, & Perfetti, this volume).

Both spelling and reading are powerfully constrained by the relatively strong correlational structure of the letter-phoneme dynamic. However, inconsistencies in these relations must be resolved by other sources of constraint. When a model "reads" a low-frequency, letter-to-phoneme inconsistent word such as *Pint*, for example, the more consistent relation between spelling and phonology would rhyme with *Mint* (Kawamoto & Zemblidge, 1992). Additionally, the letter-phoneme dynamic would yield two correct pronunciations for words like *Wind* (although it would favour the more regular pronunciation, Kawamoto & Zemblidge, 1992). In both these cases, relatively strong semantic-phoneme relations may supply sufficient constraints for the appropriate phonology (cf., Strain, Patterson, & Seidenberg, 1995). In the case of *Wind* semantic constraints may also be due to context. Contextual sources of semantic activation contribute via the relatively strong connections between semantic and phoneme nodes (cf., Azuma & Van Orden, 1995; Stone & Van Orden, 1989).

Consider now spelling, however. It must resolve the inverted patterns of ambiguity in the phoneme-letter dynamic. When a model "spells" a low-frequency phoneme-to-letter inconsistent words such as *Heap*, the more consistent spelling for /_eep/ would be as in *Deep*. Additionally, the phoneme-letter dynamic yields two correct spellings for homophones such as *Deer*/*Dear*. In these cases, correct spelling relies on relatively weak semantic-letter relations to supply sufficient activation of the appropriate letters (as illustrated in Figure 1). Even contextual support is filtered through the weaker connections between semantic and letter nodes. This relatively weak support for spelling (the semantic-letter relations) compared to the stronger one for reading (the semantic-phoneme relations) is the "macro-basis" for the asymmetry between spelling and reading.

To summarise: Spelling is more difficult than reading because phoneme-letter relations are more inconsistent than letter-phoneme relations, and because the phoneme-letter inconsistencies must be resolved by the relatively weak semantic-letter dynamic, whereas, in reading, letter-phoneme inconsistencies are resolved by the stronger semantic-phoneme dynamic. The fact that we engage less in spelling than in reading enhances this fundamental asymmetry between spelling and reading. Thus, to achieve a spelling level that is comparable to reading would require building stronger correlations between words' meanings and their spellings (or a language with less inconsistent phoneme-to-letter relations). Finally, the existence of powerful bi-directional correlations between letter and phoneme nodes explains

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[4] In the case of <u>She</u>, according to Simon and Simon (1973), /Sh/ can be spelled in nine different ways (TI, SH, CI, SSI, SI, C, CH, T, S), and /e/ in four different ways (E, EA, EE, IE).

why both spelling and reading appear to be phonologically mediated. In particular, this explains the preponderance of phonetically accurate errors in spelling.

THE RELATION BETWEEN LEARNING TO SPELL AND LEARNING TO READ

The theoretical account presented above assumes a close relationship between spelling and reading, but it also predicts an asymmetry between the two skills. Our earlier examples showed that hundreds of readings of the (proper) spelling of a word do not guarantee correct spelling.

Beyond circumstantial evidence, experiments with beginning readers also show that reading is not always effective for learning to spell. For example, Dutch children with seven months of formal spelling and reading instruction made equal numbers of spelling errors in new words they read 18 times and in new words they read only three times (Bosman & de Groot, 1991). In another study, Dutch children with ten months of formal instruction made equal numbers of errors in new words they read six times and in words they read only twice (Bosman & de Groot, 1992). Only with ten months of formal reading and spelling instruction and words presented at least nine times did spelling performance improve through reading (Bosman & de Groot, 1991). Moreover, spelling performance of adults who read pseudowords once, twice, three times, four times or eight times, only benefited from the "eight times" condition (Gompel, Tromp, de Vries, & Bosman, 1990).

In most of the aforementioned studies, spelling performance was measured by means of a dictation test. That is, the experimenter read the words and the child was asked to write them down. In one study, however, spelling performance was assessed in both a dictation task, and also by means of a two-choice recognition test (Bosman & de Groot, 1992). In the two-choice recognition task, the child was presented with the word BLAUW (blue), and a phonologically plausible misspelling BLOUW, and asked to pick the correct spelling. As in the previous studies, it did not matter whether the child had seen (i.e., read) the words twice or six times. Their recognition scores were the same in both cases, but recognising the correct spelling was easier than producing it - even after the recognition scores were adjusted for guessing. This finding is interesting. It indicates that assessment of spelling skill is strongly task dependent. Children (and adults alike) appear as better spellers when their knowledge of words' spellings is tested in a recognition task. More importantly, it is consistent with our explanation as to why spelling is more difficult than reading. Recognising a spelling is similar to reading, because the child can see the letters of the correct spelling. Alternatively, producing a spelling requires the child to generate the correct spelling from phonology and semantics.

