The effect of exposure to orthographic information on spelling

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Declaration to the University Librarian

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ABSTRACT

Exposure to incorrect and correct orthographic information has been reported to reduce and enhance, respectively, subsequent spelling accuracy. The aim of this thesis is to explore this effect of exposure to fresh orthographic information to some depth, and to gain insight into how spellings may be represented within the orthographic lexicon.

The first experiment sought to establish the effect as a reliable phenomenon, and, in conjunction with Experiments 2 and 3, to explore the role of a number of variables in the effect. The effect was found to be independent of level of proficiency of the speller, obtaining in both good and poor spellers. It was long-lasting, being evident at both immediate and one-week delayed testing. It occurred across both matching and non-matching conditions at study and test. The combined results of the these first three experiments indicate an implicit and item-specific process of priming underlying the effect. Experiment 4 highlighted the role of phonology in lexical access by demonstrating that the detrimental effect of exposure to a misspelling was dependent on the misspelling preserving phonological accuracy of the target lexical item. Experiment 5, introducing reaction time as an index of spelling performance, suggested, albeit tentatively, that the effect obtains even in words which are simple to spell. Experiment 6, extending the investigation of the exposure effect to children, found that the effect was not comparable to that in adults either in terms of pattern or of mediating processes.

At a theoretical level the findings indicate that fresh orthographic information is assimilated implicitly, altering an existing representation in the spelling lexicon and thence affecting subsequent spelling accuracy.

PART I

COGNITIVE MECHANISMS OF WRITTEN LANGUAGE PROCESSING: A REVIEW

Foreword

The aim of this thesis is to explore the nature of internal representations and processes involved in spelling. The experimental work is based on a priming paradigm. More specifically, it explores the effect of visual exposure to orthographically correct and incorrect forms of words on subsequent spelling accuracy for those words. As such, it involves elements of both spelling and reading. In fact, the question of the nature and origin of internal representations underlying spelling is closely, if not inextricably, linked to processes of reading. Furthermore, theories of spelling have traditionally been derived from theories of reading.

For these reasons Part I of the thesis provides a theoretical consideration not only of the cognitive mechanisms underlying spelling, an issue clearly central to the thesis, but also notions of lexical access in reading. The aim is to set the theoretical backdrop for the more detailed analyses of processes involved in the thesis.

Chapter 1 outlines possible mechanisms of lexical access in reading, starting with a derivation of essential elements from a consideration of the constraints and affordances arising from the writing system of a language. It considers the relative merits of both single and dual route conceptualisations and finds evidence from neuropsychological, human experimental and computer simulation sources favouring the latter. For this reason the dual-route model, in which both lexical and sub-lexical information play a role, is adopted as the main theoretical framework for the research described in this thesis.

Chapter 2 focuses on a parallel theoretical analysis of spelling processes. This chapter discusses the regularity of the English language with regard to transforming sound-to-print and, once again, explores the relative merits of single versus dual route theories of spelling production, including recent attempts at computational models of spelling.

The third chapter investigates how the representation of lexical items is conceptualized across a range of theories and explores the possible creation of these lexical items. The question of whether a single lexical representation is the basis for both reading and spelling, or whether two separate representations exist to support the separate processes, is discussed in the second half of this chapter. This is an extremely important aspect since the experimental work essentially investigates the effect of reading on spelling performance.

The final chapter focuses upon the stability of lexical representations and whether incorrect information about a word's orthography can be stored. This chapter introduces the experimental work directly relevant to the studies reported here concerning the effect of orthographic exposure on subsequent spelling ability. The possible priming processes responsible for the effect and their implications are also explored.

CHAPTER ONE

COGNITIVE ROUTES FROM PRINT TO MEANING

Deriving cognitive mechanisms of reading from the orthographic structure of the language

Theories of reading can, at least in part, be derived from the type of writing system being used. A logographic writing system such as, for example, the Chinese system, represents each word with a single written symbol. Logographic writing is a descendant of pictographic systems whereby a word was symbolised by a picture that was attempting to represent the semantic information. For example, 'dog' could be represented by a stylised picture of a dog. This was somewhat limiting because only concrete items could easily be represented, since abstract nouns and other parts of speech are difficult to symbolise via meaningful pictures.

Modern day logographic writing systems have a system of abstract symbols to encompass all types of words. These symbols are often not unique, since it would be difficult to maintain a sufficient level of visual distinctiveness of symbols. This problem has been overcome by using repetition. For example, the same symbol may have different meanings in different contexts and also more complex symbols can be built up from smaller symbols. The smaller symbols may be semantically combined. For example, in Chinese, 'bright' is represented by the combination of symbols for sun and moon. Or the symbol may convey some phonological information: for example, the word 'nurse' is derived from a combination of the symbol for woman, which is considered to be semantically related to 'nurse', and the symbol for horse, which is pronounced in a phonologically similar way to 'nurse'. (Rayner & Pollatsek, 1989). Even though some phonological information may be contained within the symbols it usually only gives an approximate cue to phonology. Even if the phonological information were complete and accurate, however, it would still be difficult to pronounce the word correctly since the Chinese spoken language is tonal. Therefore a basic syllable can acquire different meanings depending on the pitch contours of the vowel sound. Since tonal information is not represented in the orthographic symbol of the word, it is impossible to derive phonology directly from the symbol.

Since no accurate phonological information is contained within the written representation of a word in a logographic writing system such as Chinese, reading must be accomplished via a visual route, since visual information is the only cue that the symbol affords to translate the orthography into meaning. It therefore seems necessary to postulate a direct link between the orthographical aspects of the word and its semantic representation. This direct link from a whole word representation is also known as the lexical route to reading, since a word on the page can be matched to its whole word lexical representation and this can then activate the meaning. The lexicon is thought to contain a representation for every familiar word. Proponents of a single route theory of reading (Glushko, 1979; Marcel, 1980) postulate that the lexical route is sufficient to explain the cognitive mechanism underlying reading.

Single route theorists claim that nonwords and new words are also read using the lexical route even though these items are not represented in the lexicon; they argue that a lexical analogy process is used. For example, presentation of the nonword 'keet' would activate all those words in the lexicon that are orthographically similar to it. The words 'meet', 'feet' etc. would be activated and would therefore ensure a similar pronunciation for the *eet* rime[1]. The pronunciation of the correct consonant at the beginning of the nonword would come from the activation of a whole host of other neighbours, for example, 'keep', 'keen' etc. The system would choose the letters at each position in the word that were most consistently activated and would therefore be able to read the nonword 'keet' accurately.

Evidence against the sole usage of the visual route, however, comes from the fact that skilled readers are able to read pseudohomophones. A pseudohomophone is essentially a nonword, but if it is read aloud then its phonology is identical to that of a real word; take, for example, the nonword 'phocks'. Although it would be able to be read using lexical analogy, no meaning would be accessed for the pseudohomophone since it will probably not have been encountered before and it therefore will have no lexical status. The fact that the word 'phocks' can be read and understood to be 'fox' indicates that the lexical route was not used in isolation.

A possible alternative route to reading can be seen by investigating alphabetic writing systems, which represent phonology within the orthography. A word written in an alphabetic system can be broken down into a series of sounds. For example, the word 'cat' can be read aloud by sounding out each individual letter and blending these sounds together. If the correct pronunciation is achieved, then the word can be understood as if it had been spoken aloud. The meaning of a word can therefore be reached from its orthography via phonic mediation. This route is known as the phonological or sub-lexical route.

[1] A rime is the medial vowel and ending in a monosyllabic word, for example, 'eart' in 'heart'.

The acceptance of the lexical and sub-lexical routes to reading has culminated in the formulation of dual-route theory (Morton, 1969; Baron and Strawson, 1976; Coltheart, 1978, 1985). In dual-route theory, the two routes are considered to operate independently, with the normal reader being able to use both routes concurrently.

The sub-lexical system, however, can only operate accurately for all words if the alphabetic language system is completely regular as, for example, in Finnish, Italian and Polish, where the letter-to-sound (grapheme-to-phoneme[2]) mappings are consistent. English, however, although an alphabetic orthographic system, does not conform to this regularity of mapping. (This can clearly be seen in the variation in sound of the ‘ough’ grapheme in the English words ‘bough’, ‘tough’, ‘trough’, ‘though, and ‘through’). The fact that English is so irregular makes it impossible to read many words by relying purely upon the phonemic blending of a sequence of individual letter sounds.

It can be argued, however, that many words are not quite as irregular as they seem since English phonological ‘rules’ allow for the correct pronunciation. For example, the word ‘seat’ would not be pronounced correctly if transformation from letters to sounds was at the level of the individual letter. However, the correct pronunciation would be achieved if the letters ‘ea’ were considered to represent a single phoneme, because the most common pronunciation of the digraph ‘ea’ is /i/ (as opposed to a word such as ‘threat’ where /ɛ/ is a much less common pronunciation of the ‘ea’ digraph). It can therefore be seen that if some form of phonological rules were incorporated

[2] A phoneme is the smallest unit of speech sound that can be used to distinguish between words. For example, ‘bit’ and ‘pit’ are different words so /b/ and /p/ are considered to be separate phonemes. A grapheme refers to the written form of a phoneme, that is, a letter or several letters

into the phonic mediation system, rather than mapping single letters to single sounds, the sub-lexical route would prove useful for a wider range of words.

Words that are very difficult for the system, however, are irregular words: for example, 'pint', ‘yacht’ etc. The word 'pint' cannot be read via grapheme-phoneme conversion since at a single letter level that would afford /pɪnt/. Also if a larger section of the word 'int' was taken, this would still afford /pɪnt/ since all other exemplars (e.g. 'mint', 'tint', 'lint' etc.) are pronounced in this manner. Other words, for example, ‘yacht’, are difficult since they are unique. A simple grapheme-phoneme conversion would yield the wrong pronunciation and there is also no English rule governing the pronunciation of the larger section 'acht', since it has no similarly spelled rhyming neighbours. It can be seen that any attempts to read these types of words via a phonological route would result in failure to reach the correct pronunciation.

Homophones[3] present another potential problem for the phonic mediation theory. The problem in this case is not necessarily in deriving the correct pronunciation (although it may well be) but in accessing the correct meaning from single word reading. If the word 'bear' were processed via a phonological method then it would be impossible to tell just from the sound of the word whether the semantic representation of 'bear' or 'bare' should be activated. Since skilled readers rarely make this type of mistake, it would be questionable whether phonic mediation was the sole, or even preferred route, to decoding text in an irregular orthography such as English.

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[3] Homophones are words sharing an identical phonology but having different meanings, for example 'see' and 'sea'.

It seems therefore, that phonic mediation between a word's orthography and its meaning is, at best, unreliable in an irregular alphabetic system such as English. The users of a logographic system must read via a visual route since they have no sub-lexical phonology available from the word's orthography. The same mechanism is available and may be used in an alphabetic system. The use of a visual route in English reading would explain why people do not generally get confused when reading the word 'bear'. Although 'bear' is homophonous with 'bare', the two words are orthographically distinct, and so the visual route would ensure that the correct meaning was identified. If reading, even in an alphabetic system, can occur efficiently using a single route theory, it could perhaps be argued that the phonological route is not necessary or even does not exist, which is precisely the stance taken by single-route theorists.

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This section has outlined two very different writing systems, each of which has given rise to a possible route to reading. The first is a logographic system which can only be read by using a direct, visual route from the logograph to its meaning. The second is an alphabetic system which allows the opportunity of translating print to sound, with meaning being derived after the sound of the word has been accessed. Single route theorists assert that the lexical (or direct) route is the only one needed to explain how reading occurs, whereas dual route theorists suggest that both routes are necessary in a complex orthography such as English. The following sections investigate evidence for the existence of the phonological route and therefore compare single- and dual- route theories.

Single versus dual route theories: Experimental evidence

Experimental evidence asserting the existence and use of the phonological route in skilled adult reading falls into two categories: regularity effects and pseudohomophone effects. These two effects will be introduced and discussed in relation to single- and dual- route theories.

The regularity effect is where the reading of irregular words takes longer than the reading of regular words. This was first discovered by Baron and Strawson (1976) in a test of reading aloud single words. This experiment was, however, flawed since the regular and irregular items were confounded by frequency, with the irregular words having a generally lower frequency than the regular words. In 1978, Stanovich and Bauer replicated the strong regularity effect using items that were matched for length, frequency and visual appearance across regular and irregular sets of words. This finding of a regularity effect strongly supports the use of the phonological route in real word reading, since the lexical route should not distinguish between regular and irregular items.

Proponents of a single route theory of reading propose that the evidence supporting the regularity effect is, at best, contradictory. Although Stanovich and Bauer (1978) found strong regularity effects in both word naming and lexical decision tasks, Coltheart , Besner, Jonasson & Davelaar (1979) failed to find any regularity effects in lexical decision tasks. Glushko (1979) suggested that the pertinent variable was in fact sound-to-spelling consistency rather than regularity. A regular and consistent word is one whose orthographic neighbours are pronounced in the same manner (for example, 'pill' whose neighbours are 'will', 'kill'. 'bill' etc.), whereas a regular but inconsistent item has orthographic neighbours which differ in pronunciation (for example, 'where' whose neighbours are 'here', 'were' etc.).

A study by Seidenberg, Waters, Barnes & Tanenhaus (1984) was designed to investigate whether spelling-to-sound consistency was the real factor behind the regularity effects found by Stanovich and Bauer (1978). Seidenberg *et al.* (1984) partialled out regularity by looking at the effects of spelling-to-sound consistency. Seidenberg *et al.* (1984) found clear consistency effects on the lower frequency items. The reason why the effect only occurred for low frequency items is unclear but two explanations are offered. The first is that naming times for low frequency items are much slower, thus allowing more time for the orthographic neighbourhood search. The alternative explanation concerns uncertainty in the pronunciation of some of the lower frequency items so that orthographic neighbours are actively searched as an aid to pronunciation. Humphreys and Evett (1985) conclude that spelling-to-sound regularity is an unreliable effect which can be better explained in terms of spelling-to-sound consistency. Since knowledge of orthographic neighbours can only be achieved via a lexical search, it appears that what was considered to be evidence for the isolated operation of the sub-lexical route in real word reading now further supports the implementation of the lexical route.

However, the spelling-to-sound consistency data has also been criticised. In 1985 Parkin reanalysed the original data produced by Glushko (1979), and found that pronunciation latencies were not affected by very irregular words (such as ‘pint’) and were only increased for those items that had an ambiguous pronunciation (i.e. the alternative pronunciation was reasonably common, such as, for example, 'ead' in 'bead' and 'head'). This finding was also replicated by Kay and Bishop (1987), suggesting that only a specific subgroup of the spelling-to-sound consistency data affects pronunciation latency. There is also some experimental evidence that the pronunciation of an inconsistent regular word like 'stove' is only slowed following the presentation of a less regular alternative, for example, 'dove' (Seidenberg et al., 1984, Experiment 2; Stanhope and Parkin, 1987). These findings further question the usefulness of considering the difference in pronunciation latencies to be due to spelling-to-sound consistency rather than regularity. From the evidence discussed, it appears that the spelling-to-sound consistency data is less reliable than that of regularity, and therefore the role of the phonological route in this effect cannot be ruled out at this stage.

The pseudohomophone effect investigates the special status that nonwords which sound identical to a real word have on lexical decision tasks. In 1977, Coltheart, Davelaar, Jonasson & Besner performed a lexical decision task investigating the effect of homophonic and non-homophonic nonwords on lexical decision times. They discovered that subjects took longer to reject pseudohomophones (e.g.'shrood'), than to reject the control nonwords that were not homophonic with a lexical item (e.g. 'slint'). These results were interpreted as indicating that the phonological similarity of a pseudohomophone activates the lexical representation of the real word ('shrewd') whereas the orthographic form (shrood) provides conflicting information. It is therefore the conflict between orthographic information and phonological information following presentation of a pseudohomophone that leads to the delay in response time, an effect known as the pseudohomophone effect. Supporting evidence for this effect has also been found by Rubenstein, Lewis and Rubenstein (1971), and Besner and Davelaar (1983). These results clearly provide strong support for a existence of the phonological route to reading.

Taft (1982), however, argued that the pseudohomophone effect can be explained in terms of a single route theory of reading. He suggested that grapheme-grapheme, rather than grapheme-phoneme, rules are responsible for the effect. He argued that presented nonwords exert an effect on lexical decision times by virtue of the possibility of exchanging graphemes that map onto a common phoneme (for example, 'ee', could be exchanged for 'ea', 'ei', 'e_e' etc.). He found that rejection times for nonwords were increased if the nonword contained an orthographic segment which could be replaced, without affecting the phonological representation, by an alternative orthographic representation which then formed a lexical item (Taft, 1982, Experiment 2). For example, rejection time for the nonword ‘steek’ was longer than that for the nonword ‘fleek’ because in the former case transformation of the orthographic segment ‘ee’ to an alternative representation of the same phonology, ‘ea’, results in the formation of the lexical item ‘steak’, whereas in the latter case no alternative representation of the phonological segment /i/ results in a real word (‘fleak’, ‘fleik’, ‘fleke’, etc., are all nonwords). Hence a pseudohomophone 'speek' would also produce longer lexical decision times than 'fleek', since replacing 'ee' with 'ea' forms a word ('speak'). Taft therefore interprets pseudohomophone effects without acknowledging a role for phonology.

In 1985, Besner, Dennis and Davelaar conducted two experiments to test whether the pseudohomophone effect was mediated via phonology or by grapheme-grapheme rules. In the first study, they compared the effects of priming on lexical decision times using pseudohomophones (e.g. groce - gross) and a graphemic control pair, where the number and position of identical letters were matched, (croth - cross) compared to unrelated nonwords (e.g. brult - gross). They found that there was a main effect of priming using the pseudohomophones and the graphemic controls compared to the unrelated nonwords. However, they also found a significant interaction between priming (related prime vs. unrelated prime) and type of prime (pseudohomophone vs. graphemic control) , demonstrating that the pseudohomophone prime exerted an influence over and above that of the graphemic prime. Their second experiment investigated the difference between primes which included grapheme-grapheme rules (e.g. shoart - short) and the graphemic controls used in Experiment 1 as compared to unrelated nonwords. In this experiment, they found an insignificant effect of priming (i.e. the related primes produced shorter, but not significantly shorter, lexical decision times than unrelated primes) and there was no interaction between priming (related prime vs. unrelated prime) and type of prime (grapheme-grapheme rules vs. graphemic control). These results indicate that any effect of priming from grapheme-grapheme rules can be explained purely in terms of the priming occurring from the graphemic controls. They therefore support the notion that the pseudohomophone effect is mediated via phonological access to the lexicon, rather than by grapheme-grapheme rules within the lexicon, therefore providing further support for the dual-route theory of reading. (Further discussion of the pseudohomophone effect can be found in Chapter 7.)

Experimental evidence investigating the regularity effect and the pseudohomophone effect have, therefore, provided strong evidence that the phonological route exists and is used by skilled readers in normal reading. This evidence is clearly contrary to the notion of a single route theory of reading where the role of phonology is not considered. However, dual-route theory has also been challenged for its notion of independence between the lexical and phonological routes (Humphreys and Evett, 1985).

The dual route model hypothesises that nonwords are read using the sub-lexical route, but there is evidence that lexical influences are brought to bear when reading nonwords. Kay and Marcel (1981), for example, found that the nonword 'yead' is usually read aloud as /yid/, (to rhyme with bead) but that its pronunciation can be altered to rhyme with 'head' if this word is shown immediately prior to presenting 'yead'. According to the strong version of the dual route model this should not occur since lexical and sub-lexical routes are independent and there should be no interaction between them.

However, according to Coltheart (1985), the finding that real words can influence the reading of nonwords does not pose a threat to the dual route theory of reading. He stresses that evidence of a lexical influence does not necessarily challenge the assumption of the independence of the two routes. For example, the lexical influence could occur after the item has been built up nonlexically but prior to pronunciation. Or the nonword priming effect could be occurring within the grapheme-phoneme conversion system at vowel digraph or orthographic body level. For example, the presentation of ‘head’ may produce a temporary change within the grapheme-phoneme conversion system from the dominant form of ‘ea’ pronounced as /i/ to ‘ea’ pronounced as /ε/.

The experimental evidence outlined in this section supports the notion that two routes to reading exist and are used by skilled readers: these are a lexical route and a phonological route. Dual-route theory asserts that these two routes are independent and although evidence has been provided to challenge this assumption, it is not indisputable. Single-route theory does not allow a role for phonology in reading, and therefore is not able to provide an adequate explanation for the effects discussed in this section. The following section continues comparison between single- and dual- route theories using evidence from neuropsychological cases.

Single versus dual route theories: Neuropsychological evidence

The existence of visual and phonological routes to decoding text has been supported by cognitive neuropsychological data. Studies of acquired dyslexia have shown evidence of two routes to reading. Surface dyslexia has been identified (Marshall and Newcombe, 1973) as a type of acquired dyslexia whereby the specific reading disabilities are consistent with the loss or partial disablement of the visual route. Surface dyslexics must therefore rely primarily on their sub-lexical (phonological) route in order to read (Marshall & Newcombe, 1973; Shallice & Warrington, 1980). This route to reading produces a notable ‘regularity effect’: a superiority for reading regular over irregular words. This is because regular words can be read via phonology whereas irregularly spelled words require specific lexical information. Another common error displayed by surface dyslexics is the regularisation error. A regularisation error is said to occur when grapheme-phoneme correspondence rules have been applied to an irregular or inconsistent word. These errors can result in the pronunciation of a nonword, for example, 'island' pronounced as 'izland' or in the pronunciation of an inappropriate real word 'face' instead of 'phase' or 'grinned' instead of 'grind'. There is also some evidence to suggest that the semantics of the word are also accessed by phonic mediation. Marshall & Newcombe (1973) report a patient JC, who, on reading *begin* as *beggin,* explained "That's collecting money" (having accessed 'begging'). Examples of reading patterns of acquired surface dyslexics therefore show that reading can, and sometimes does, occur via the phonological route.

Another type of acquired dyslexia that has been identified is phonological dyslexia. Phonological dyslexics are able to read the majority of familiar words regardless of length or regularity (Beauvois & Dérouesné 1979; Shallice & Warrington 1980; Funnell 1983). These patients are generally very difficult to identify without explicitly directed testing, since their real word reading is almost perfect. The main problem for phonological dyslexics is the reading of pseudohomophones (for example 'phocks') and nonwords. Funnell's (1983) patient WB was the most severe phonological dyslexic of those in the three studies cited above, in that he had completely lost his phonological route because he was unable to read aloud any nonwords. He could still not be considered to be a `pure' case of phonological dyslexia, however, since his lexical route had also suffered some damage. Although theoretically a case of 'pure' phonological dyslexia would be ideal to investigate the dual route theory of reading, it is still of interest to those who hypothesise the existence of a phonological route to find a case like WB where this route has been completely abolished. Since, generally, the lexical route is still intact, any word that a person has previously encountered and has already been reliably stored can be directly accessed. A novel or nonword, however, would have no pre-existing lexical entry and could therefore only be read by a phonic mediation process.

It can therefore be seen that surface dyslexics, who have lost their lexical route to reading, and phonological dyslexics, who have lost their sub-lexical route to reading, produce markedly different patterns in their reading disabilities. The fact that either function can be lost while leaving the other intact implies a double dissociation between them, which has been regarded as strong evidence for both the existence and the independence of two separate routes to reading.

However, Humphreys and Evett (1985) claim that this pattern of results does not constitute a true double dissociation. They argue that in none of the cases mentioned has there been a clear-cut situation where one of the systems has been completely destroyed leaving the other completely intact. They therefore question the strength and independence of the two routes. Coltheart (1985) points out that there have been cases where, first, the sub-lexical route was entirely abolished (patient WB - Funnell, 1983) and second, the sub-lexical route was entirely preserved (patient MP - Bub, Cancelliere & Kertesz, 1985). Since these two patients show completely different patterns of results consistent with the complete abolition and complete preservation of the sub-lexical route, respectively, this in itself could be argued to constitute a double dissociation, thus supporting the dual route theory of reading.

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This section has presented neuropsychological evidence to show that there are, at least two different types of dyslexia, associated with different patterns of reading problems. Surface dyslexia reveals a pattern of reading difficulties consistent with the loss or disablement of the lexical route to reading, and phonological dyslexia shows reading problems consistent with the loss or disablement of the phonological route. These two distinct patterns of reading problems cannot be explained in terms of a single route to reading and are more consistent with dual route accounts. The following section investigates the relatively recent development of computer simulations of single and dual route theories of reading and compares their psychological feasibility.

Single versus dual route theories: Computational models

The single route theory has recently had a revival in credibility when Seidenberg & McClelland (1989) created a computer simulation of reading aloud using a single route system - the Parallel Distributed Processing (PDP) model of reading. The 'parallel' part of the description refers to the fact that all the letters in the word are processed at the same time rather than serially from left to right and the 'distributed' part refers to how the words are stored. The PDP model rejects the dual-route notion that there are particular nodes or areas where a word is represented, in favour of a system where words are represented by a distributed pattern of activation between the pathways of sub-word units.

The model proposed by Seidenberg and McClelland (1989) consists of a three-layer feed-forward system where 400 orthographic units are connected to 200 hidden units which, in turn, are connected to 460 phonological units. The different connections are initially given random weights, but these are modified using a system of back-propagation. An orthographic unit (known as a 'wickelfeature') is formulated to identify character triples for any word (included in this character triple is a sign for a word boundary symbol - in this case #). So, for example, the word 'poor' would activate the triples '#po' 'poo' 'oor' 'or#'. Since this system incorporates both letter and positional information, it manages to overcome the problems of anagrams and repeated letters in words. This was also overcome by McClelland and Rumelhart (1981) by having a full set of letter detectors for each position in a word, but this was a rather cumbersome solution.

Similar problems with repetitions and anagrams are also relevant to phonological units. Seidenberg and McClelland (1989) adopted the Rumelhart and McClelland (1986) coding scheme of the 'Wickelphone' - a sequence of three consecutive phonemes. This works on the same basis as the orthographic triples, that is, that positional information of the phonemes is incorporated into the triples. However there were originally 1210 Wickelfeatures and these were reduced somewhat arbitrarily to 460. This reduction was unsatisfactory, since some of those retained are phonotactically illegal and some that have been eliminated are phonotactically legal[4]. The choice of output is governed by putting a lower limit on the model's error rate in pronouncing a set of stimuli. If an item does not exceed this lower limit then an answer is not given. If an item generates several alternatives then the top matching answer is generated. This process is known as the BEATENBY criterion.

Seidenberg and McClelland (1989) claim that their single route system accounts for the behavioural data better than a dual route system on the basis of the following argument: "A key feature of the model we propose is the assumption that there is a single uniform procedure for computing a

[4] In this instance, phonotactic legality refers to whether the resulting wickelfeature is pronounceable within the English language.

phonological representation that is applicable to exception words and nonwords as well as regular words" (from Seidenberg and McClelland, 1989, p525).

In 1993, Coltheart, Curtis, Atkins & Haller created a comparable computer simulation of reading based upon a dual-route model called the Dual Route Cascade (DRC) model of reading, which was based on the same set of test words that Seidenberg and McClelland (1989) had used for their model. Coltheart et al.'s (1993) model involves two stages - the first consists of a level of letters which feed the lexical route and the non-lexical grapheme-to-phoneme conversion system. Secondly, the model is programmed to learn grapheme-phoneme correspondence rules. This operates by applying the more complicated grapheme-phoneme rules first - for example the model checks to see if there is an 'o-e' rule before resorting to a simple /o/ pronunciation if there is an 'o' in the middle of a word; so the model always chooses the pronunciation of the rule of the longest letter string.

The DRC model uses a system called slot-based coding, which means that there is a letter detector in each position of a word i.e. for the first letter, the second letter and so on. There are currently eight letter detectors, with each capable of detecting a total of 27 different units - 26 letters and a space, the space detection ensuring that the end of a word can be identified. If the letter 'c' is detected in the first position of the word then all words beginning with the letter 'c' will be excited and all those starting with any other letters are inhibited. In this model there are a total of 7991 lexical entries and 7127 phonological entries; the number of phonological entries is fewer than the number of lexical entries due to the existence of homophones. As soon as a word is presented cascaded processing occurs, and this processing is fully interactive i.e. the information feeds both forwards and backwards. Coltheart *et al.* (1993) also state that the lexical route uses parallel processing, as in the PDP single route models, whereas the grapheme-phoneme rules work serially from left to right. Excitation throughout the model starts off very slowly and then speeds up reaching an asymptote at the value of 1.

Coltheart et al. (1993) concluded that the DRC model of reading accounted more closely on a qualitative and a quantitative level for current behavioural data than the PDP model. For example, when the Seidenberg and McClelland (1989) PDP model was tested on the set of nonwords used by Glushko (1979), the model correctly read 65% of the nonwords - supposedly mirroring normal subjects who scored between 80% and 90%. Seidenberg and McClelland (1989) account for this model-human difference by suggesting that the training vocabulary used for the model was too small and a more varied and wider vocabulary would produce results which reflect human performance more accurately. The Coltheart *et al.* (1993) DRC model of reading, however, read the same set of nonwords with an accuracy of 98%, having been trained on the identical corpus of words as the PDP model, thereby questioning Seidenberg and McClelland's (1989) claim that a wider training vocabulary was required. This therefore suggests that a dual route conceptualisation can model human reading more accurately than a single route view.

A criticism often levelled at computational models of reading is that although it could be possible to produce a simulation that exactly replicates human experimental data, this does not necessarily advance our understanding of how reading occurs. In order to attempt to discover whether the PDP or DRC models of processing are more likely to be psychologically accurate, Coltheart

& Rastle (1994) conducted an experiment exploring theoretical differences between the two models and testing human subjects. The difference that they investigated was the fact that the PDP model relies on parallel processing whereas the DRC model uses the notion of parallel processing for the lexical route but serial processing from left to right for the phonological route. To test this difference, a set of irregular words was chosen where the irregularities ranged from the first position to the fifth position in the word. For example, 'chaos' is irregular in the first phoneme whereas 'debris' is irregular in the fifth position. For each irregular word chosen a regular word was matched for number of letters and initial phoneme. The purpose of this experiment was to investigate the regularity effect, that is the superiority of regular over irregular word reading, across position of phoneme irregularity. The dual route model proposes that the regularity effect in low frequency words occurs due to conflicting information from the lexical and sub-lexical route. For example, the word ‘bear’ could produce a pronunciation of ‘beer’ from the phonological system and the correct pronunciation of ‘bear’ from the lexical system. Since in this example the two items are both real words a time-consuming conflict could occur. Given that the DRC model states that the sub-lexical route processes words serially from left to right, it can be argued that the further to the right that the irregularity lies the more likely that the lexical route can complete processing before conflicting information from the sub-lexical route is accessed. Therefore if the sub-lexical route does work in a serial fashion, a decreasing regularity effect across position of irregularity in words should be found. When human subjects were tested this was indeed found to be the case, regardless of whether the target words were presented with high frequency exception words as fillers (to promote the use of the lexical route) or when the fillers were nonwords (to promote the use of the sub-lexical route). When the same set of words were given to the DRC model of reading aloud, the results of the original human subjects were replicated very closely. This is in sharp contrast to the PDP model which would have to hypothesise that there would be no differences as a function of serial position of irregularity, since all items are processed in parallel.

It appears that the DRC model of reading is more psychologically accurate in its underlying assumptions than the PDP model, and Coltheart et al. (1993) also argue that it accounts for the behavioural data better. The evidence from the computational models, taken with the preceding two sections investigating experimental and neuropsychological evidence, points towards the fact that the phonological route does exist and is used in the normal course of skilled adult reading. For these reasons, the dual-route model will be used from henceforth as a general framework within which to discuss reading and lexical access.

CHAPTER TWO

THEORIES OF SPELLING

The fact that the English language is irregular with regard to translating print to sound has been discussed in the preceding chapter with respect to reading. However, English is considered to be even more irregular when translating sound to print (Seymour and Porpodas, 1980). For example, the vowel /i/ (ee) can be represented in English in 12 different ways. The three most common of these are represented by 'ee', 'ea' and 'ie', but the sound can also be represented by 'eo' as in 'people', 'i' as in 'ski' and 'oe' as in 'foetal', and so on. As Hatfield and Patterson (1983) point out, there are very few words which are completely predictable in the way they are spelled.

Two routes to spelling

The two main routes to spelling are, as with reading, that of phonic mediation or a direct lexical route. Phonic mediation refers to the fact that a word like 'sat' can be spelled by segmenting the word into phonemes and assigning graphemes for each one of those sounds. Therefore the first phoneme can be represented using an 's', the second by an 'a' and the third by a 't'. Joining these letters together in this order affords the correct spelling of the item.

The phonological route for spelling, however, cannot explain how irregular words are spelled. Although the correct spelling of the word 'sat' can be reached using purely phonological techniques, this is not so with an irregular word such as 'colonel'. First, there is an ambiguity in the translation of the first phoneme which could be graphemically represented by a 'c' or a 'k'. Furthermore, the second phoneme is even more ambiguous. The phoneme 'er' can be represented by 'er' 'ur' 'ir' etc., but representation by 'olo' is unique to this English word. It can therefore be seen that the phonological route is not sufficient to produce the correct orthography for irregular words. However, Barry (1994) argues that English spelling may be considered more 'regular' if words are parsed into onset and rime[5] (Treiman, 1985), rather than individual phonemes. An example of this is that although the vowel /eI/ can be orthographically represented in 12 different ways, the rime /eIn/ only contains four different alternatives as can be seen in 'cane', 'gain', 'deign' and 'rein'. If the phonological system does parse items into onset and rime, then it would be more reliable than parsing into individual phonemes by virtue of the reduction of the number of choices per item. However, how the system would be able to choose the correct alternative from among the reduced number of choices is admittedly no clearer.

Homophones are yet a further set of items that create a problem for the phonological route. With the spelling process, the starting point is semantic information (or the spoken word). Given that the only method for transcribing, for example, the word 'bear' via the phonological route, is to use phonological information, the homophone 'bare' is equally likely to be produced. Other alternatives for example 'beir', 'baire' etc. could also be generated.

The other route to spelling, the lexical route, consists of a direct route from semantics to the orthography of the word. This is sometimes known as addressed spelling (Ellis, 1984). The semantic representation for each item serves as an input to the orthographic store and this releases the correct letter

[5] Onset is the initial consonant or consonant cluster in a monosyllabic word and rime is the remainder of the word i.e. the medial vowel and ending. In a word like 'start' 'st' represents the onset and 'art' represents the rime.

string for all known words. Given that writing is far slower than speaking, a graphemic buffer (Ellis, 1984; Caramazza, Miceli, Villa, & Romani, 1987) of some kind is hypothesised, where the orthographic form of the word is stored until the word has been externally generated. This route explains how both regular and irregular words can be spelled correctly, since, if they have already been encountered, the correct orthographic information would be stored awaiting retrieval when required. If the lexical route was used in isolation, however, it would be difficult to explain how nonwords or novel words could be spelled, because they would have no prior representation in the orthographic store. It would also be difficult to account for the fact that spelling mistakes tend to be phonologically plausible, even though this type of error accounts for a large majority of misspellings in skilled adult spellers (Wing & Baddeley, 1980). Finally, an accurate lexical system would predict that spelling mistakes would be rare.

As with reading, some of the evidence for the existence of two routes in spelling comes from cognitive neuropsychological cases of acquired dysgraphia. Shallice (1981) reported a patient, PR, who could spell over 90% of real words accurately, but was unable to produce phonologically plausible orthographies for nonwords. This was not due to the fact that he could not hear the words since he was able to repeat them, and he was also able to read a fair proportion of nonwords. This deficit was therefore specific to spelling procedures. This implies that the lexical route has a very slight impairment (since only 10% of real words which should be stored in the orthographic lexicon were irretrievable), but the inability to produce plausible orthographic representations for nonwords suggests a severe impairment to the phonological route. This pattern of cognitive impairment has been termed phonological dysgraphia, since the phonological route to spelling production is severely damaged, leaving a reliance on the lexical route.

The opposite cluster of symptoms has been found in a patient TP, who seemed to have a damaged lexical route, and was therefore reliant upon phonology in order to spell (Hatfield and Patterson, 1983). TP appeared to find regular words easier to spell than irregular ones and nearly all the errors made were phonologically plausible. She also made errors when writing homophones, where she would sometimes substitute the orthography of the inappropriate homophone, for example, writing 'sum' as 'some'. Homophone substitution errors would be expected since her spellings were likely to be phonically mediated; however, in this particular example, the substitution of 'some' seems to imply that she had at least limited access to lexical information since 'some' is an irregular word. On subsequent testing, it was found that some higher frequency irregular words e.g. 'cough', 'answer' etc. were spelled correctly, demonstrating that TP's lexical route was not completely destroyed.

Evidence that both routes to spelling are used in subjects with intact brains can be found in a series of studies by Kreiner and Gough (1990) and Kreiner (1992). Kreiner and Gough (1990) measured subjects' performance on three variables that were thought to be representative of the lexical system (word frequency, word length and centrality of the phoneme within the word), and three variables that were considered to represent a phonological rule-based system (ambiguity of rules, relative probability of phoneme-to-grapheme correspondence and phoneme frequency). Using a multiple regression technique on subjects' spelling errors they found that lexical based variables still accounted for a significant proportion of the variance in errors after phonological rule-based variables had been partialled out, and that rule-based variables were significant after lexical based variables had been accounted for. These results provide important confirmation that both the lexical and sublexical processes are used in normal spelling production.

Kreiner and Gough (1990) were also interested in the way in which the two processes interacted in normal reading (Experiment 3). They investigated the effect of word frequency and rule ambiguity on accuracy of spelling a target phoneme within a word. Ten sets of 4 words were compiled, each word in the set sharing an identical letter in the same serial position. The study was designed factorially so that two out of the four words contained a schwa[6] and two contained nonschwa vowels, also half of the words which contained schwa vowels and half which contained nonschwa vowels were high frequency and the other half of both sets were low frequency (for example, high frequency schwa - 'climate'; high frequency nonschwa - 'compare'; low frequency schwa - 'vintage'; low frequency nonschwa - brigade'). The order of the words was randomised and the words were orally presented in a dictated spelling test. Kreiner and Gough (1990) discovered that there was a significant effect of frequency (pointing towards the use of the lexical route) and a significant effect of ambiguity (pointing towards the use of the sub-lexical route). These results therefore provide further support that both lexical and sub-lexical processes are used in normal spelling procedure. More importantly, however, Kreiner and Gough (1990) also discovered that there was a significant interaction between ambiguity and frequency. A closer look at the results shows that there was a large frequency effect in words with highly ambiguous phonological rules and

[6] A schwa is a vowel with a special status since it only appears in unstressed syllables and is created by the placing of the tongue in its natural resting position (mid-central). A schwa can be graphemically represented by using any one of the five vowels.

a large ambiguity effect of low frequency words. Kreiner and Gough (1990) concluded that phonological rule information may be used when lexical information is less certain (i.e. in the case of a low frequency representation) and that lexical rules may be used when phonological rule information is very ambiguous. This provides some tentative support that the lexical route is not necessarily the dominant route in normal spelling.

Further experimental work by Kreiner (1992) investigated the notion of primacy of the two routes. It has long been suggested that the lexical route 'wins the horse race' (Allport, 1977; Coltheart, 1978; Coltheart, Besner, Jonasson and Davelaar, 1979; Seidenberg, 1985) and that phonology is only used as a slow support mechanism. Kreiner (1992) used the variable of polygraphy to investigate the phonological route, whereby the more polygraphic the phoneme the more difficult it is to spell, and word frequency to investigate the lexical route, where the higher the word's frequency the easier it is to spell. In this experiment a reaction time measure of spelling was used (amount of time to state whether a letter probe is contained within a word or not). The target variables of polygraphy (representing phonological aspects) and word frequency (representing lexical aspects) explained separate and significant proportions of the variance even after the control variables (for example, word length and position of the error) had been partialled out. Kreiner (1992) concluded that polygraphic information is used more for low frequency words but that it also influenced the reaction time (but not the accuracy) for high frequency words. These results found no evidence of a temporal primacy of the lexical route, and it was concluded that the two separate processes, lexical and sub-lexical, are probably activated in parallel.