In other studies, we compared the effectiveness of reading practice for learning to spell with explicit methods of spelling practice: *copying* (writing down the word onto a notebook), *problem naming* (practising the ambiguous phoneme(s)), *visual dictation* (writing down the word after it has been presented for a brief period of time), *word composition* (making up the word using letter tiles), and *oral spelling* (spelling the word aloud). Children benefited most from 'oral spelling', and adults also benefited most from oral spelling while learning to spell pseudowords. Most importantly, however, all spelling-instruction methods were superior to just reading as a means to learn the spelling (Bosman & de Groot, 1992, Bosman & van Leerdam, 1993; Gompel, Tromp, de Vries, & Bosman, 1990; van Daal, van der Leij, & Geertvliet-van der Hart, 1989; van Doorn-van Eijsden, 1984).

Another interesting result from the previous studies is that spelling performance benefited most when the *whole word* was practised. In principle, practising the spelling of the whole word would be redundant in a relatively shallow orthography like Dutch, because the major part of each word is unambiguous and can be derived by phoneme-to-letter rules. Thus, practising the ambiguous part of the word, as in the problem-naming method, should be as effective as practising the whole word (as in oral spelling). Nevertheless, the whole-word oral-spelling condition yielded superior spelling performance for all subjects at all ages. This finding is also interesting with respect to our account of spelling and reading. General knowledge about the relationships between letters and phonemes is not sufficient for correct spelling. The context in which letters are embedded, which is different for all words except homographs (e.g., *Wind*), contributes strongly to knowledge about the spelling of words. In our account, we illustrated the intricate interplay between letters and phonemes, in showing how each letter, each phoneme, and each semantic node contributed to the emergence of a words' spelling or a word's reading.

Again, reading is not a very effective way to learn the spelling of a word. This raises the complementary question: Is learning to spell an effective way for learning to read? Again, most orthographies are more consistent in their letter-to-phoneme relation than in their phoneme-to-letter relation. It is possible that learning about the phoneme-to-letter relation strengthens the letter-to-phoneme relation. However, studies that have investigated this issue yielded conflicting results, and results that are difficult to interpret. Uhry and Shepherd (1993) conducted a training study in which beginning readers from Grade 1 were instructed in phonemic segmentation and spelling. Their findings indicated that the spelling training was beneficial for reading, but the training method left the subjects ample time to practice reading as well, because the words remained visible during the training. This confound masks the basis of better reading performance. The same problem occurs for results from studies by Ehri and Wilce (1987), and Roberts and Ehri (1983).

Bosman, de Groot, and van Leerdam (1994) conducted spelling-training experiments in which reading and spelling were disentangled. Children and adults practised the spellings of letter strings they had not seen before, and they were never visually confronted with the words. First graders were taught the spellings of actual words, whereas the adults learned the spellings of pseudowords. The spelling training was a form of the oral-spelling instruction method. After the experimenter named the word (or pseudoword), the subjects spelled the word aloud, and appropriate feedback was provided. Each word was practised four times. The experiment included two control conditions. In one control condition, a set of words were repeated orally after the experimenter, and the second control condition included to be spelled words that were not practised at all. Later, in a naming task, orally-spelled and control repetition words were read faster than the words that were not practised in the training, but there was no effect of oral spelling over simple repetition. A subsequent test showed that both groups learned the correct spelling of the oral-spelling items, but not those of the items in the repetition condition. These results suggest that learning the spelling of words without visual presentation does not benefit reading performance over mere repetition. This issue is a subject of our on-going research.

We conclude this chapter with some general remarks concerning the implications for education.

SOME IMPLICATIONS FOR SPELLING INSTRUCTION

In this final section, the discussion will emphasise formal spelling instruction of normally developing children in the Netherlands, but the general implications hold for other languages too. As will become clear, spelling difficulties should not be viewed as a static problem, they change over time. Over 80% of Dutch schools use a phonics-based reading-and-spelling method called "Veilig leren lezen" (Learning to read safely, Caesar, 1979). It is a fairly rigid pre-programmed curriculum, with a strict day-to-day and week-to-week progression. Initially, the child is exposed to mono-syllabic words that are predominantly consistent in their letter-to-phoneme relations. Thus, proper phonemic analysis provides the beginning speller with predictable spelling patterns. After four months, children are presented with words containing inconsistent phoneme-to-letter relations. In first grade, this is mainly limited to the following phonemes: [ɛi] can be spelled IJ as in *Blij* (happy), or EI as in *Geintje* (joke); [ou] can be spelled AU as in *Paus* (pope), or OU as in *Touw* (rope); and [x] can be spelled G as in *Zeg* (say), or CH as in *Lach* (laugh). Dutch first graders primarily face the problem of spelling ambiguity of words with historically determined spelling patterns (cf., Assink, 1990). The spelling pattern of these words must be 'memorised', because phoneme-to-letter analysis yields ambiguity in the letter pattern, and there are no rules to disambiguate these patterns.