Non-independence of the two routes

The neuropsychological cases serve to demonstrate that the phonological and lexical routes can exist independently of each other and the experimental work of Kreiner and Gough (1990) and Kreiner (1992) shows that both processes are used in normal spelling. But the question of whether the two routes are independent in subjects with intact brains is still undecided. One of the major sources of evidence that these two routes do in fact interact comes from nonword spelling. A dual route theory can easily explain how nonwords are written, since the positing of a phonological route means that nonwords can be built up from either simple, or more complex, phoneme-to-grapheme correspondences. If this were the case and the two routes were completely independent then there should be no effect of lexical information on the spelling of nonwords.

Single route theorists would argue that nonwords can be spelled via lexical analogy. Campbell (1983, 1985) suggests that a spoken nonword will activate a large set of words, all of which will be embedded within the nonword and that these will influence the final spelling. Henderson (1982) suggests that a spoken nonword may activate only those items which rhyme with the word. From this he argues that a procedure either selects from the alternatives or somehow pools the activated items to elicit a particular spelling. Marcel (1980) suggests that a spoken nonword will activate all lexical exemplars with phonemes in equivalent positions; for example, the nonword 'bope' would activate all words beginning with /b/, all words with /o/ in a medial position and all words ending with the /p/ phoneme. Any of these mechanisms postulated by various single route theorists could theoretically produce a plausible spelling for any nonword, and therefore single route theorists would argue that lexical information is crucial in the production of plausible orthographies for nonwords.

There have been a small number of studies investigating lexical influences on nonword spelling. One of the first was that of Campbell (1983), who, using auditory presentation, preceded each targeted nonword by one of two words that contained alternative spelling patterns for the targeted nonword. For example, the nonword /wis/ was preceded by one of the two following primes, 'niece' or 'fleece'. The purpose of this technique was to discover whether the real word influenced the subsequent spelling of the nonword, in the above case producing 'wiece' or 'weece', respectively. Campbell (1983) found a very significant priming effect where, on average, 65% of the nonwords used were effectively primed (i.e. the nonwords were spelled using the orthography of the rime from the preceding real word). This estimate of priming may be too high, however, since there was no control procedure in this study to establish the natural orthographic preferences of the subjects in a free spelling condition of the target words. A further study by Burden (1989), investigating the effect of lexical priming of nonwords in good and poor spellers, demonstrated smaller effects of lexical priming. This study controlled for baseline performance by asking the subjects to spell the nonwords three months after the original study. It was found that net priming for good spellers was approximately 23% and for bad spellers 34%. Although the level of priming of nonwords differs quite dramatically between the studies of Campbell (1983) and Burden (1989), they both show that nonword spelling, a task which could be purely phonological, can be influenced by lexical information.

The effect of lexical influence over nonword spelling has been shown using not only direct priming, but also associative priming (Seymour and Dargie, 1990). In this study, the overt primes used were associates of covert direct primes; for example 'vatican' was used as an associate for 'pope' and 'detergent' was used as an associate for 'soap'. Subjects were therefore presented with an associative prime followed by a nonword, for example, /bOUp/. It was found that if subjects were primed with 'vatican', there was a significant increase in the number of 'bope' spellings for /bOUp/ via the influence of 'pope'. However, if they were primed with ‘detergent’, there was a significant increase in the number of 'boap' spellings via 'soap'. In 1994, Dixon and Kaminska investigated the relative potency of direct and associative priming in nonword spelling in adults and children. They found significant priming effects in both priming conditions, with direct priming being significantly stronger than associative. However, even the highest percentage of net priming (measured as percentage of words spelled in the priming condition in the direction of the prime, minus percentage of words spelled in this manner in the free spelling condition) was only 27%, which shows that lexical information by no means influences all nonword spelling. From this it may be concluded that although nonword spelling can be influenced by lexical information, the primary route to nonword spelling still appears to be the sub-lexical phoneme-to-grapheme process.

The role of contingency weightings on nonword spelling has also been used to argue for the interdependence of the lexical and phonological routes to spelling (Barry and Seymour, 1988). Barry and Seymour (1988) extended Campbell's (1983) study by manipulating sound-to-spelling contingency, that is, the frequency with which spelling patterns represent vowel sounds in words. For example, the vowel sound /i/ is commonly represented by 'ee' and 'ea' and these are therefore considered to be high contingency phoneme-to-grapheme correspondences. An example of a low contingency correspondence in the case of the above example would be 'ie', which only occurs in 7% of words containing the vowel sound /i/. Barry and Seymour (1988) examined priming effects under four different priming conditions. In one, the nonword was preceded by a prime containing the most frequent spelling pattern for a particular vowel sound (for example, the nonword /dUt/ was preceded by 'foot'). In the second, the prime used was the second most commonly occurring orthography, but still a high contingency exemplar (for example, the word 'put' was used as a prime for /dUt/). The third condition used a prime exemplifying a low contingency correspondence (i.e. a rarely occurring orthography), but was considered to be phonologically regular (for example, the word 'fruit' was used as a prime for /put/). In the final condition a low contingency prime with a phonologically irregular orthography of the vowel was used (for example the word 'move' was used as a prime for the nonword /puv/).

Barry and Seymour (1988) found significant effects of lexical priming on nonword spelling (as had been shown by Campbell, 1983 and others), but also found significant effects of sound-to-spelling contingency. Subjects were more likely to produce high contingency than low contingency spelling patterns both in the control (free spelling) and primed conditions.

Further work in the area by Burden (1989) and Seymour and Dargie (1990) yielded more information concerning the effects of sound-to-spelling contingency on priming of nonword spelling. Burden (1989) investigated sound-to-spelling contingences with respect to good and poor spellers. She found an interaction between degrees of priming and contingency, in that high contingency correspondences exhibited less priming than low contingency for both good and poor spellers. Seymour and Dargie (1990) found, in their study of associative priming, that the effects of contingency were additive rather than interactive (i.e. that contingency significantly affected the spelling pattern that the subjects produced under free spelling and primed conditions, but the overall amount of priming remained similar for high and low contingency items). It seems, therefore, that despite controversy over the role of sound-to-spelling contingency on nonword priming, sound-to-spelling contingency appears to play a significant role in the production of nonword vowel sounds.

Henderson (1982) suggested that when a word is written, information about sound-to-spelling contingency is accessed by activation of a large number of lexical items containing the same sounds that are in the word. He argues, therefore, that phoneme-to-grapheme contingencies are the result of lexical 'pooling'. If this is indeed the case then it could not be argued that the two routes to spelling are completely independent. Barry and Seymour (1988) also argue for the functional interaction of the two routes to spelling. They consider that contingency information is abstracted from the orthographic lexicon but is stored separately. This implies that sound-to-spelling contingency is developed from lexical information and, as such, nonword spelling, a seemingly phonically mediated task, can be argued to have at least some basis in lexical information though not necessarily an interaction in real time.

Despite these arguments, the role of sound-to-spelling contingency in relation to the issue of the autonomy or otherwise of the sub-lexical system is unclear, since there are two major difficulties in the assumption that phonological rules are abstracted from the orthographic lexicon. First, the orthographic lexicon does not contain any information about phonology and since the grapheme-phoneme conversion system receives information of the orthographic form of the word from the written version at input it would be unlikely that the orthographic representation in the lexicon would be required. Rather what is required for rule derivation is the correct pronunciation of the word, which is to be found in the phonological output lexicon. The second difficulty concerns homographs. The word 'read' can be pronounced in two different ways according to its context. At the level of the orthographic lexicon it is impossible to tell which of these alternatives is the correct one for the context, so the system needs access to syntactic and semantic information in order to make this decision. The correct pronunciation will therefore occur at the phonological output lexicon. Hence it seems reasonable to postulate that phonological rules are derived from feedback between the discrepancy of output of the grapheme-phoneme conversion system and the pronunciation accessed in the phonological output lexicon.

It is possible that sound-to-spelling contingency information could be built into the phonological system from exposure to the words, in a similar manner to the way orthographic representations are considered to develop. Sound-to-spelling contingency rules could be acquired by the grapheme-phoneme conversion system breaking down the orthography into its constituent parts, assigning phonemes to them and then passing the result of this to the phonological output system. The phonological output system stores the phonological form of all known words and so, if a word was pronounced incorrectly according to simple grapheme-phoneme conversion, the nearest real-word alternative would be produced. At the same time confirmatory information in the phonologically output lexicon would be provided by the lexical route, since the presented word would also be identified by the lexical system (if it is a familiar word), and would activate the correct phonological form at output. The dual activation should ensure the correct pronunciation at output and therefore provide feedback information in terms of the discrepancy with the original pronunciation. This output information could therefore be fed back into the grapheme-phoneme conversion system and in this way rules could begin to be acquired.

If sound-to-spelling contingency patterns are abstracted from phonological analysis of repeated exposure to words and feedback from the phonological output lexicon, it is rather difficult to assess the degree to which lexical information is used. For the moment it can be concluded that it is impossible to identify the precise source of sound-to-spelling contingency information, and only carefully directed testing will be able to address this issue. It is therefore difficult to address the controversy concerning the independence of the two routes to spelling via sound-to-spelling contingency.

Single route theories also have problems in explaining current experimental results on nonword spelling. It could be argued that nonword spelling provides the downfall for the single route theory, since experimental results (Campbell, 1983, 1985; Barry and Seymour, 1988; Burden, 1990; Seymour and Dargie, 1990; Dixon and Kaminska, 1994) show that lexical influence using a real word prime only appears to affect the minority of nonword production. This means that the majority of nonword spelling uses a phonological process, a possibility which the single route system does not allow. Also it is difficult to explain the patterns of spelling dysfunctions found in phonological dysgraphia.

If the lexical route is still intact, which it is assumed to be since real word spelling remains unimpaired, then nonword spelling should also remain unimpaired since single-route protagonists argue that nonword spelling is achieved via lexical analogy. Phonological dysgraphics, however, do show impairment of non-word spelling despite retaining lexical knowledge for real-word spelling (e.g. Shallice, 1981, Patient PR).

Computational modelling of spelling

More recently, there has been a move to attempt to implement computational models of spelling using a single process of translating sounds to print. One such model is a system devised by Brown and Loosemore (1994). This model is quite a small system since it is based upon a vocabulary of only 225 words. These words were carefully chosen for experimental purposes so that 19 were 'regular' words that could be considered to be entirely consistent in that the words had only lexical 'friends' and no 'enemies' (Laxon, Coltheart and Keating, 1988), for example, 'hill', 'pill', 'kill' etc.; 19 were 'irregular' words that were inconsistent in that both 'friends' and 'enemies' were contained in the vocabulary (e.g. 'soap', 'hope', 'rope' etc.); 19 words were unique in that they had no 'friends' or 'enemies' within the network vocabulary (e.g. 'bulb'), and the remaining words were simply included to provide ‘friends’ and ‘enemies’ to the target words.

The architecture of the model is similar to that of the Seidenberg and McClelland (1989) connectionist model of reading. It consists of a layer of input units where information concerning a word's phonology is fed in using a binary code. In this model, words with rhyming endings irrespective of orthography are represented as being similar within a binary code. The model also has a layer of hidden units between the input units and the output units, where the patterns of activity representing spellings is accessed. The model was trained using 'epochs' where each word was presented once: thus all words were afforded an equal frequency which, of course, is not the case in human spelling systems. Brown and Loosemore (1994) discovered that the computer was quicker to learn the spellings of the ‘regular’ words than the unique words, and quicker in turn to learn unique words than the words which they had termed ‘irregular’. These data were supported by experimental data with children (Brown and Loosemore, 1994), who also found ‘irregular’ words harder to learn than unique words, which were harder than ‘regular’ words. Brown and Loosemore (1994) concluded that “it is possible to spell both regular and irregular items with just one mechanism” (p326).

However, the words used in the model could not be considered to be truly irregular since the examples given can all be spelled using very simple phoneme-grapheme conversion rules. The words in the sample were actually consistent and inconsistent rather than ‘regular’ and ‘irregular’ and it would be expected that a phonological route to spelling, which is essentially what the model consists of since it learns the associations between the sounds of rimes and their spellings, would be affected by consistency of orthographic neighbours. This model is rather limited by the type of words used (monosyllabic items which are simple to spell using phoneme-to-grapheme conversion), the number of words used (57 target words, with the remaining 168 words rhyming with the target words), and by the fact that other information which is generally considered to be represented in the lexicon, for example, frequency, was not represented within the system. Therefore, in its present state it is difficult to consider this model seriously as a useful model of spelling.

A more comprehensive connectionist model of spelling was devised by Olson and Caramazza (1994). The system, 'NETspell', is a backpropagation system that converts phonemes to graphemes and was developed from the already existing model 'NETtalk' (Sejnowski and Rosenberg, 1987). The same basic design of three layers of units was used: input units, hidden units and output units. The input is a set of seven phoneme windows, where the target phoneme is placed in the central window and the other windows are there to provide context for the neighbouring phonemes within the word. A word is presented by putting the first phoneme in the central window and the other phonemes in the three boxes to the right. The second phoneme is then moved to the central window and the first phoneme moves left off centre and so on until the word is completed. The input units are connected to the hidden units via weighted connections and this determines the most likely output. NETspell was trained on two separate corpora of 1000 and 1628 words. These words were chosen to represent the range of regularity and frequency within the language, although certain limitations were necessary. For example, it was not possible to include a word like 'range' where the presence of a final 'e' affects both the pronunciation of the earlier vowel *and* the sound of the 'g'

Network 1000 was trained using 60 epochs and produced correct spellings for 70% of the words in the sample, whereas Network 1628 was trained on 100 epochs and achieved a total of 83% correct spellings. Most of the errors produced were phonologically plausible since the system essentially consists of a phoneme-to-grapheme conversion system. The system was also tested on words that were not in the training corpus to see if it was able to generalise from its learning. Of these new words, the system produced phonologically plausible spellings for 87.09% of the words, phonologically implausible spellings for 6.45% and context violations for 6.45% of the words. Context violation refers to the fact that, since the system is unable to use orthographic context rules, it cannot know that although 'y' is the most common spelling of the phoneme /i/ in the final position it is almost never used in the initial position. The system therefore produces mistakes that are implausible in the context that they appear, for example 'comentere' for 'commentary', where an 'e' in the final position is rarely pronounced as /i/. Although the system performed reasonably, Olson and Caramazza (1994) point out some of the drawbacks. First, they acknowledge that although the network managed to spell 83% of all learned words correctly, this is well below performance of skilled spellers. Second, many of the items entered into the network failed to reach criterion so that no output at all was provided and this has no parallel in human performance. Third, there was no tendency to replace a vowel with a vowel, or a consonant with a consonant, a constraint which is evident in human subjects (Caramazza & Miceli, 1990). Fourth, the network was unable to process homophones, and finally, the system was unable to learn word position constraints. Since NETspell is essentially a phonological system and as such is unable to use any orthographic information, none of these difficulties are surprising and all of them would be predicted from a single phonological route to spelling. What is interesting to note, however, is the considerable extent to which spelling *is* feasible using a phonological system. Olson and Caramazza (1994) conclude that the usefulness of connectionist modelling is rather unclear since "not knowing how NETspell solves the problem also makes it difficult to evaluate how interesting the solution is" (p.360). However, this model does seem to provide further evidence that a phonological system alone is not sufficient to explain how humans spell under normal conditions.

Accepting the caveat that there are limitations to computer simulations as an explanatory or insightful device, since even when they apparently successfully replicate human performance there is no guarantee that human information processing procedures are in fact the same as those employed by the model; they may in fact be entirely different, but lead to the same overt performance patterns. The above evidence of failure of single route computation to model human performance sufficiently closely indicates that perhaps the single route is not the way in which spelling processes operate, and a more psychologically accurate model is provided by a dual-route conceptualisation.

However, even proponents of dual-route models have argued that the lexical route is the more reliable method with which to achieve skilled reading and spelling in a deep orthography such as English (Sloboda, 1980; Coltheart, 1978). This would appear to make common sense since, if a lexical entry is correct and it is used as a source of information for spelling, there is no reason why a spelling mistake should ever occur. However, spelling mistakes do occur and they are often phonologically plausible misspellings (Wing and Baddeley, 1980), which would not be predicted on a purely lexical processing account. It appears, therefore, that the lexical route in isolation is not enough to produce consistently accurate spellings, even for words that have been previously encountered.

It is possible that the lexical route is more effective for reading than for spelling simply because of the nature of the two processes. In reading, a template matching scenario can exist, whereby if, for example, the word 'elephant' is seen, it can be matched against the closest lexical entry and therefore be read correctly. The nature of reading means that lexical entries can be flexible, at least in their criterion for matching a word to its lexical entry, with the effect that words that have been slightly misspelled can be accurately read because the misspelling is still closer to its target lexical entry than to any other. In spelling, however, the lexical information needs to be both precise and complete for a word to be correctly spelled. Any slight mistake or competition in the lexicon could mean that the resulting orthography for the word is incorrect. It is therefore important to consider whether it is possible for incorrect or imprecise lexical information to be stored and used at a later date.

The following chapter addresses this question. It considers how lexical representations are created and whether it is possible to store imprecise or incorrect lexical information. It also investigates whether a single lexical representation underlies both reading and spelling processes or whether there are two separate lexical stores.

CHAPTER THREE

LEXICAL ACCESS AND THE NATURE OF LEXICAL ENTRIES

Developmental theories of reading all posit the notion that some form of orthographic representation exists in the cognitive system, where information about a word's orthography is stored. Although the form of the representation differs between models (as will be discussed later) the majority of theories assume that lexical representations are created via experience with the printed word. For example in dual route theory, multiple presentations of the printed word result in the creation of a lexical entry and further presentations are considered to strengthen the representation. Therefore only words that have been encountered before can be represented within the lexicon. This idea is also supported by frequency effects in word recognition (Forster & Chambers, 1973; Frederiksen & Kroll, 1976; Balota & Chumbley, 1985; Waters & Seidenberg, 1985). The word frequency effect is where those words which are of high frequency in the reading vocabulary are accessed more quickly than those of a lower frequency. This can be explained in terms of high frequency words having higher resting activation levels and so require less additional activation for recognition to occur (Morton, 1969). Connectionist models of reading also stress the role of frequency of presentation in creating reliable lexical representations, since their systems rely upon repetition with feedback for reliable associations between orthography and phonology to be made. The connectionist networks are typically trained using many 'epochs' which consist of constant repetition of input to the system. It appears that reliable orthographic representations can only be made by multiple re-presentations of the stimulus. From this it can be seen that it is possible for incorrect lexical entries to arise via exposure to the incorrect form of a word.

At present there is very little research to suggest how many presentations are required to establish a reliable lexical representation, but a study by Stuart, Masterson and Dixon (submitted) has shown that a rather large amount of repetition may be needed, at least in beginning readers. In this experiment, children were taught to read words from books or flashcards and it was found that even those children who were phonologically aware[7], and generally fared better in learning to read, required over 40 presentations in order to be able to read a word reliably. A subsequent experiment by Dixon, Stuart and Masterson (in preparation) showed that even when the children were able to read a word correctly after much repetition, they were unable to reproduce it in a spelling test, showing that the lexical information was not adequate for the more demanding task of spelling the word. The fact that many more presentations of a word are required in order to establish a lexical representation that is useful for spelling rather than reading was also supported by data from Seymour and Elder (1991). Seymour and Elder (1991) collected data from a class of children who had just entered school. They discovered that although the children were able to read each other's names reliably from encountering them on a daily basis at school, they were not able to reliably spell the names until approximately 5 terms later.