At the end of first grade, children are presented with spelling ambiguities that can be solved by applying rules. Spelling plural forms of nouns generally consists of adding the morpheme -EN at the end of the singular form. For example, the phoneme-to-letter consistent singular noun BOEK [book] becomes BOEKEN, which is a phoneme-to-letter consistent plural noun. However, a large proportion of phoneme-to-letter consistent singular nouns, for example, SOK [sock], have a plural form that is phoneme-to-letter inconsistent, namely SOKKEN (and not SOKEN). Phonemic analysis of *Sokken* is ambiguous with respect to the spelling of the phoneme [k]. An additional rule is needed to correctly spell the word, namely, if the body of a singular noun consists of a single-letter vowel and a consonant, then double the final consonant before adding the EN-morpheme (compare the English spelling rule of doubling the final letter B of RUB in RUBBING, but not the final K in LOOKING).

Other types of spelling problems arise with increasing reading and spelling experience. The majority of phoneme-to-letter inconsistent words can be spelled correctly by the application of a set of linguistic rules. But even most skilled adult spellers are usually unaware that these rules exist or are unable to apply them because of their rather complex nature (Assink, 1985, 1990; Verhoeven 1979). In most cases therefore, children and adults alike memorise the spellings of words with ambiguous spelling patterns.

The problems for Dutch spellers in first grade begin a never-ending progression. Spellers encounter increasingly complex relations between phonemes and letters (Verhoeven, 1979; see Bailet, 1990 for the English language). The types of problems that appear in lower grades disappear in higher grade, but are replaced with new types of problems. In turn, these problems disappear to be replaced yet again by new spelling problems upon entering high school. Changing spelling problems pose a challenge for the provision of detailed directions. But some implications, all related to the assumption of phonologically mediated spelling, are less specific to a particular type of spelling problem.

For most people spelling acquisition lasts until adulthood, and for some people learning words' spellings is a life-long enterprise. Dutch spellers, and probably most non-English speakers face an additional problem. New words, in particular from English, are continuously being added to their languages, and these loan words are by nature sound-to-spelling inconsistent. The spelling of loan words with highly inconsistent phoneme-to-letter patterns may best be learned by phonologically regularising the pronunciation of a word (Bråten, 1994; Ormrod & Jenkins, 1989). In fact, *Corned beef*, *Rawhide*, and *Palmolive* are regularised in standard Dutch and do not retain the English pronunciation (/kor/ /net/ /bief/, /ra/ /we/ /de/, and /pol/ /mo/ /lee/ /ve/ respectively). Pronouncing an inconsistent word as a letter-to-phoneme regular word may also serve as a mnemonic for deriving its correct spelling. Examples are "private pronunciations" of the word *Aisle* as /ai/, /s/, /le/, or the word *Wednesday* as /wed/, /nes/, /day/. This method stems directly from the assumption that spelling and reading are phonologically mediated.

Another issue related to the assumption of phonologically mediated spelling is the role of dialects in education. Dutch spelling is based on Standard Dutch (*A*lgemeen *B*eschaafd *N*ederlands, ABN). Children who do not also speak Standard Dutch cannot take full advantage of the consistency between phonemes and letters. Various examples from spelling tests show the influence of children's dialect on their spelling performance (Bosman & van Leerdam, 1993). However, there are also situations in which children who speak a dialect can use the knowledge of their local dialect to spell otherwise, ambiguous spelling patterns. Children in "De Achterhoek" and "De Veluwe" (Middle-Eastern part of The Netherlands) generally know the spelling of the phoneme [ɛi], because their pronunciation of words spelled with IJ as in MIJN (/mien/ meaning 'mine') is different from the EI as in KLEIN, /klɛin/ meaning 'small'), whereas in the rest of the country the two spelling patterns IJ and EI have identical pronunciations (/mɛin/and /klɛin/).

A final issue concerns the use of spelling tests that present incorrect spellings to students in the form of multiple-choice tests. In a multiple-choice test the correct spelling of a word is presented together with one or more incorrect (pseudohomophone) spelling(s), and students are required to mark the correct spelling. For example, *Harrass*, *Harass* or *Harras*; a Dutch example is: *Enigzins*, *Enigszins* (somewhat), or *Enigsins*. An important educational question is whether spelling performance is affected by encountering phonologically acceptable misspellings. We both experienced the erosion of spelling knowledge after conducting large numbers of experiments using pseudohomophones. These private experiences are corroborated by experimental studies (Brown, 1988, for an overview; but see Ehri, Gibbs, & Underwood, 1988 for a null-effect). It appears that being visually exposed to incorrect, but phonologically possible spellings, may have an adverse effect on extant spelling knowledge. Thus, despite the convenience of multiple-choice tests they may not be the best possible way of testing spelling performance (Bradley & King, p. 430, 1992)

We conclude that spelling and reading are interdependent, and phonology mediates both of them. Reading, however, is not the most effective way to learn to spell. Correct spelling seems to require strategies specific to this skill - strategies that strengthen or supplement semantic-letter correlational structure. Apparently, the most effective methods of instruction mimic actual spelling production. However, which method of instruction is most effective may change over time as children encounter an increasing variety of complex relations between phonology and spelling. Successful instruction must take all this and more into account, keeping in mind the unique matrix of proclivity, background and motivation that each child brings to this task.

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