A lexical entry could be incorrectly specified if, for example, all previous encounters with the word were incorrectly spelled. If all of the misspellings encountered were consistent, this would result in a single incorrect representation of the word in the lexicon. If, however, a word had been seen misspelled inconsistently then the alternatives could be represented within the lexicon in two different ways. The first of these is that each representation of a

[7] A phonologically aware child is able to recognise and analyse the sound patterns of a spoken word. For example, he/she may be aware that the first sound in the word 'dog' is /d/ and/or that 'dog' sounds like 'log', 'frog', 'hog', 'jog', etc.

word could have a separate lexical entry and these entries would only be strengthened via presentation of an exact replica of the item (that is all the letters in the word match the lexical representation in both identity and order). This would mean that if a word had been seen spelled correctly and misspelled in two different ways, then there would be three separate lexical entries for the word (Ekstrand, Wallace and Underwood, 1966). The alternative is that correct and incorrect representations are stored within the same lexical entry. This would mean that any item that was close enough to the orthographically correct target would act as a reinforcement to the lexical entry, but that conflicting information would be stored within the representation.

Although theories tend to agree that repetition is vital for the creation of lexical entries, they differ as to the type of representations that are instigated. Connectionist models of reading (McClelland and Rumelhart, 1981; Seidenberg and McClelland, 1989) argue that representations are patterns of distributed activity within the brain which are activated in parallel. For example, the word 'stamp' could be represented by the concurrent activation between the wickelfeatures '#st', 'sta', 'tam', 'amp' and 'mp#' (Seidenberg and McClelland, 1989). With constant repetition of the item the pathways between the constituent parts become more distinct/practised and therefore eventually accurate mapping from orthography to phonology can be achieved. Dual route theories propose that orthographic representations are localised, in the sense that there is a site or node where the whole word is stored. When the item is presented, the representation is activated in parallel (meaning that each letter in the word is processed simultaneously, and not sequentially from left to right) and following repeated presentations, the activation level within the representation increases to allow for accurate reading.

To investigate whether lexical representations are local (dual route models) or distributed (single route connectionist models), Coltheart (1995) conducted a priming experiment which used a mixture of real words, pseudohomophones and nonwords (for example *bruise, brooz* and *crooz*, respectively) in a lexical decision task. Each of the word types served as both target and prime throughout the testing procedure, and hence this method allowed for nonwords to be primed as well as real words. The results showed that only real words were facilitated by the prior presentation of a real word or pseudohomophone, nonwords showed no effect of priming (this result was also replicated using the DRC model of reading). This pattern of results implies that the representation of the word is local rather than distributed, since a distributed account would hypothesise that presentation of both a word and a nonword would activate the 'sub-lexical' orthographic features of the item. Therefore, if the sub-lexical orthographic features of a nonword had been activated, a facilitation would be expected upon re-presentation of the same item. Since no facilitation occurred for nonwords, it appears that the priming mechanism relies upon activation of a whole word representation, thus supporting a local representation account.

A slightly different alternative to the traditional dual route model is represented by Morton's logogen model (Morton, 1969; 1979) which was adapted to incorporate spelling production (Morton, 1980). Morton suggested that the same two processes were used as in normal dual route models (i.e. a visual route and a phonological route) but that the orthographic form of a word was stored in a 'logogen'[8] rather than a lexical entry. The visual input logogen has two thresholds that have to be reached in order to send information on further;

[8] A logogen is essentially a word detector that becomes activated when the information collected reaches a threshold.

the first threshold allows information to be sent to the cognitive system and the second threshold sends information to the output logogen system. It was considered possible that evidence collecting at a visual input logogen could be at threshold without all the letters being recognised, so that a word could be identified before all its constituent parts had been processed (unlike connectionist models of reading that rely upon the patterns of activation between the sub-word units to represent the word). The main difference between a logogen and an orthographic lexical entry, however, is that the graphemic output logogen produces a string of letters which are processed serially from left to right whereas lexical entries are considered to be processed in parallel. Also, only letter identity information is considered to be stored in a logogen, whereas it has been argued that lexical representations also contain other types of information such as syllable structure or consonant-vowel status (Link and Caramazza, 1994).

Morton (1980) himself provided evidence against serial processing in orthographic output. He described a young woman (Gail) who had suffered damage to her left temporo-parietal region and had subsequently acquired problems in spelling. Morton described the damage, in terms of his model, as a block between the cognitive system and the graphemic output logogen system, which was sometimes overcome by producing the first letter of the word. When trying to spell a word Gail often produced the initial letter, but sometimes she was also able to produce some other letters from the word even though she was unable to complete it. For example, she wrote 'N   Z   ' for New Zealand, 'Tur   y', for Turkey and 'J p n' for Japan. It can be seen that she was able to access partial letter knowledge leaving gaps in the words where she was unable to recall the letters. It is difficult to explain these results using the notion of a graphemic output logogen since, on that basis, it would be predicted that letters could only be retrieved serially from left-to-right, whereas it appears that Gail was able to 'picture' the word, since she could leave gaps where she knew the letters were, and could recall letters from anywhere within the word. Although from the above examples it could be argued that she was using a phonological code, especially for 'J p n', since children learning to spell also have a tendency to omit vowels and concentrate on the consonants (Read, 1971, 1986; Treiman 1993), she also produced errors such as 'C na' for China. This is interesting because the letter 'c' should not be produced for a 'ch' sound if using a phonological route to spelling. It would appear that these results are very difficult to explain in terms of serial processing of orthographic output and point strongly towards the notion of parallel processing as is hypothesised in other dual route models and the PDP model of reading.

The fact that lexical representations (as compared to logogens) could contain more than just letter identity and order information could be a source of possible confusion in lexical spelling. Link and Caramazza (1994) argue that orthographic representations are multi-dimensional objects that also independently store letter quantity information, consonant-vowel status and graphosyllabic structure. Evidence for this comes from an investigation into the spelling errors of a dysgraphic patient, LB (Caramazza and Miceli, 1989). Caramazza and Miceli found that when LB made errors involving double letters within a word, substitutions almost always involved replacing both of the letters (e.g. 'sorella' - 'soretta') suggesting that information about the number of letters is stored independently from identity of the letter. Evidence that consonant-vowel status is stored comes from the fact that LB's substitution errors always conserved consonant-vowel status and transposition errors only ever occurred between consonants or between vowels, but never between a consonant and a vowel. Finally, Caramazza and Miceli (1989) concluded that graphosyllabic structure was stored because errors all preserved their syllabic structure in terms of number of syllables. For example, LB made errors like writing 'nostro' as 'nosro' but never made errors that changed syllabic structure like writing 'denaro' as 'denro'. Together these spelling errors indicate that lexical entries are more complicated than an abstract representation of the word containing letter identity and order information and that other potentially useful information is abstracted from the word and stored concurrently.

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From the preceding discussion it can be seen that lexical representations are established via reading experience and that the information stored is more complicated than just a simple abstract representation of the letters in the word. One pertinent question to be addressed is whether the lexical representations established via reading processes are the same as those accessed for spelling purposes.

Reading and spelling: One common or two separate lexicons?

Originally Morton's (1969) logogen model of reading postulated a single logogen system that was responsible for both input and output, i.e. reading and spelling. However, a series of experimental studies forced Morton into splitting the single logogen system into separate systems for input and output. One of these experiments was by Clarke and Morton (1983), investigating priming in tachistoscopic recognition of words. Subjects were primed with typed words, handwritten words or definitions of the words, and it was found that the former two conditions had a significant facilitation effect on subsequent word identification, whereas presenting the definition did not. Morton argued that these results necessitate the postulation of two separate logogen systems, since the definition of the word should activate the intended item via the semantic system and since this does not produce subsequent facilitation of the word, the item must have been activated in a separate (output) logogen. However, as Allport and Funnell (1981) have pointed out, this interpretation depends on the assumption that activation produces a long lasting change within the logogen itself. These results could also be explained as a strengthening of the access pathways to the logogen, in which case activation from the cognitive system would not produce facilitation on subsequent input.

Many of the dual route models have also hypothesised two separate orthographic lexicons for input and output, (Coltheart, 1981; Patterson & Shewell, 1987), even though it appears that there has been very little research investigating this notion, and the research that has been done has resulted in no clear answer.

A series of studies by Monsell and Banich (in Monsell, 1987) has resulted in conflicting evidence concerning the notion of single versus dual lexicons. In an experiment where subjects were required to output a lexical item by writing the word blind, no facilitation effect was found for subsequent input using a lexical decision task. If a single lexicon was responsible for both input and output then the representation that was activated for spelling output should facilitate subsequent input and hence the finding of no facilitation appears to support the notion of separate lexicons for reading and spelling. However, a further experiment revealed that if a spelling is generated blind and is then matched to a visually presented definition of that item, facilitation does occur in a subsequent lexical decision task, a finding more consonant with a single lexicon view.

Campbell (1987) reported a study supporting the notion of separate lexicons for reading and spelling. She investigated the consistent misspellings of two undergraduates, RM and JM, who were poor spellers. She found that when they were presented with a list which included their own consistent misspellings with other, experimenter generated misspellings, as well as correctly spelled words, they performed at chance level at identifying whether their own misspellings were correctly spelled or not. However, when they were shown correct versions of the items that they consistently misspell they were able to tell over 90% of the time that they were indeed the correct spellings. Campbell (1987) interpreted these results as evidence for two separate lexicons, since, if output is probabilistic and the correct spelling input is stronger than the misspelling (which in this case is shown by the higher probability of accepting the correct spelling rather than the incorrect one as correct), then, if there were only one lexicon, the correct orthography should be chosen at output. However, these results could also be interpreted in terms of a single orthographic lexicon with separate weightings attached to the input pathways to the representation and output pathways from the representation based upon input and output word frequency.

A number of single case studies of neuropsychological patients have also resulted in data that address the question of separate or common lexicons for reading and spelling. A neuropsychological study by Coltheart and Funnell (1987) investigated a patient, HG, who was a surface dyslexic. Very detailed testing of HG's reading revealed that although he was a surface dyslexic his reading problem was specific to access within the lexicon, rather than any of the pathways connected to the orthographic lexicon (Coltheart and Funnell, 1987). Coltheart and Funnell found that the difficulty in accessing orthographic information in HG's reading was also present in his spelling. They asked HG to read a set of 171 regular homophones twice. From this they constructed two lists: Set A, which consisted of those words HG always read correctly, and Set B, which consisted of those items where at least one error was made in reading. They then asked HG to spell the same sets of words. They found that when word frequency was taken into account, more spelling errors were made for Set B words than for Set A words. Moreover, there was a significant effect of frequency for those words that were not perfectly read, as compared to no effect of frequency for Set A words, showing that more frequently encountered items have a higher probability of being spelled correctly.

The fact that spelling errors were located in the same word set that produced reading problems is consistent with the idea of a single lexicon, in that damaged or inaccessible lexical representations should equally affect reading and spelling. Although these results are not inconsistent with the idea of two lexicons, to explain them it would have to be hypothesised that there was coincidentally identical damage within both the reading and spelling lexicons. Since this is very unlikely, it can be considered that these data provide evidence of a single orthographic lexicon which subserves both reading and spelling.

A study by Behrmann and Bub (1992) also provides evidence supporting a single lexicon view of reading and spelling. They investigated the reading and spelling abilities of a patient, MP, who was a surface dyslexic with a severe semantic deficit in auditory and written language comprehension. Behrmann and Bub discovered that MP was better at reading and spelling regular words than irregular words, but also that irregular word performance decreased as a function of word frequency, within both reading and spelling. Following an investigation into the relative performance of free report of constituent letters within words and pseudowords, they concluded that the deficit in spelling low frequency irregular words was due to a difficulty in activating the lexical representation. To investigate the issue of separate or common lexicons for reading and spelling, Behrmann and Bub investigated the item-specific consistency of reading and spelling performance. Highly consistent accuracy on reading and spelling of individual items would provide evidence for a single lexicon view, since a dual lexicon view would be forced to interpret this consistency as a coincidence. It was discovered that the consistency between reading and spelling performance on individual items was quite high even when variables that are generally considered to affect lexical performance (for example, word frequency) were partialled out. Behrmann and Bub therefore argued that these results are more consistent with the notion of a single lexicon for reading and spelling. However, Weekes and Coltheart (1996) question the idea that Behrmann and Bub's data support a single lexicon view, since they argue that consistency across spelling and reading tests was always lower than consistency within reading tests or within spelling tests.

Neuropsychological evidence supporting a two lexicon view of reading and spelling comes from a study of a patient, NW, who appeared to be a surface dyslexic and a surface dysgraphic (Weekes and Coltheart, 1996). An intervention study on NW's reading was implemented by pairing the word to be learned with a picture which was considered to be a mnemonic aid. This technique was assumed to improve the orthographic system for recognising words (Byng and Coltheart, 1986). The results of this intervention significantly improved reading ability but there was no parallel increase found in spelling ability. Weekes and Coltheart (1996) suggest that this provides evidence against a single lexicon view since, if orthographic ability is increased following the teaching programme, this should also generalise to spelling ability. In a further study Weekes and Coltheart (1996), adopting the approach of Behrmann and Bub (1992), investigated item-specific consistency of reading and spelling although they also included an investigation of possible confounding effects of imageability and word length as well as word frequency. They discovered that the item consistency found between reading and spelling sometimes disappeared when the confounding variables are taken into account. Although the data are unequivocal, they strongly suggest that a dual lexicon view of reading and spelling is more consonant with their findings than a single lexicon.

However, Weekes and Coltheart's (1996) first assertion, that improvement of orthographic reading ability should extend to spelling ability, presupposes the notion that reading and spelling processes are qualitatively similar and that each process exerts a similar effect on the underlying lexical representation. Reading and spelling processes are not similar, however, because a simple matching procedure can be used in order to read a word even if the lexical representation is not complete. Conversely, spelling requires fully specified lexical information in order to produce an accurate orthography of the item. The effect that spelling and reading processes have on underlying lexical representations has also been found to be different in a study by Funnell (1992).

Funnell tested a boy (Thomas), who was considered to be both a good reader and a good speller. She found that, of those words that he was able to spell correctly, he was 100% accurate at correctly identifying correct spellings and 64% accurate at correctly identifying misspellings. However, for those words that he was unable to spell, he was 100% accurate at identifying correct spellings and 0% accurate for identifying the misspellings. Funnell argues that identifying a correct spelling relies on the fact that a word is stored in the lexicon (i.e. it has been seen before) whereas in order to be able to recognise a misspelling the person needs complete letter and order information (as is required in order to spell the word correctly). She investigated this further by looking at the effects of word frequency. If judging whether a word is correctly spelled requires matching the stimulus word to its lexical entry, then familiar words (or highly frequent words) should be judged as correctly spelled more often than less familiar words. Also, misspellings that resemble the lexical entry should be accepted as correct spellings more often for less familiar items. Funnell found support for these hypotheses and suggested that "judgements about correct and incorrect spellings of words that the subject cannot spell are influenced by previous experience with reading the words" (p 95).

Further evidence that reading and spelling exert differential effects upon underlying lexical representations, comes from a study of Helen, a poor reader and a poor speller (Funnell, 1992). Helen was taught to read five words that she had previously been unable to read and to spell five words that she had been unable to spell. A week later she was given a sorting test of correct spellings and misspellings for the ten words and distinct differences were found in the two training conditions. The correct spellings were identified on 80% of occasions as being correct regardless of training condition. However for the misspelled items, the words that had been in the spelling training condition were recognised as incorrect on 14 out of the 15 occasions whereas those in the read training condition were recognised on less than half of the occasions. Funnell (1992) claims that since precise information is required for both spelling and detecting misspellings in a way that is not required for reading, the teaching of spelling contributes to an accurate lexical representation which can be utilised to detect misspellings. This study clearly shows that not only is lexical output information stored and utilised for subsequent reading, but also that spelling information may carry more representational weight in the lexicon, since it is precisely specified in a way that lexical information gained from reading does not appear to be. The results of this study, therefore, counter the claims of Weekes and Coltheart (1996) that improving orthographic knowledge through a reading programme must improve orthographic knowledge in spelling.

To summarise, although the notion of separate lexicons for reading and spelling has sometimes been proposed within the literature, it can be seen that there is no clear evidence to support it. In addition, a dual lexicon theory has the added difficulty of how representations in the output lexicon are created. Either the information is passed from an input lexicon in some way, in which case the theoretical assumptions would be similar to those of a single lexicon theory, or the information is created by output attempts using phonological, morphological and semantic knowledge. In the latter case, since it has been argued (Weekes and Coltheart, 1996) that improving orthographic knowledge through reading programmes would have no effect on spelling, if there are separate input and output lexicons, it appears that reading experiences cannot affect spelling experiences. This means that an incorrect output representation cannot be altered to achieve the correct spelling via visual feedback from the input lexicon.

Since there is very little evidence supporting a dual lexicon account and also that the issue of transfer between input and output lexicons is not specified, it is perhaps more reasonable and parsimonious to assume that reading experiences can influence spelling output via a single orthographic store which subserves both reading and spelling processes.

Chapter Four

The Stability of Lexical Representations

The previous chapter investigated how lexical representations are created and strengthened, and whether it is possible to store imprecise or incorrect lexical information. This chapter follows on from this by investigating the stability of an existing lexical representation. It is usually considered that the lexical representation is quite stable and that fresh incoming information will have little effect upon a well established representation. However, there is some evidence to suggest that lexical representations are not particularly stable.

A study in 1929 by Pintner, Rinsland and Zubin showed that presenting a misspelling to a subject could damage their ability to spell that same word. The study was conducted within an educational context and consisted of a comparison of two different recognition spelling tests. It appeared that subjects were much worse at recognising a correct spelling when it was placed with four alternative (and incorrect) orthographies of the same word than when it was placed in the context of four different real words, even though the subjects could spell the target words correctly on a subsequent dictated spelling test. This seemed to suggest that the presence of incorrectly spelled items at test had a destabilising effect upon the lexical representation for that item and therefore produced a detrimental effect on people's ability to identify the correct spelling.

A finding from a study by Nisbet (1939) also provided anecdotal evidence that presenting an incorrect spelling could affect lexical representations. In this study, children were tested using a range of spelling tests. One of the tests used was the 'Wrongly-Spelt Word' test. This consisted of presenting a child with a sentence in which a misspelled word appeared, as for example, 'The Romans came to (conker) Britain', which they were subsequently asked to spell correctly. Nisbet found that this test elicited far more errors than normal dictated spelling tests, or multiple-choice spelling tests. Children misspelled 9% of the words that they had been able to spell correctly prior to the testing procedure and over half of these misspellings were the same version as those shown in the 'Wrongly-Spelt Word' test. Nisbet (1939) suggested that this effect may be due to the 'disturbing influence' of the misspelling. He also stated that "It may happen, moreover (although I do not stress this) that these wrong spellings affect the child's spelling after the test is over" (p. 40).

Both of the aformentioned studies provide some evidence to suggest that the presentation of a misspelling at the time of testing has a disturbing effect on the lexical representation, resulting in a debilitating effect on spelling accuracy. However, these results occurred as incidental findings rather than being the main focus of the studies. Recently, there have been two studies focusing on the stability of lexical representations through the presentation of incorrect orthographies: a study by Brown (1988) and one by Jacoby and Hollingshead (1990), who provided converging evidence for the lability of lexical representations in spelling from a different perspective. Since the stability of lexical representations is a central focus of the thesis, these two studies will be explained in some detail, followed by a discussion of the possible mechanisms underlying the processes.

The first explicit investigation of the effect of presenting a misspelling was performed by Brown in 1988 using a series of experiments. In the first experiment, Brown gave subjects two dictated spelling tests, one at the beginning of the session and one at the end. In between these tests subjects were asked to generate two misspellings for half of the words in the original list. (The subjects were divided into two groups so that the words could be counterbalanced between subjects). Brown was interested in the number of correct to incorrect (CI) switches between initial and final test; that is, in the number of items that were spelled correctly in the initial dictated spelling test but were subsequently misspelled in the final spelling test. He found that for those items where the interpolated task involved generation of misspellings, 17.8% switched from correct to incorrect spellings, as opposed to 7.8% of those items where no interpolated task was given. From this he concluded that generating misspellings of a word significantly increases the likelihood of switching from correct to incorrect spellings of that word and, since this effect was limited to the target items, that the intervening task did not produce generalised disruptive effects on spelling ability, but was probably located within the lexical representation.

In a second experiment, Brown investigated the effect of passive exposure to misspellings as opposed to the more active task, in the first experiment, of generating the misspellings. He also compared performance on a final dictated spelling test with a final recognition spelling test, in which subjects were asked to choose the correct option from five alternative spellings of a word. He found two significant main effects: passive exposure to misspellings between the two spelling tests led to an increase in CI switches, just as active generation had done in the previous experiment; and a final recognition test led to significantly more CI switches than a dictated spelling test.

In his final experiment, Brown (1988) extended Experiment 2 to incorporate a variety of different exposures to the misspelled word. In one condition, subjects were shown no misspelled versions of the target words. In another condition, a single exposure to a misspelling was given. Other conditions involved showing either three repetitions of the same misspelling or one exposure to three different misspellings of the same word. When subjects were shown the misspellings they were also asked to rate them on how close to the real spelling they judged them to be, using a five point scale, where 1 represented 'almost identical' and 5 represented 'very different'. The results from this experiment did not replicate those of Experiments 1 and 2 since, although recognition testing still revealed more CI switches than dictation, there was no significant effect of type of exposure. Brown (1988) argues that the expected trend was evident and the reason it failed to reach significance may have been due to the reduced number of items (due to a within-subjects manipulation of materials there were only six items in each condition). However, there *was* further evidence of the detrimental effect of a misspelling, from the analysis of the ratings. For those items that were spelled incorrectly and repeated three times there was a significant drop in ratings (from 2.31 to 2.13 to 2.04) as opposed to those items where three different misspellings were presented (2.28 to 2.33 to 2.21). These results suggest that repeated exposure of a particular misspelling makes it appear more like the correct spelling.

From this series of experiments Brown concluded that both reading and generating misspellings has a detrimental effect on the spelling of those particular targeted items, as does exposure to a misspelling, either at test (in the recognition test condition) or at times between tests (in the interpolated task). These results support the incidental findings of Nisbet (1939) and Pintner *et al.* (1929). Brown (1988) argued that the detrimental effect of exposure to a single misspelling supports the view that there are multiple representations of some words within the lexicon. Thus for words that are difficult to spell, there may be a pre-existing orthographically incorrect lexical representation which becomes stronger upon each encounter with the misspelling. The detrimental effect of presenting a misspelling, therefore, is derived from the increased lexical competition between the correctly spelled and the incorrectly spelled representation. It is clear, however, that he restricts the notion of multiple representations within the lexicon to "those words that are of moderate difficulty or are moderately confusing" (p 492). It does not extend to all words. The prediction is that presumably words which have never been seen incorrectly spelled would not suffer from being exposed in incorrect form as much as more difficult words. (This notion is explored in more detail in Chapter 8)

In 1990, Jacoby and Hollingshead also investigated the detrimental effect of exposure to misspellings on subsequent spelling performance. They conducted two experiments that not only investigated the effect of exposure to misspellings, but also examined the effect of exposure to correct spellings. In the first experiment they presented 40 words exposing them one at a time on a computer screen: half of these were spelled correctly and half spelled incorrectly. 'Training' condition was varied by asking the subjects either to read the words aloud or to read them aloud and then reproduce them, after they had been removed from the screen, by typing or by printing by hand. At the test phase spelling accuracy and spelling times for 60 words, the original 40 words and a further 20 that were new to the experimental situation, were recorded using a dictated spelling test. Finally, as a test of recognition memory, subjects were asked to go over their written responses and circle those words they thought they had seen earlier in the presentation phase of the experiment. Jacoby and Holllingshead (1990) found that, relative to performance on new, previously unexposed words, (in effect a baseline measure of spelling proficiency), the probability of a word being spelled correctly at test was raised for those words previously seen correctly spelled, and lowered for words which had been exposed incorrectly spelled. They found no effect of training condition (read vs. print vs. type) on spelling accuracy and no interaction between training condition and prior presentation, showing that passive exposure to a misspelling was as effective as active copying in affecting spelling accuracy.

The effects of training, however, exerted an influence on recognition test performance, demonstrating an improvement with an increase in degree of elaborative processing (Mandler, Graf and Kraft, 1986) at exposure, from reading, through copying by hand, to typing. Thus a clear dissociation was demonstrated between the orthographic exposure effect and recognition memory with respect to type of processing at encoding. Jacoby and Hollingshead (1990) argued that since recognition memory is explicit, this dissociation, typical of dissociations between explicit and implicit memory (Jacoby and Dallas, 1981; Graf and Schacter, 1985; Roediger and Blaxton, 1987), suggests that the priming of spelling performance by exposure to different spellings is an implicit process.

The difference between reproducing a spelling while it is still exposed on a computer screen, versus reproducing it after a ten second period was investigated in a further experiment (Jacoby and Hollingshead, 1990). A strong detrimental effect on subsequent spelling performance was again found following presentation of an incorrectly spelled item, and a facilitatory effect was found following presentation of a correctly spelled item, compared to words that were new at test. This effect will henceforth be referred to as the *orthographic exposure effect.* The training manipulation, however, did not affect subsequent spelling accuracy, although there was an effect on recognition memory, with the 10 second delay condition producing significantly higher hit rates than the immediate condition.

In both experiments the factors that affected recognition memory (active versus passive encoding) did not influence the detrimental effect of exposure to a misspelling or the beneficial effect of exposure to a correct spelling, indicating a functional dissociation between recognition memory and the orthographic exposure effect. Since it is acknowledged that recognition involves explicit processing, it seems that the orthographic exposure effect is not based on an explicit, but rather on an implicit, process.

The preceding discussion of the two major studies investigating the effect of presenting orthographies on subsequent spelling ability, has demonstrated quite clearly that there is a detrimental effect of presenting a misspelling and a facilitatory effect of presenting a correct spelling on subsequent spelling accuracy. It appears that the factors mediating this process are not explicitly controlled since they have shown to be independent from the effect of recognition memory. The following section discusses possible mechanisms underlying the orthographic exposure effect.

Cognitive processes mediating the Orthographic Exposure Effect

The dissociation between the orthographic exposure effect and explicit memory discovered in Jacoby and Hollingshead's study mirrors that found between explicit memory tests and repetition priming. Repetition priming occurs when the processing of an item is facilitated by a previous encounter with the same item. This is similar to the effect of presenting a correct spelling in Jacoby and Hollingshead's experiments. Repetition has been found to facilitate lexical decision time (Scarborough, Gerard and Cortese, 1979), naming latency (Scarborough et al., 1977), accuracy of perceptual identification (Jacoby and Dallas, 1981), as well as syntactic and semantic classification times (Monsell, 1985).

Repetition priming, generally speaking, relies upon the notion that some form of representation is stored between the initial experimental encounter with an item and the subsequent encounter. This representation may be created on the first experimental encounter or could reinforce an already existing representation. There has been much debate about the processes underlying the repetition effect.

The first theory, proposed by Jacoby (1983), concerns an episodic account of repetition priming. According to the episodic retrieval account, each encounter with a word sets up a new context-specific memory trace. Episodic memory is a memory system holding a record of autobiographical, personally-experienced events, in contrast to semantic memory, which contains more general factual knowledge without contextual or historic detail (Tulving, 1983). Hence not only is the item stored at presentation, but so also is the whole context around initial presentation of the item: for example, where it occurred, how the subject was feeling, how the item was presented and so on. The episodic account of priming therefore makes the prediction that the closer the conditions at test are to those employed at study, the stronger the priming effect will be. This is because the better the match between the processing episode and conditions at study, the stronger the retrieval cues will be.

The above account has been the basis of 'transfer-appropriate processing' theory of memory (Roediger and Blaxton, 1987). Roediger and Blaxton argue that the type of overlap that is important, at study and at test, is the processing that the subject is asked to do. There is some support for this account of repetition priming, since cross-modal priming (different conditions at study and test) has been shown to be lower than priming within a particular domain (for example, inverted and normal text - Kolers, 1975; pictures and words - Winnick and Daniel, 1970; auditory and visual presentation - Roediger and Blaxton, 1987). However it should also be noted that Scarborough, Cortese and Scarborough (1977) and Morton (1979) found no diminished effect of cross-modal priming while investigating the role of variation in typeface or case of words between study and test.

The alternative account of repetition priming initially stemmed from Morton's (1969, 1979) logogen model (see Chapter 3 for a more detailed consideration). In this account, repetition priming is seen as a long-lasting change within the threshold level of the logogen. This can be adapted for alternative views of the reading process, so that a dual route theorist would argue that the long-lasting change occurs within the lexical representation and connectionists would argue that the change occurs within the pattern of weights between the orthographic sublexical units. To encompass all of these possibilities the term ‘item-specific priming’ (Dean and Young, 1996) will be used. This essentially means that priming occurs by activation of the particular item in question and should therefore not be sensitive to the context in which the item was first encountered. This view has recently been adopted by Tulving and Schachter's (1990) notion of a pre-semantic representation system (PRS). The PRS also predicts reduced cross-modal priming since there are separate sub-systems hypothesised for different representations (e.g. visual and auditory presentations utilise different sub-systems). However context changes that occur within a sub-system should not reduce repetition priming.

A series of experiments performed by Dean and Young (1996) investigated whether episodic or item-specific accounts were more accurate at explaining the findings of repetition priming experiments. Their basic method was to ask subjects to make same-different judgements about picture and word combinations. For example, the presentation of a picture of a ball and the word 'shoe' should produce a 'Different' response from the subject. Pairs were then either re-presented at test in the same pairing or were recombined with other items. If episodic traces were responsible for repetition priming, priming should be reduced or absent when the pairs presented at test were recombined, a situation which would represent different contexts at study and at test. Dean and Young found no evidence to suggest a reduction in cross-modal priming and argued that their results are largely consistent with an item-specific account of repetition priming.

Monsell (1991), however, argues that although item-specific accounts explain longer term priming, episodic traces may play an important part in priming at shorter time spans: within two or three minutes after the initial presentation. The repetition effect has been found to be quite pronounced over short time spans after which it decreases rapidly leaving a smaller but longer-lasting facilitatory effect (Humphreys, Besner and Quinlan, 1988; Ratcliff, Hockley and McKoon, 1985). Monsell (1985) has argued that this sharp decrease in priming could represent a qualitative change in priming, reflecting the influence of episodic traces over short time spans (almost immediate testing) and the influence of item-specific activation over longer time spans.

There has been some support in the literature for the view that long term priming occurs within the lexical representation. Monsell (1985, 1987) discovered that while priming of a word was relatively long-lasting and stable, there were no comparable effects of priming of nonwords. Nonwords either tended to show no priming at all, or a very short-lived effect of priming. Monsell argues that this reflects the lack of lexical status of nonwords which prevents or reduces item-specific priming.

The framework of knowledge surrounding repetition priming might be a useful tool to investigate further the orthographic exposure effect. However, there is a fundamental difference between the processes that is worthy of note: repetition priming reinstates the processes that were used in the study procedure whereas the orthographic exposure effect does not. For example, in repetition priming, an item presented visually at study is then re-presented visually at test (albeit for a fraction of a second in the case of tachistoscopic exposure). It is therefore very difficult to tell whether item-specific priming is due to alteration within the lexical representation or whether it is a strengthening of the input pathway to the lexical item. The orthographic exposure effect, however, involves visual presentation in the study phase, followed by auditory presentation and visually guided output in the test phase. The only site that is accessed in both the study and test conditions therefore, is within the lexical representation itself. If the orthographic exposure effect is found to possess very similar properties to repetition priming, then item-specific priming must represent a change within the lexical representation. A finding of this type would also suggest that the same lexical exemplar must underlie both input and output processes, thus supporting a single orthographic lexicon theory (See Chapter 3).

Investigation into the orthographic exposure effect could therefore yield potentially interesting results concerning the notion of separate lexicons for input and output, whether correct and incorrect orthographies of a word are stored together or separately, and what processes could mediate the effect. In order to compare the orthographic exposure effect with item-specific priming it would be important to investigate the longevity of the effect, as well as whether the effect is confined to a re-instatement at test of the initial exposure context. The experimental work in the following two chapters was aimed at these questions.

PART II

EXPERIMENTAL STUDIES

CHAPTER FIVE

VARIABLES INFLUENCING THE ORTHOGRAPHIC EXPOSURE EFFECT

Experiment 1

Time, Spelling Proficiency and the Orthographic Exposure Effect.

Introduction

This study pursued several aims. First, it sought to establish the orthographic exposure effect as a reliable phenomenon by attempting to replicate the essential findings of Jacoby and Hollingshead (1990), outlined in the preceding chapter. Second, it sought to examine the generality of the effect by exploring it as a function of proficiency of speller. Third, it sought to explore the longevity of the effect.

The experimental approach followed the essential elements of the Jacoby and Hollingshead study, and consisted of asking subjects to read a number of correctly and incorrectly spelled words, followed by a dictated spelling test consisting of the exposed words and a number of new words not used during the exposure phase. The prediction was that spelling accuracy for correctly and incorrectly exposed words would be raised and lowered, respectively, relative to performance on new words. To meet the second and third aims of the experiment, two other variables were included: Spelling proficiency of subject (good vs. poor), and a time factor between item exposure and test (immediate vs. delayed).

Spelling proficiency was included in this experiment for several reasons. First, it would serve as a test of the generalisability of the orthographic exposure effect . If the effect were found in both good and poor adult spellers, the results of this experiment could be generalised across the adult population. The investigation of good and poor spellers might also serve to highlight whether the effect found by Jacoby and Hollingshead was caused by just one particular group of spellers. For example, it could be that poor spellers are unable to process the detailed visual input effectively and hence are not affected by the presentation of an orthography. The effect would therefore be carried by the good spellers in the subject sample.

Second, this experiment could address the recent research investigating the differences in reading strategies underlying good and poor spellers. Frith (1980, 1985) investigated spelling abilities in relation to reading abilities and identified three main groups of spellers. Type A were children who were both good at spelling and good at reading. Type B consisted of those who were good at reading but poor at spelling. Type C were those who were poor at both reading and spelling. Frith's interest was mainly in Type B spellers, that is, in the question of why a person who can read and recognise a sequence of letters is unable to reproduce them. Frith noticed that Type B spellers produced a much larger percentage of phonetically plausible misspellings than Type C. She also found that Type B spellers were much worse at reading than Type A spellers, when the reading task required translation from print to sound, for example, when reading aloud or reading nonwords. She hypothesised that the reason for the discrepancy between reading and spelling ability in Type B individuals was due to their use of a partial cue, rather than a full cue, strategy for reading. A full cue strategy entails a full analysis of the word on a letter by letter level. Partial cue reading, however, does not fully analyse all the letters, so reading occurs through the use of clues, such as context, length of a word or beginning letter.

According to the partial cue theory, Type B spellers should find it more difficult to detect misspellings than Type A spellers. Frith (1980) investigated the children's ability to detect misspellings and found that although if the misspelling was phonologically implausible Type A and Type B spellers performed at a similar level, if the misspelling was phonetically plausible then Type B spellers were indeed worse at detecting them.

In the present experiment, the poor spellers are most likely to belong to Type B, since they are all undergraduates and, as such, are likely to be good readers. Since all the misspellings in this experiment are also phonetically plausible, it follows that the poor spellers should find it more difficult to detect a misspelling than the good spellers. If poor spellers are worse at detecting misspellings because the full information from the word is not processed before the lexical entry is accessed, then presentation of a phonetically plausible misspelling should exert little or no influence on their subsequent spelling performance. Good spellers who process the entire word, however, *are* likely to be affected by presentation of an item. Frith (1980) indeed states that "good spellers can easily be made uncertain about the correct spelling of a word that they know well. Simply, frequent exposure to an incorrect version can make a good speller waver" (p.511).

Holmes and Ng (1993) have questioned whether Frith's partial cue hypothesis is relevant to adult poor spellers who are clearly skilled in reading. Holmes and

Ng (1993) found differences in reading between good and poor adult spellers. They discovered that poor spellers were worse than good spellers at reading low frequency, long words. A lexical decision task revealed that poor spellers took longer than good ones to classify long words with regular spellings as real words and they classified words with idiosyncratic spellings more slowly and less accurately than good spellers. Finally, poor spellers frequently mistook words that were medially distorted (for example, letter reversals occurring in the middle of a word) for the correct versions. Holmes and Ng therefore argue that poor spellers place particular importance on the beginnings and endings of long words and fail to process the order of the middle letters accurately.

Holmes (1994) also studied the performance of good and poor spellers over a number of different tasks. Poor spellers were found to misclassify words in a lexical decision task more often than good spellers, especially if those words were either ambiguous or irregular in their orthography. Poor spellers were also more likely to misclassify nonwords that contained a word or word part, and nonwords formed by transposition of two medial letters in real words. In addition, poor spellers demonstrated more difficulty in classifying real words in a lexical decision task if medial letters were transposed than if they were substituted for different letters. Holmes argued on the basis of these findings that poor spellers are slower at organising individual letter units into higher level orthographic units and that the criteria they use to check a word are not sufficiently rigorous. The fact that individual letter units are identified by poor spellers has led Holmes to suggest that poor spellers are less accurate at processing this information at a higher level. This inability to process orthographic information at a higher level than individual letters has been called a partial checking procedure. Partial checking differs from a partial cue strategy since a user of a partial cue strategy does not necessarily process all the letters in a word. Holmes suggests that two aspects of higher level processes may be involved. The first is that poor spellers might be slower at imposing a structural organisation onto the basic letter information. The second process concerns the criteria used to check a word's orthography with its lexical representation. Holmes suggests that poor spellers are much more likely to accept a word with medially misordered letters to be a word in a lexical decision task due to a less stringent orthographic checking procedure than that of good spellers.

It could therefore be argued that if poor spellers do use a partial checking procedure rather than partial cue reading, then misspellings that are presented but not detected could exert an influence over subsequent spelling. This is because, in partial checking, full information reaches the lexical representation but it is then not processed fully. It is therefore possible that the orthographic exposure effect only relies upon the letter information reaching the lexical representation rather than the higher order information resulting from processing of the letters.

Recently, Burt and Butterworth (1996) conducted a series of experiments investigating functional differences between good and poor spellers. They found that good spellers were better than poor spellers at discriminating between orthographically similar words that are semantically and syntactically acceptable in the same sentence (e.g. 'Even with binoculars they couldn't see the two DISCREET / DISCRETE figures near the hibiscus shrubs in the park'). However, it was found that the advantage of good spellers over poor spellers for letter discrimination did not extend to words that did not differ semantically (e.g. Catherine/Katharine). Burt and Butterworth concluded that good and poor spellers are able to use qualitatively similar processing strategies, but that poor spellers have difficulty in the *acquisition* of word spellings, that is, lexical representations, due to inadequate phonological, orthographical and morphophonemic skills.

Burt and Butterworth (1996) conducted a further experiment to test the notion that good and poor spellers differ in their ability to acquire lexical representations. In this experiment, subjects were asked to recall nonword spellings. Three sets of nonwords differing in transparency of orthography were chosen: high transparency (e.g. 'distangle'), medium (e.g. 'dispeign') and low (e.g. 'dysthoegm'). Words were shown in blocks of 12 and the subjects were shown each word once. At the end of each block, subjects had to wait for one minute and then recall the nonwords in order (so as to minimise any recency effect). Burt and Butterworth found that good spellers outperformed the poor spellers on all types of nonwords, but especially those with medium and low transparency. It therefore appears that good spellers are better able to encode and retain complete information following a single exposure than poor spellers. This could mean that the presentation of a misspelling in the present study would have more of an impact for good spellers than for poor spellers, simply by virtue of the good spellers being more able to store the new information for subsequent retrieval.

It can therefore be seen that the recent literature on good and poor spellers leads to the hypothesis that good spellers should be more affected by the presentation of an orthography than poor spellers, either because poor spellers only access partial information (Frith, 1980, 1985) or because they have more difficulty in storing the presented item due to inefficient phonological skills (Burt and Butterworth, 1986). However, if the orthographic exposure effect relies only upon full letter information accessing the lexical representation, Holmes and Ng (1993) would argue that good and poor spellers could be equally affected.

The second variable included in this experiment serves to investigate the longevity of the effect of orthographic exposure. Previous research investigating the effect of presenting orthographies (Brown, 1988; Jacoby and Hollingshead, 1990) has involved the testing of spelling immediately following the presentation phase. In the present experiment testing was performed either immediately after presentation of the items or after a delay of a week.

The longevity of the orthographic exposure effect is an important consideration for both practical and theoretical reasons. At a theoretical level, the findings of this experiment could possibly distinguish between item-specific and episodic accounts of priming (see Chapter 2). Jacoby and Hollingshead (1990) suggested that the orthographic exposure effect was due to a perceptual priming mechanism. The finding of a long lasting effect would support an item-specific account of priming, rather than an episodic account of priming, since episodic information has been found to decay very quickly (Humphreys, Besner and Quinlan, 1988; Ratcliff, Hockley and McKoon, 1985). The finding of a significant orthographic exposure effect over the time-lag of a week would therefore imply that the presentation of the orthography had caused a long-term alteration within the lexical representation. On a practical note, if the effect of exposure to a misspelling lasts for a long time, then questions concerning the wisdom of presenting misspellings in advertising need to be raised.

In addition, the dimension of delay between presentation and test potentially provides a more probing test of individual differences. It is possible, for example, that good and poor spellers perform equally on immediate testing, but that the good spellers retain the effect of exposure to orthography over time whereas poor spellers quickly resort back to their original spelling.

Method

Design

A 2 x 2 x 3 design was implemented, where spelling proficiency (good vs. poor spellers) and time of testing (immediate vs. delayed) were manipulated between-subjects, and orthographic accuracy at study (incorrect vs. correct vs. new) was manipulated within-subjects. Spelling proficiency was measured using an advanced spelling screen, consisting of 38 words picked from 'The Awful Spellers Dictionary' (Krevisky and Linfield, 1990) on the basis of being difficult to spell for educated adults. This test was piloted on 372 undergraduates and produced scores ranging from 1 to 38. The mean of the scores was 19.43 (standard deviation = 7.09), the median was 19 and the mode was 20. The fact that the three measures of central tendency are very similar suggests that the scores are normally distributed. (A graph showing the frequency distribution can be seen in Appendix A.)

This spelling screen was administered to all the subjects who participated in this experiment. Subjects were divided into two groups about the median; those who scored above 50% on the spelling screen were assigned to the 'good spellers' group and those who scored 50% or below were assigned to the 'poor spellers' group. The mean score for the poor spellers was 41.5% correct (standard deviation = 12.4) and the mean score for the good spellers was 70.54% correct (standard deviation = 9.3). These scores were found to be highly significantly different when tested using an independent t test (t_{46} = 9.32, $p < 0.0005$). This procedure resulted in two equal sized groups of subjects.

To investigate the orthographic exposure effect, subjects were presented with 40 words; half of these words were spelled correctly and the other half were spelled incorrectly. The words were typed in lower case letters onto individual cards and were shuffled to randomise presentation order for each subject. Following presentation, subjects were asked to participate in a dictated spelling test consisting of 60 words of which 20 had been seen spelled correctly (Correct), 20 had been seen spelled incorrectly (Incorrect) and the remaining 20 were new to the experimental situation (New). The items were counterbalanced between subjects using a full Latin square design, requiring six subjects to complete.

Time of testing was operationalised by randomly assigning half of each group of subjects to the immediate testing condition and half to the delayed condition, where they were tested one week after the initial exposure.

Subjects

A total of 48 subjects participated in this experiment; 24 were assigned to the 'good spellers' group and 24 to the 'poor spellers' group on the basis of their performance on a spelling screen. Half of each of the two groups of subjects were randomly assigned to the immediate testing condition and the remaining subjects were assigned to the delayed testing condition. All subjects were undergraduates studying at City University, London and were paid for their participation. All subjects spoke English as their first language and they were all tested on an individual basis.

Materials for Spelling Exposure and Post exposure test

A set of 60 words were selected for this experiment, on the basis that they were all generally considered to be difficult to spell as evidenced by the fact that they were listed in 'The Awful Spellers Dictionary' (Krevisky & Linfield, 1988). For each word chosen, a plausible misspelling was produced, either by substituting a letter (for example, independent - independant), removing a silent letter (for example, rhythm - rythm) or reversing double and single letters in a word (for example, broccoli - brocolli). Every misspelling created for this experiment was carefully chosen so that it preserved the phonology of the original item. For example, the word ‘nauseous’ was changed to ‘nausious’, a substitution error which yielded an identical phonology. Under no circumstances was a substitution made where a slight change in phonology would result, for example ‘naiseous’. (A full list of the correct and incorrect versions of the stimulus items can be found in Appendix B.)

The stimulus items were divided into three different sub-sets which were, as far as possible, matched for length and frequency. For the presentation phase words were typed in lower case onto individual cards. Each sub-set served in rotation as Correct, Incorrect and New words for testing purposes, so that no subject saw a correct and an incorrect version of the same word.

Procedure

Advanced Spelling screen

Spelling proficiency was measured by a dictated spelling test of 38 words. Subjects were encouraged to work at their own pace since the emphasis was on accuracy, rather than speed, of spelling. They were told that they were allowed to alter their spellings as much as they required whilst writing the word, but as soon as the next item was presented they were not allowed to alter previous spellings.

Presentation phase

Subjects were then exposed to correctly and incorrectly spelled words in a random order. Each word was typed onto a card and the experimenter presented the cards at a rate of one item every three seconds. Subjects were instructed to read each word aloud and to tell the experimenter if they noticed an incorrectly spelled item. During this stage subjects were corrected if they made an error on reading aloud, to make sure that the intended target word had been accessed.

Post-exposure dictated spelling test

The final part of the experiment, which for half the subjects took place immediately and for the other half after one week, consisted of a further dictated spelling test of 60 words; 20 which had been exposed correctly spelled, 20 incorrectly spelled and 20 were new. The testing procedure for the final spelling test was the same as for the initial one.

Following the post-exposure spelling test, all the subjects were handed a list of the words used in the experiment in their correctly spelled form. The aim of the experiment was explained to the subjects and they were advised to read through the correct spellings in order to counteract the effect of presentation to a misspelling.

Results

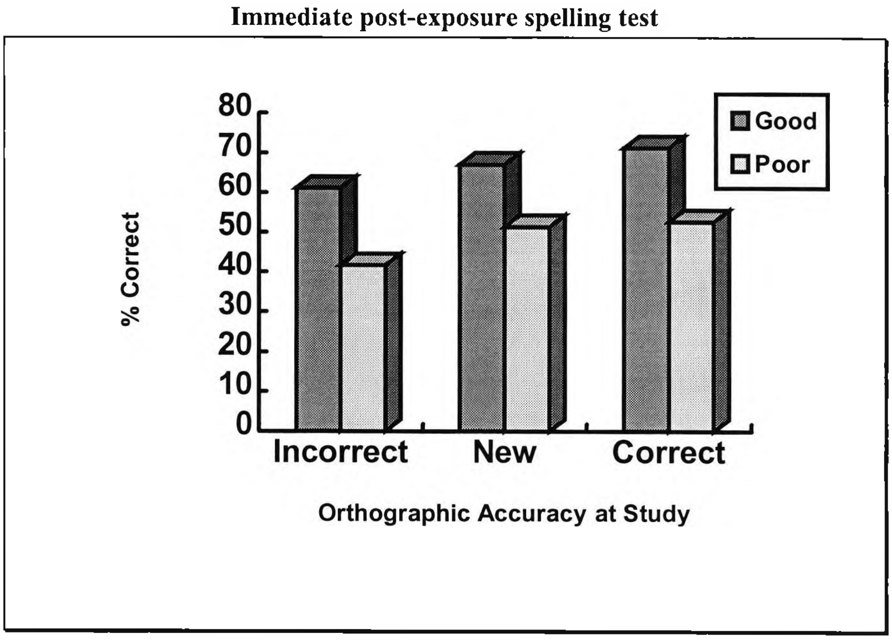
Results in the final dictated spelling test were scored for accuracy. At this stage no distinction was made between a spelling mistake that was a pure repetition of the earlier presented word and any other mistake. Any words that were misperceived in the spelling test were omitted from the analysis. Percentages of correct spelling for each condition can be seen in Table 5.1 below (and in Appendix C).

Table 5.1 Means (and standard deviations in parentheses) of percentage of correct spellings at final spelling test.

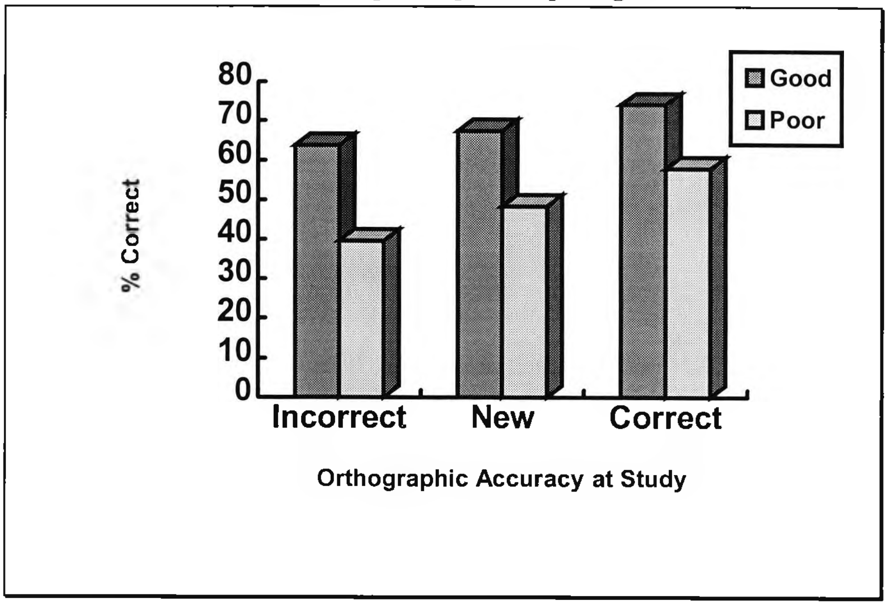
	Orthographic Accuracy at Study			
Immediate	**Incorrect**	**New**	**Correct**	**Mean**
Good	**61.08** (13.19)	**67.08** (11.96)	**71.25** (9.08)	**65.92** (11.55)
Poor	**41.67** (10.52)	**51.25** (12.99)	**52.50** (13.23)	**48.47** (12.92)
Delay				
Good	**63.75** (11.31)	**67.41** (15.95)	**74.17** (17.56)	**67.69** (16.49)
Poor	**39.58** (12.52)	**48.33** (14.82)	**57.92** (16.58)	**48.61** (16.19)
Mean	**51.52** (16.00)	**57.89** (16.53)	**64.02** (16.85)	

An inspection of the means of Table 5.1 reveals that the percentage for correct spelling was lowest for those words that had been seen spelled incorrectly and highest for those words that were seen spelled correctly with the percentage of correct spelling for New words falling in between. This pattern of results is consistent across both good and poor spellers and across immediate and delayed testing. The consistency of the orthographic exposure effect is also evident on the two graphs (Figure 5.1) demonstrated by a linear increase from Incorrect to New to Correct scores. These results therefore appear to provide support for the orthographic exposure effect, as reported by Jacoby and Hollingshead (1990).

Figure 5.1 Orthographic Exposure Effect at Immediate and Delayed Testing



Delayed post-exposure spelling test



A mixed analysis of variance (ANOVA) was used to analyse the results, where time of testing and proficiency of spelling were between-subjects variables and type of prior presentation was a within-subjects variable. The main effect of orthographic accuracy at study was found to be highly significant [$F(2,88) = 19.16$, $MSe = 97.87$, $p < 0.0005$]. Planned comparisons revealed that both the difference between the Incorrect and New conditions, and between the Correct and New conditions were highly significant [$F(1,44) = 10.39$, $MSe = 87.23$, $p = 0.002$ and $F(1,44) = 26.26$, $MSe = 108.51$, $p < 0.0005$ respectively]. This pattern of results was also confirmed by the use of a Page's L trend test which demonstrated a clear trend of increasing scores from Incorrect to New to Correct [$L = 630$, $N = 48$, $p < 0.01$]. These results demonstrate a clear orthographic exposure effect, with the probability of correct spelling being greater than New for those words seen spelled correctly at study and lower than New for those words seen spelled incorrectly at study, and as such replicate the results of Jacoby and Hollingshead (1990).

The main effect of proficiency of spelling was also found to be highly significant [$F(1,44) = 32.71$, $MSe = 378.21$, $p < 0.0005$], in that good spellers scored significantly higher than poor spellers. This difference serves to validate the initial division of subjects into two groups. What was particularly interesting, however, was that there was no significant interaction between spelling proficiency and orthographic accuracy at study [$F(2,88) = 1.03$, $MSe = 97.87$, $p = 0.36$], indicating that there was no differential effect of orthographic exposure on good and poor spellers.

Time of testing yielded no significant difference [$F(1,44) = 0.044$, $MSe = 378.21$, $p = 0.835$], demonstrating there was no decrease in spelling accuracy from immediate to delayed post-testing. More importantly, however, there was no significant interaction between orthographic accuracy at study and time of testing [$F(2,88) = 1.45$, $MSe = 97.87$, $p = 0.24$]. The absence of a significant main effect, coupled with an absence of a significant interaction, indicates that the effects of orthographic exposure are as strong following a week's delay as they are at immediate test.

The fact that there was no significant three way interaction [$F(2,88) = 0.38$, $MSe = 97.87$, $p = 0.686$] can be seen as further confirmation of the absence of a difference between good and poor spellers, since both good and poor spellers were equally affected after immediate and delayed testing.

Taken as a whole these results demonstrate a very robust orthographic exposure effect, which is as strong across good and poor spellers, and after the delay of a week.

The fact that the orthographic exposure effect lasts for a week is consistent with an item-specific account of priming, since Monsell (1991) argues that episodic based priming lasts for very short time spans. If the priming found in this study is item-specific, then the misspelling should, in the majority of cases, be spelled in the same way as the one that was presented. To investigate this a further analysis was performed on the proportion of spellings misspelled in the same way as the presented misspelling ('Primed') and the proportion misspelled in some other way ('Other'). The data shown in Table 5.2, are the percentage of Primed and Other misspellings out of the total number of presented incorrect spellings. The means and standard deviations for each condition can be seen in the table below (Table 5.2 and the raw data can be found in Appendix C).

These data show that approximately two thirds of the spelling errors were a replication of the presented misspelling. A mixed ANOVA was performed, with spelling proficiency and time of testing as between-subjects variables and type of misspelling as a within-subjects variable. There was a significant main effect of spelling proficiency [$F(1,44) = 40.03$, $MSe = 71.15$, $p < 0.0005$], with good spellers making fewer errors than poor spellers. There was also a significant effect of type of misspelling produced, (Primed vs. Other) [$F(1,44) = 8.93$, $MSe = 211.84$, $p = 0.005$], reflecting that more spelling mistakes were made in the direction of the presented misspelling than were misspelled in some other way. There was no significant effect of time of testing [$F(1,44) = 0.007$, $MSe = 71.15$, $p = 0.93$] and no significant two or three way interactions. These results show that the priming effect of a misspelling is consistent across good and poor spellers and is still evident up to a week after exposure.

Table 5.2 Means (and standard deviations in parentheses) of percentage of misspellings at final spelling test for the 'Incorrect' condition.

	Type of Misspelling Produced		
Immediate	**Prime**	**Other**	**Mean**
Good	**24.30** (8.86)	**14.62** (8.89)	**19.46** (9.98)
Poor	**34.17** (12.22)	**22.08** (10.33)	**29.17** (12.31)
Delay			
Good	**23.33** (8.35)	**12.92** (10.34)	**18.13** (10.61)
Poor	**32.92** (14.84)	**27.50** (17.77)	**30.21** (16.25)
Mean	**28.68** (12.07)	**19.80** (13.52)	

Discussion

The results from this experiment are very clear. Exposure to an incorrectly spelled word depresses subsequent spelling accuracy for that word, while exposure to a correctly spelled word enhances it. The finding of a detrimental effect of exposure to misspelled words on subsequent spelling performance supports previous findings derived from a variety of methodological approaches (Brown, 1988; Jacoby and Hollingshead, 1990; Nisbet, 1939;

Pintner et al. 1929), and the finding of a beneficial effect of a correct item, supports the previous work by Jacoby and Hollingshead (1990). It therefore appears that the orthographic exposure effect is real and reliable.

The present experiment shows that the orthographic exposure effect is as strong in good adult spellers as in poor adult spellers. This finding is important for several reasons. First, it shows that the orthographic exposure effect is generalisable and cannot be considered to be an epiphenomenon caused by a particular group of spellers. Second, it shows that both good and poor spellers access detailed letter information from the presented stimulus. This is contrary to Frith's (1980) theory that poor spellers rely on partial cues for word reading, rather than on complete information. It appears that, at least with adults, good and poor spellers input precise letter identification from the presentation of a word. This supports research by Holmes and Ng (1993), who assert that letter information is accessed, but that poor spellers have problems in utilising and ordering the letter information at a higher level.

Third, the fact that the orthographic exposure effect is evident across good and poor spellers appears to demonstrate that the visual presentation of a word (either spelled correctly or incorrectly) is stored equally well by good and poor spellers. This evidence is contrary to Burt and Butterworth's (1996) finding that good spellers are able to store nonwords more accurately than poor spellers. This difference might be explained in terms of lexical status of the presented item. Burt and Butterworth's findings were derived from nonwords, which required that a new ‘lexical’ representation be created following a single presentation of an item. In the present study, the target items were all real words which would already have some form of lexical representation. It may be easier for poor spellers to store information from a single exposure when this information can be mapped on to an already existing exemplar.

Further evidence for this interpretation comes from a closer investigation of the misspelling data. If poor spellers were worse at storing precise letter information in the already existing lexical exemplar, then they might well be adversely affected by the presentation of a misspelling, but at test should produce fewer misspellings mimicking the presented item than good spellers. This is because good spellers would be able to store precise information which is likely to be repeated on subsequent spelling, whereas poor spellers may store imprecise information so that the presented misspelling would be less likely to be produced on subsequent spelling. The data from this experiment show that, for both good and poor spellers, approximately two-thirds of the spelling errors following the exposure to incorrect spellings were replications of the exposed items. This supports the idea that good and poor spellers are able to store similar information following a single presentation of an item. The difference between the results of this study and those of Burt and Butterworth, who found that poor spellers were less able to assimilate information following a single exposure, suggests that it could be easier for poor spellers to alter an already existing lexical representation than to create a new one.

Finally, the finding of a comparable size of orthographic exposure effect in both types of spellers provides some indirect supporting evidence for Burt and Butterworth's (1996) suggestion that good and poor spellers use qualitatively similar processes in spelling.

The inclusion of a delay between exposure and test also yielded some theoretically important results. The orthographic exposure effect was found to be as strong in the Delay condition as in the Immediate condition, demonstrating the effect to be robust and to reflect a long-lasting change in underlying representations. The fact that there was no differential effect of delay as a function of proficiency of speller speaks to the question of stability of lexical representations in good and pocr spellers. A plausible hypothesis as to why poor spellers are less proficient than good spellers is that they have less stable representations in their spelling lexicon. However, the present data on comparability of the orthographic exposure effect argues against this notion. There is no evidence that the changes brought about by recent exposure to a particular orthographic form of a word are any more labile in poor than in good spellers. This provides converging evidence for the proposal put forward by Burt and Butterworth (1996), that the advantage of good spellers over poor spellers occurs not from representation of word-specific knowledge, but from more generalised knowledge of orthographic, morphological and phonological rules.

The long lasting nature of the orthographic exposure effect also points towards the implicit nature of the phenomenon. The priming effects following a single exposure of a word are similar to other long lasting implicit priming effects found for a variety of stimuli (Kolers, 1979; Tulving, Schachter & Stark, 1982). There is further support for the orthographic exposure effect being mediated by implicit processes from the investigation into the type of misspellings produced. There was a greater number of misspellings replicating the presented misspelling than those misspelled in some other way. If the orthographic exposure effect was caused by explicit 'confusion' about the spelling following presentation of an incorrectly spelled word, then few of the subsequent misspellings would be expected to be replications of the original exposed misspelling.

A further piece of evidence concerning the implicit nature of the effect can also be found in the misspelling data. When subjects were initially asked to read the target words aloud, they were also asked to identify any misspellings. From an initial investigation of these data, it appeared that the detrimental effect occurred regardless of whether the word was recognised as a misspelling. Since a word recognised as a misspelling still exerted its influence over subsequent spelling ability it can be argued that the processes involved in producing the effect are beyond conscious control. The data on the apparent independence of spelling performance from the conscious recognition of the exposed item as a misspelling were not subjected to statistical analysis in the present study, partly because of the low frequencies observed, and partly because they were considered subsidiary to the main points of the experiment. However, the question of the relationship between conscious recognition of a misspelling and subsequent spelling performance requires further investigation, and forms the subject of an experiment reported in Chapter 6.

In pointing to the implicit nature of the orthographic exposure effect, the present results concur with the interpretation suggested by Jacoby and Hollingshead (1990), who arrived at the same conclusion on the basis of the dissociation between recognition memory and the orthographic exposure effect with respect to degree of elaborative processing at input.

The fact that the implicit priming lasted for a period of a week also addresses the current argument concerning the nature of the implicit priming: item-specific or episodic. Monsell (1987) has argued that episodic information decays very quickly and therefore the small effect of repetition priming found over longer time-lags is due to item-specific activation which reflects a long-lasting change in the lexical representation. This type of priming would therefore appear to be limited to items with lexical status, and indeed it was found that nonword priming did not occur over long time periods (Monsell, 1985, 1987). The fact that a significant priming effect was found in the present experiment supports an item-specific account of priming, and hence points to the orthographic forms of the experimental primes having pre-existing lexical status. Additional support for this stems from the fact that good and poor spellers were comparably affected by the priming manipulation, since Burt and Butterworth (1996) found that if primes lacked lexical status (i.e. were nonwords), then good spellers were at an advantage over poor spellers in storing and retrieving information from the prime. Since the primes used in the present experiment included both orthographically correct and incorrect forms of words, the fact that priming occurred for both types of primes implies that both correct and incorrect spellings are lexically represented.

The lexical representation of a misspelling is somewhat contentious since it is often assumed that only correct spellings are stored (for views that incorrect spellings are stored, see Chapters 3 and 4). Misspelled representations may exist in two possible forms. The first is that the misspelling could be stored as a separate representation in the lexicon (Ekstrand, Wallace and Underwood, 1966) in addition to the correct form. The second is that both the misspelling and the correct spelling access a single abstract representation which stores all encounters with the word. At present it is difficult to distinguish between these two alternatives, but this theme will be referred to again in subsequent chapters.

One of the points raised by the findings of this first study is the implicit nature of the orthographic exposure effect, and this issue forms the focus of investigation of the next chapter.

CHAPTER SIX

THE NATURE OF PRIMING OF SPELLING: ITEM-SPECIFIC VERSUS EPISODIC

The aim of the work reported in the present chapter is to examine further the implicit nature of the orthographic exposure effect. The previous chapter reported some data that supported the item-specific account of priming, which implies that the presented misspelling has some sort of lexical representation either as a separate entity to the correct spelling or the correct spelling and the misspelling are represented in a single abstract lexical item. The following two experiments manipulate variables that are considered to address the question of item-specific versus episodic priming, namely matching and non-matching study and test conditions.

If the orthographic exposure effect is found to be stronger in the matching, than the non-matching, study and test conditions, this would provide some support that the orthographic exposure effect is mediated via episodic priming (as Jacoby and Hollingshead, 1990, suggested). This is because, at study, the entire episode would be stored, that is, not just the item but also the surrounding context. If these conditions are then reinstated at test, the match between study and test is very close and retrieval cues are more effective (Jacoby, 1983). The more effective the retrieval cues, the stronger the priming effect will be. If, however, priming is item-specific, priming occurs through the activation of a pre-existing lexical exemplar. This type of priming, therefore, would demonstrate no advantage for matching conditions at study and test since only the item is activated, not the whole study episode.

The cross-matching manipulation employed in the following two studies is also important on a more practical level, since, if the entire encoding episode is stored and requires strong matching retrieval cues for the orthographic exposure effect to occur, then this effect is very unlikely to be encountered in real life situations. This would mean that the effect could be considered to be an interesting phenomenon with respect to theoretical advances, but would only be encountered under rigorous experimental procedures. If, however, the effect is due to a long-lasting change in the lexical representation which could affect spelling across different conditions, this would have far wider implications. For example, the current trend to use misspellings in advertisements (e.g. 'Special Guest Stars Tonite') may be subconsciously affecting the population's subsequent spelling of those items, even though the spellings may be being produced in a completely different context.

Experiment 2: The Effect of Orthographic Exposure when Target Words are Presented in Text

Introduction

Previous studies looking at the effect of presentation of incorrectly spelled words on subsequent spelling performance (Jacoby & Hollingshead, 1990; Brown, 1988; Experiment 1 of this thesis) have, so far, only investigated the effect using single word presentation. At study the words have tended to be presented in isolation irrespective of the orienting task, for example reading, writing or typing the item in question. At test the words have also, nearly always, been presented in isolation (there have been cases of forced choice test procedures, but these still concentrated on the orthography of a single lexical item e.g. RECONSTRUCTION - RECONSTRUCSION: Pintner, Rinsland and Zubin, 1929). Although children learning to spell may be familiar with this kind of presentation and test procedure, it is not representative of the ways in which adults perceive and recreate spellings; hence the experimental procedure can be regarded as an artificial task for adults. The present experiment sought to provide a more naturalistic task for adult readers by incorporating the possibility of encountering and reproducing specific words embedded in text.

Text reading, whether it be books, newspapers, letters and so on, covers the majority of reading experiences for skilled adult readers. It follows that misspellings are also most likely to be encountered in context (e.g. typing mistakes in printed material, spelling mistakes in letters etc.). Providing target words spelled correctly and incorrectly in text material will therefore provide a better indication of the generalisability of the results of previous studies on the effects of presenting different orthographic forms of a word to real life situations.

Single word reading and text reading differ in some fundamental ways. First of all, single word reading involves only a process of word recognition. Text reading requires far more attentional and cognitive capacity, and word recognition is merely the starting point for this process. Text reading also requires the ability to hold words in some sort of working memory in order to analyse syntactic and semantic information. Since text reading places far more demands on the cognitive system, it can be argued that misspellings are less likely to be explicitly noticed than when they are presented singly. This is because, when reading text, acquiring the meaning of the text is the primary motive and, as such, reading for meaning has become an automatic process.

The notion that misspellings are harder to spot in text is supported by research on proof-readers. Schindler (1978) investigated the ability of subjects to proof-read either a piece of coherent text, a piece of scrambled text or a word list. They discovered that spelling errors, particularly in function words, were more likely to be missed in the coherent text than in either the scrambled text or the word list. This, therefore, demonstrates that it is not just presenting a word in isolation or in text that is the important manipulation, but that the surrounding text must be semantically and syntactically meaningful. Rayner and Pollatsek (1989) suggest that when reading '... coherent text, it may be difficult for proof-readers to turn off their reading habits which are so deeply ingrained' (p. 450).

Since misspellings are harder to detect in meaningful text than in word lists, it follows that explicit letter information is more likely to be available in single word reading. If the orthographic exposure effect, therefore is dependent upon explicit letter information at study, it would be hypothesised that the experimental manipulation would produce a stronger orthographic exposure effect in conditions where the words were presented individually at study than when those words were embedded in meaningful text. If the orthographic exposure effect is dependent upon implicit processing of the presented target items, as the results of Experiment 1 suggest, an orthographic exposure effect of the same strength would be expected whether the words were presented in isolation or embedded in text.

The above hypotheses depend on the assumption that lexical access of the target item is not affected by the experimental manipulation of presenting the words singly or in text. The research investigating lexical access following a single presentation of a word compared to a word in text has concentrated on the area of eye movements. For example, in text reading some words are skipped or skimmed over in terms of eye fixations and it is therefore possible that the orthographic information of some items is not assimilated. If this is indeed the case, then the experimental manipulation would no longer be addressing the question of the role of explicit information at presentation, since it is possible that the orthographic detail of the misspelling would not even reach the lexical input mechanisms. Rayner and Pollatsek (1989) have addressed this issue and they argue that lexical access for single word and text reading is similar since the time taken to fixate a single word does not differ significantly from the amount of time taken to fixate a word in text. However, they do argue that higher order processes are used to a greater extent in text reading. The pertinent question is, therefore, whether higher order processes are used in the word recognition part of text reading. Stanovich (1980) has argued that it would be 'unprofitable' for top-down processes to be used for lexical access in text reading. He argues that higher order processes are not necessary for word recognition and that this would utilise resources that are needed for the higher order tasks, such as semantic and syntactic processing of the sentences. He also argues that using top-down processes for predicting subsequent words in reading text is usually unnecessary and is likely to be prone to errors. The only time that top-down processes may be needed is in reading degraded material, for example, handwriting. In this case top-down processes are needed to make sense of the text by filling in the gaps in the degraded material.

One way of testing the effect of top-down processes in written word recognition is to investigate the speed of lexical access with and without text. A study by Zola (1984) provides just such information by investigating eye movements in text reading. The study compared the effects of using words in a sentence that are either highly predictable in context or rather unpredictable. An example of the type of sentence used in their experiment is 'Movie theatres must have __________ popcorn to serve their patrons'. When they placed the word 'buttered' in the sentence, the word 'popcorn' became highly predictable and this resulted in shorter fixation times that when the word 'adequate' was used. This appears to show that context does have some effect on processing time, but the difference between the times were of the order of 15ms and so were considered to be rather marginal.

Zola (1984) and Ehrlich & Rayner (1981) also investigated the effect that presenting misspellings in a meaningful context exerted on eye movement fixations. They discovered that a misspelled target word took longer to process than a correctly spelled target word, irrespective of the context in which it was placed. Accurate timing of the fixation was made more difficult because many of the misspelled items were refixated by a regression. However, Ehrlich & Rayner (1981) found a small effect of predictability, in that if the misspelled word was predictable in its context, it was more likely to be skipped.

These data were supported by the findings of an experiment by Balota, Pollatsek and Rayner (1985). They presented subjects with sentences such as 'Since the wedding was today, the baker rushed the wedding cake / pies to the reception'. In this sentence the word 'cake' is highly predictable, whereas the word 'pies' is not. Balota et al. used a technique whereby the target word could be presented as a different string of letters until fixation occurred. In this particular example, when the subject's gaze reached the word 'wedding' but before it had moved on to the target item, the target word changed to its correct spelling. Balota et al. used a number of different conditions for changing the target letter string but, for the purpose of this thesis, two conditions are very important. If the target word was 'cake', the string of letters that was substituted before the word was fixated was either a visually similar misspelling (e.g. cahc) or the real word (cake). (The other possible target word for the sentence was 'pies' and the visually similar misspelling used in this case was 'picz'.)

There were two important findings from this study. First, the word 'cake' (following either 'cake' or 'cahc') was fixated less often than 'pies' (following either ‘pies’ or ‘picz’). Although 'cake' was not fixated it could still be seen in the parafovea[9]. This shows that placing the target word in a meaningful context plays an important role in the information accrued by the parafoveal preview and hence in the duration required for fixation. Thus the parafoveal sight of the highly predictable word ‘cake’ acquired enough information to allow its subsequent skipping, whereas the less predictable ‘pies’ still required fixation for recognition to occur.

The second effect concerned a difference in benefit between the parafoveal view of ‘cake’ and ‘cahc’ on cake, and the absence of a difference in benefit between the effect of ‘pies’ and ‘picz’ on pies. Since the highly predictable word afforded a difference according to whether it was spelled correctly or not and the less predictable word was not affected by its spelling, Balota et al. argued that more letter information is processed in the parafoveal preview of highly predictable target words. It therefore appears that context can affect reading by extracting visual information from words seen in the parafovea. The fact that context is important in parafoveal vision is analogous to arguing that top-down processes are required in the reading of handwriting. Since parafoveal vision is not as clear as foveal, it would profit from contextual assistance in a way in which foveal vision would not.

It can be seen from the preceding discussion that context does affect lexical access since, in some cases, the word is accessed via foveal vision, which is clear and requires only bottom-up processing, and sometimes by parafoveal vision, which requires top-down processing. However, there remains the

[9] The fovea surrounds the fixation point and allows clear vision. The parafovea surrounds the foveal region and has much less acuity.

question of whether top-down parafoveal processing means that less attention is paid to the letters in the word. A study by McConkie and Zola (1979) suggests that it does not. They presented subjects with a sentence with each word written in alternating cases and which changed in form on each fixation the subject made. So, for example, the subject may have seen a sentence like 'ThE cAt SaT oN tHe MaT' on their first fixation, but on their second fixation it was reversed to 'tHe CaT sAt On ThE mAt'. McConkie and Zola found that subjects were as quick to read the sentence when the case of the letters was switched on each fixation, as when they remained the same. They took this to be evidence that any information from parafoveal vision was stored at an abstract letter level since both visual information and letter case information were disturbed in the presentation.

It appears that routes to lexical access of a word in context may differ slightly depending upon whether a target word is predictable in context or not. If a word is predictable then it may be skipped, but it appears that in these cases parafoveal vision allows for accurate letter identification to take place. If the word is not highly predictable, it is fixated and accurate letter information is acquired as it would be in single word reading. It can therefore be concluded that, in the proposed experiment where target words are to be placed in text or presented singly, all spellings (and misspellings) should be processed, at least at a subconscious level. If the orthographic exposure effect is found when the words are presented singly, and not found when presented in text, this would imply that the effect is mediated by explicit processes. This is because explicit identification of misspellings is more difficult when the words are presented in text than when they are presented singly. If, however, the orthographic exposure effect is also found when subjects are asked to read the target words in text, this would imply that implicit processing at the lexical level would be more appropriate as an explanation of the effect. This is because it appears that lexical access does not differ for words presented in text and those presented singly.

The manipulation of presenting target words singly or in text in the present experiment was implemented in the test procedure as well as at study. A straightforward single word dictated spelling test procedure was used for half of the subjects and the other half were asked to take dictation to a fairly long passage of text containing the target words. This test manipulation was included for two main reasons. The first, as with the manipulation at study, was to create a more ecologically valid experimental procedure. A single word spelling test is unusual for an adult who is supposedly fluent in literacy skills, and so it was assumed that writing text to dictation was a closer approximation of free writing. Since spelling is primarily a tool for writing, it was considered to be better to place the role of spelling in its proper context rather than isolating the spelling procedure. The second reason was that a spelling test consisting of words that are difficult to spell could be a little daunting and is certainly an obvious check of the subject's spelling ability. This could induce subjects to be more aware of their spelling performance, possibly making them more likely to use explicit processes to refer back to the example of that word experienced during the exposure phase. By introducing dictation as the test procedure, the subject would be less aware that this was a test of spelling thus reducing the likelihood of explicit reference to a salient previous example.

Finally, a fully counterbalanced design was used to investigate whether the detrimental effect of encountering a misspelling was restricted to a particular context at study and at test or whether it could take place across different contexts. Subjects therefore either encountered the same conditions at study and test (either single word presentation or text presentation on both occasions) or the conditions were crossed (single word at study and text presentation at test and vice versa). An effect of orthographic exposure in all conditions would imply that the effect of encountering a word (either correctly or incorrectly spelled) is highly generalisable, since its effect would be evident across different situations.

The fully counterbalanced design was also implemented to investigate the nature of the possible priming that could mediate the orthographic exposure effect. If the matched conditions at study and at test produce a larger orthographic exposure effect than the non-matched conditions, this would support an episodic account of priming since the retrieval cues are more effective the greater the overlap between study and test. If, however, the orthographic exposure effect is found to be similar across matched and non-matched conditions, this would provide converging evidence for the item-specific account of priming, since any change occurs within the lexical representation and is not sensitive to changes in context.

Method

Design

A 2 x 2 x 3 design was implemented, where conditions at study (Single word vs. Text) and test (Single word vs. Text) were manipulated between subjects and orthographic accuracy at study (Incorrect vs. New vs. Correct) was manipulated within subjects. The study phase involved the reading aloud of correctly and incorrectly spelled words; half the subjects were asked to read the words in isolation and for the other half, the target words were embedded in text. The test phase of the experiment consisted of asking subjects to spell a series of words to dictation; half the subjects in each study group (Single word vs. Text) spelled the words in isolation and the other half were required to write text, which included the target words, to dictation. This 2 x 2 manipulation of study and test conditions resulted in a total of 4 groups of subjects: those who were presented with words in isolation in both study and test periods, those who were presented with words embedded in text at study and test, those who were presented with words in isolation at study and in text at test, and those who were presented with words in text at study and in isolation at test.

For each subject, a third of the target words presented at test had previously been seen spelled correctly at study (Correct), a third had been seen spelled incorrectly (Incorrect) and the final third were new to the experimental situation (New). The sets of target words used were fully counterbalanced between subjects.

Stimuli

A set of 54 words were selected for this experiment, on the basis that they were all generally considered to be difficult to spell as evidenced by the fact that they were listed in 'The Awful Spellers Dictionary' (Krevisky & Linfield, 1988). For each word chosen, a plausible misspelling was produced which preserved the phonology of the item (for further details, see Experiment 1). The stimulus items were assigned to three different sub-sets which were, as far as possible, matched for length and frequency. Each sub-set served in rotation as

‘Correct’, ‘Incorrect’ and ‘New’ words for testing purposes, so that no subject saw a correct and an incorrect version of the same word.

For the study part of the experiment, subjects were presented with two of the three sub-sets of words: one sub-set containing all correct spellings and the other sub-set containing the spellings presented in their incorrect forms. In the individual word presentation condition, the two sub-sets, one containing all correct, the other all incorrect spellings, were randomly mixed and were printed, one word per line, on a single sheet of paper. For the text presentation, three separate texts were created to embody the three combinations of sub-sets of words (sub-sets 1 and 2, sub-sets 2 and 3, sub-sets 1 and 3). Each text was printed twice to allow for the reversal of correct and incorrect exemplars within (for example, the text containing the target words from sub-set 1 and 2 was printed with the words from sub-set 1 spelled correctly and sub-set 2 spelled incorrectly, and then with the words from sub-set 1 spelled incorrectly and sub-set 2 spelled correctly).

For the final spelling task, the experimenter read aloud all 54 words either individually (Single word), or read aloud a further piece of text (Text) containing the 54 target words. (Full details of materials can be found in Appendix B.)

Subjects

A total of 48 students were paid for their participation in this experiment. All the subjects were undergraduates studying at City University, London, they all spoke English as their first language and were all fluent in literacy skills. None of the subjects participating in this experiment had taken part in any similar experiments investigating the orthographic exposure effect.

Procedure

Study Phase - Study condition 1: Word

Subjects in this study condition were asked to read each word aloud. Initially they were given a sheet of paper with the words printed in a list down the page, where only the first word was showing and the rest were covered. When the subject had read the first word aloud, they were asked to uncover the next word and read this aloud and so on, until they had reached the end of the list.

Study condition 2: Text

Subjects in the Text condition were asked to read aloud a passage of writing. They were warned that it might be difficult since it did not always scan very well (restrictions on the length of the text for concentration purposes meant that at times there was a high concentration of targeted words, which tended to be quite difficult low frequency words, and so meant that the text was quite difficult to read - especially when laced with incorrect spellings!).

There were no time limits imposed on the subjects in either of these conditions and all subjects were corrected by the experimenter if they misread one of the target words. None of the subjects was told that there would be incorrect spellings in the presented material and, if subjects spotted a mistake, the experimenter explained that the sheets had been produced in a hurry and apologised for any further mistakes.

Post-exposure Test Phase - Test condition 1: Word

Subjects were asked to participate in a dictated spelling test. The experimenter read aloud a list of 54 words; 18 of which the subject had seen spelled correctly and 18 which they had seen spelled incorrectly during exposure. The subjects were asked to spell each word to the best of their abilities and were instructed to attempt all words. There was no time limit imposed on the testing procedure since accuracy of the spellings was deemed to be more important than speed.

Test condition 2: Text

Subjects were asked to take dictation to a passage of text. The experimenter read aloud the text in small phrases and the subjects were instructed to write the text in full, trying not to omit any words. The experimenter's oral presentation took place at a pace appropriate for each subject and any words that were missed were always repeated upon request.

Debriefing

All subjects were debriefed on the aims of the experiment and were handed a full list of the 54 words, all spelled correctly, that were used in the experimental situation. Subjects were encouraged to read through the list of words in order to counter the negative effects of encountering a misspelling.

Results

The measure of each subject's performance was calculated as the percentage of correct spelling (as defined by the Oxford English Dictionary) achieved under each test condition for the 54 target words. The spellings of the other, 'context', words in the final text condition were disregarded. Percentages of correct spelling for each condition can be seen in the table below (and in Appendix C).

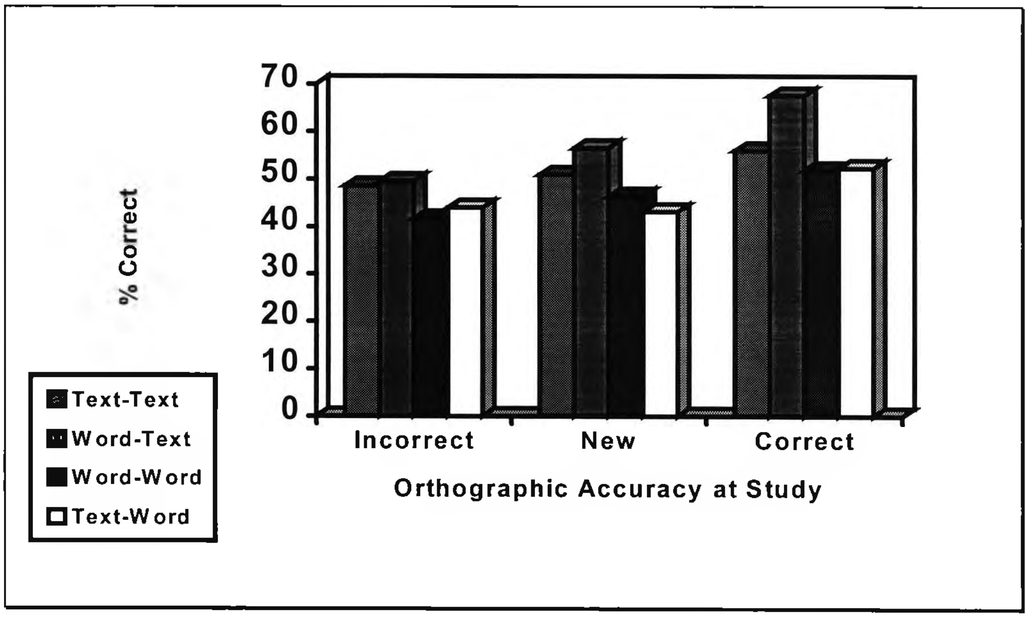
Table 6.1 Means (and standard deviations in parentheses) of percentage of correct spellings at final test

Presentation mode		Orthographic Accuracy at Study			
Study	**Test**	**Incorrect**	**New**	**Correct**	**Mean**
Text	Text	**48.61** (15.91)	**50.93** (21.82)	**56.02** (11.95)	**51.85** (16.85)
Word	Text	**49.55** (21.64)	**56.50** (13.57)	**67.59** (16.04)	**57.87** (18.51)
Word	Word	**41.67** (18.42)	**46.29** (18.06)	**51.85** (22.39)	**46.60** (19.77)
Text	Word	**43.98** (17.32	**43.06** (15.78)	**52.31** (18.72)	**46.45** (18.45)
Mean		**45.95** (18.15)	**49.19** (17.75)	**56.94** (18.28)	

The first point worthy of note from the data of Table 6.1 is that the orthographic exposure effect is clearly evident: the proportion of words spelled correctly at test is higher for those items seen correctly spelled at study than for new words, and is lower than the new words for those items that were encountered incorrectly spelled. For example, the mean for the condition where words were presented singly at study and at test is lower for those words that were initially presented spelled incorrectly (41.67%), than for those that were new to the final test (46.29%) and this in turn is lower than for those that were presented spelled correctly (51.85%).

This basic effect can also clearly be seen in Figure 6.1, where, in all but one condition, there appears to be a strong linear effect from Incorrect to New to Correct for all conditions. The condition where the orthographic exposure effect is not clearly evident is where the target words were initially presented in text and were spelled in isolation at test. However, even for this condition, the percentage of correct spellings in the final spelling test is higher for those words seen correctly spelled than those seen incorrectly spelled and, although the difference between Incorrect and New words goes in the opposite direction, this difference is very small (0.92%). Further discussion of this pattern of results follows the analysis.

Figure 6.1 Mean percentage correct spellings at final test



The presence of the orthographic exposure effect is supported by the results of a mixed ANOVA, where conditions at study and test served as between-subjects variables and orthographic accuracy at study as a within-subjects variable. A highly significant effect of orthographic accuracy at study was found [Incorrect vs. New vs. Correct: $F(2,88) = 12.28$, $MSe = 124.82$, $p < 0.0005$]. Further investigation of this variable using planned comparisons revealed a significant difference between Correct and New conditions [$F(1,44) = 24.35$, $MSe = 115.49$, $p < 0.0005$], although the difference between Incorrect and New conditions did not reach significance [$F(1,44) = 1.87$, $MSe = 134.15$, $p = 0.177$]. A significant linear trend from Incorrect to New to Correct was found, however, using a Page's L trend test [$L = 607$, $N = 48$, $p < 0.05$]. Although the data of the 'Text-Word' condition appear to exhibit a slightly deviant pattern from the other conditions, in that the probability of correct spelling for Incorrect (at presentation) words was higher than for New words, the absence of a three-way interaction between study by test conditions by type of exposure [$F(2,88) = 0.69$, $MSe = 124.82$, $p = 0.51$] indicates that the slight deviation from the overall pattern found in the other conditions is not significant. Hence the overall pattern of data supports the findings of the previous experiment, in which exposure to correctly and incorrectly spelled words led to increased and lowered spelling accuracy for these words at test.

The between-subjects main effect of presentation mode at study (Text vs. Word) revealed no significant differences [$F(1,44) = 0.48$, $MSe = 712.41$, $p = 0.491$]. This shows that type of presentation produced no effect on the level of subsequent spelling performance. There was also no significant interaction between presentation mode at study (Text vs. Word) and orthographic accuracy at test [$F(2,88) = 1.06$, $MSe = 712.41$, $p = 0.35$]. This shows that type of presentation at study had no effect on the overall orthographic exposure effect, which was present across both Text and Word study conditions. The overall orthographic exposure effect also did not vary as a function of the type of test used, as evidenced by the lack of a significant interaction between orthographic accuracy of target words and presentation mode of test (Text vs. Single Word) [$F(2,88) = 0.32$, $MSe = 124.82$, $p = 0.73$].

The main effect of presentation mode at test (Text vs. Word) revealed a difference that was approaching significance [$F(1,44) = 3.51$, $MSe = 712.41$, $p = .068$]. Accuracy of spelling in the single-word spelling test was slightly worse than when a dictated text was used. The mean overall percentage of correct spelling for the dictated single-word spelling test was 50.31%, whereas the dictated passage yielded an overall mean score of 54.88%. It is possible that this difference occurred merely by chance (as reflected by the significance level) or it could be a very small effect that requires either a larger number of subjects or a more rigorous design to reach significance at the 0.05 criterion. If this effect is real it may reflect the explicit nature of the spelling task which has been anecdotally reported to induce stress in the participants and therefore perhaps depresses spelling performance. The results from this experiment, on this particular point, are not clear enough to draw any firm conclusions and will be investigated further in the following experiment.

The interaction between orthographic accuracy of target words and presentation mode of test (Text vs. Single Word) was not significant [$F(2,88) = 0.32$, $MSe = 124.82$, $p = 0.73$]. This indicates that the overall orthographic exposure effect did not vary as a function of the type of test used.

The absence of any significant two- or three- way interactions in the data support the notion that the orthographic exposure effect was evident in every experimental condition. However, a further test was performed to check that there was no difference in the orthographic exposure effect as a function of matching or non-matching conditions at study and test. An ANOVA was performed where matching conditions at study and test was a between-subjects variable (matching vs. non-matching) and orthographic exposure was a within-subjects variable. Although the orthographic exposure effect was highly significant [$F(2,92) = 12.44$, $MSe = 123.16$, $p < 0.0005$], there was no significant main effect of matching [$F(1,46) = 0.416$, $MSe = 743.238$, $p = 0.52$] nor a significant interaction between matching and orthographic exposure [$F(2,92) = 0.70$, $MSe = 123.16$, $p = 0.49$]. This provides clear support that the orthographic exposure effect is as strong in matching conditions at study and test as in non-matching conditions.

Discussion

These results show that there is a detrimental effect of encountering a misspelling and a beneficial effect of previous exposure to a correct spelling on subsequent spelling performance. This pattern of results was found to be similar in all four study-test conditions: Text-Text, Text-Word, Word-Text and Word-Word. These data support the findings of previous studies by Brown (1988), and Jacoby and Hollingshead (1990), and lend weight to the argument that the orthographic exposure effect is a valid and replicable effect.

The implications of these results are very important. First of all, the fact that the orthographic exposure effect occurred when the words were initially presented in text (as well as in isolation) means that precise lexical information was accessed despite the possibility of gaze skipping when the context was predictable. Although it was not tested specifically, these results provide some support for McConkie and Zola (1979) since it appears that abstracting letter information from the orthographic stimulus was as effective when the target word may only have been encountered parafoveally as when it was seen through the fovea. More importantly, however, it can be argued that, since encountering the target words in text is a more implicit task than seeing them in isolation, an implicit process is responsible for the encoding stage of the orthographic exposure effect. If the orthographic exposure effect required explicit knowledge of the orthography at encoding then a stronger orthographic exposure effect for the words exposed in isolation would have been expected.

The explicit nature of a traditional spelling test (especially one which contains only words that are considered difficult to spell) could be argued to induce the subject to try to consciously recollect the most recent encounter with the word. This argument is even more plausible considering the stress reported by the subjects when they were told that they would have to take part in a spelling test. However, the fact that the orthographic exposure effect was found not only in 'Word', but also in the 'Text' test condition, a condition which is more conducive to less conscious processing of the words, suggests that it was not the explicit recall of a prior experience that was responsible. It therefore appears that the orthographic exposure effect is based upon some unconscious retrieval of the prior encounter which is beyond the subject's control.

The inclusion of text at both study and test in the present experiment aimed to investigate the ecological validity of the results of previous studies by Jacoby and Hollingshead (1990) and Brown (1988) and those of Experiment 1. If these results were restricted to the presentation of words in isolation and tested in isolation, then they would only be of interest to school teachers and other teachers of literacy and spelling, where single word reading and spelling is used on a regular basis. The fact that the orthographic exposure effect was as evident across text conditions at study and test as in single presentation of the target words is important since it allows for the generalisation of the orthographic exposure effect to the way in which skilled adult readers encounter and reproduce words. Even more importantly, the results of this study showed that the orthographic exposure effect is as strong across different contexts at study and test as the same context, thereby supporting the item-specific account of priming. This will be discussed in greater detail in the General Discussion.

Experiment 3: Accuracy Ratings of Orthographies

Introduction

The present experiment, following the aims of Experiment 2, also sought to investigate whether the orthographic exposure effect is mediated by item-specific or episodic priming by implementing matching conditions at study and test and non-matching conditions at study and test. As for the previous experiment, it was hypothesised that if episodic priming is responsible for the orthographic exposure effect, the effect should be enhanced when conditions at study and at test are matched, rather than non-matched, because matched conditions at test provide stronger retrieval cues for the episode. If, however, there is no difference in the size of the orthographic exposure effect when conditions are matched or non-matched, this supports an item-specific notion of priming since priming occurs within the lexical representation and is therefore not sensitive to context cues.

This experiment also aimed to manipulate the degree of explicitness of spelling at study and at test, but instead of target words being embedded in text (as in Experiment 2) subjects were asked to rate each word on a percentage scale to say how accurate they thought each spelling was. Subjects were asked to assign a value of zero if they knew the word was spelled incorrectly and a value of one hundred if they knew it was spelled correctly. This variable was introduced at study for the presented items and also at test for the items that the subjects spelled themselves. It was this manipulation, therefore, that provided matching and non-matching conditions at study and at test. A 2 x 2 implementation of these variables occurred, so that subjects either encountered the same rating conditions at study and at test (rating or not rating) or the rating conditions were crossed (rating at study and not rating at test or vice versa).

Ratings were introduced into the study phase to provide a more carefully controlled follow up from some preliminary data found in Experiment 1. In Experiment 1, subjects were asked to state if they thought a word was spelled incorrectly and this was noted by the experimenter. An inspection of the data appeared to show that subjects were detrimentally affected by a misspelling even when they were aware that the presented item was a misspelling. However, because the number of identified misspellings was very small in the first experiment, a proper analysis of these data could not be completed. It was therefore considered that an assessment of every presented spelling on a scale of accuracy would yield richer data that could be investigated further.

It was hoped that these data would provide some insight into whether priming of spelling is more likely to occur for items about whose orthography subjects are less confident. It could be that confidence in recognising a spelling or a misspelling as such, could be related to the strength of the orthographic representation. For example, a strong well-defined representation may be required in order to recognise that the presented orthography is misspelled (Funnell, 1992). It is possible, therefore, that the same strong representations could be less affected by a single presentation of the orthography than weak representations.

Inclusion of the rating variable at test was introduced for two main reasons. First, asking subjects to rate their own misspellings for accuracy could be considered to be a more 'explicit' task of spelling than a normal spelling test. In the previous experiment the difference between the single word spelling test and the text spelling test approached significance: subjects tended to perform better on the dictated passage test than the single word dictated spelling test. It was considered that if this was a real difference, it might reflect an influence of anxiety on the part of the subjects since a dictated spelling test is an obvious test of spelling ability and the words used were generally considered to be difficult to spell. The inclusion of asking subjects to rate their own spellings for accuracy in the present experiment potentially provides an even more anxiety provoking situation than a dictated spelling test. If, therefore, it is found that subject's spelling performance is lower when they are asked to rate their own spellings for accuracy, it will provide converging evidence for the anxiety explanation of the almost significant effect found in Experiment 2.

The second reason to include ratings at test concerns a more general aspect of the orthographic exposure effect. It is possible that the presentation of a misspelling not only produces a detrimental effect on future spelling of the item, but may also result in the subject being less confident about the spelling of the item. For example, a subject may be able to spell 'rhythm' but after presentation of a different version, such as 'rythm', might be less confident about its subsequent spelling whether they spell it correctly or incorrectly. If, however, subject's confidence in their response is not reduced following exposure to a misspelling, regardless of whether the response is in fact correct or not, this would provide further evidence that the orthographic exposure effect does not operate at a conscious level.

Method

Design

A 2 x 2 x 3 design was implemented for this experiment, where conditions at study (Rate vs. Not Rate) and test (Rate vs. Not Rate) were manipulated between subjects, and orthographic accuracy at study (Incorrect vs. New vs. Correct) was manipulated within subjects. At study, subjects were required to either simply read the words presented aloud or asked to read them aloud and assign confidence ratings as to the correctness of each word's orthography. These two levels were also included at test, so the subject was either asked to simply spell the target words or was asked to spell each word and rate it for spelling accuracy. The between-subjects variables, therefore, provided a 2 x 2 design where subjects either rated at study and test, at neither, at study but not at test, or at test but not at study. The rating scale was 0 - 100, where 0 represented certainty that a word was spelled incorrectly and 100 represented certainty that a word was correctly spelled. This scale was chosen since people are used to dealing with percentages and it was thought that it would give scope for a wide range of scores. No time limits were imposed throughout the testing procedure, since accuracy was deemed to be a more important factor than speed of response.

The within-subjects variable of Orthographic Accuracy at Study was introduced in an identical way to Experiment 2, with Correct and Incorrect words being exposed at study, and both these and unexposed, New words being used at test.

Materials

The words used in this experiment were identical to those used in Experiment 2, with the stimulus items assigned to three different sub-sets. Each sub-set served in rotation as 'Correct', 'Incorrect' and 'New' words for testing purposes, so that no subject saw a correct and an incorrect version of the same word. For the presentation phase of the experiment, subjects were presented with two of the three sub-sets of words: one sub-set containing all correct spellings and the other sub-set containing the spellings presented in their incorrect forms. The words were mixed in a random order and were printed, one word per line, on a single sheet of paper. For the testing phase of the experiment, all three sub-sets of words were read aloud by the experimenter in a random order.

Subjects

Forty-eight subjects, all of whom were students at City University, London, were paid for their participation in this experiment. All participants spoke English as their first language and were fluent in literacy skills. None of the subjects who participated in this experiment had taken part in any previous experiments investigating the orthographic exposure effect.

Procedure

Study Phase - Study condition 1: Not Rate

Subjects allocated to this condition were given a sheet of paper with 36 items typed in a list on the page. Subjects were asked to read each word aloud and to continue until the end of the list. The experimenter corrected any mispronunciations to ensure that the targeted words had been identified.

Study condition 2: Rate

Subjects allocated to this condition were also asked read each word aloud, but were, in addition, asked to rate each word after reading it, according to whether it was spelled correctly. If they considered the word to be correctly spelled, they were asked to assign it a value of 100; conversely if they were sure that a word was spelled incorrectly, they were asked to assign a value of zero. A rating of 50 denoted that the subjects were completely unsure as to whether it was spelled correctly or not. Subjects were encouraged to use the broad spectrum of scores.

Post-exposure Test Phase - Test condition 1: Not Rate

Subjects in this condition were given a final dictated spelling task consisting of 54 items (Correct, Incorrect and New). The presentation rate was set at a pace suitable to the individual, since accuracy rather than speed was the important factor. Words were repeated upon request and subjects were allowed to change the spelling as many times as they required while they were writing a particular item but were asked not to go back to alter a previous spelling once a new item had been presented.

Test condition 2: Rate

Subjects in this condition were given the same final dictated spelling test as those in the 'Not Rate' condition. They were instructed to write down each spelling and then to rate each spelling according to how confident they were that it was orthographically correct. The same rating scale was used here as in the study condition. Subjects were, once again, encouraged to work at an appropriate pace.

Debriefing

The aims of the experiment were explained to the subjects and each subject was handed a sheet containing the correct spellings of all the words used in the experimental situation. Subjects were instructed to read through the correct spellings in order to counter the detrimental effect of encountering a misspelling.

Results and Discussion

Recognition of Orthographic Accuracy at Presentation

A preliminary finding from the rating of orthographic accuracy of presented words at study was that the mean rating given for the incorrect spellings used at presentation was 59.59% and the mean rating for correct spelling was 71.6% (where 100 equals certainty of a correct spelling). It is important to note how poor the subjects were at recognising incorrectly spelled words, even when the items were presented one at a time with explicit instructions to consider the accuracy of the spelling. It is perhaps even more surprising given that the subject group were all university students and, as such, should be reasonably fluent in literacy skills. The difference between the ratings for Correct and Incorrect items was significant using a Wilcoxon test [$T = 48.5$ ($N = 24$), $p < .0005$]. However, on a one sample t-test, there appeared to be no significant difference between chance responding (50%) and the score obtained for words that were spelled incorrectly. Indeed this score was above the 50% level rather than lower as would have perhaps been expected for skilled adult spellers. Since it appears that subjects are so poor at recognising when a word is misspelled, it is perhaps important to investigate the subjects assessments of what is and is not correct, as well as true orthographic accuracy at exposure.

Confidence ratings at test as a function of actual orthographic accuracy at study

When comparing ratings at test, regardless of accuracy of spelling response, there appeared to be no difference in confidence levels between those words that were presented spelled incorrectly at study and those that were presented spelled correctly. Words that were presented spelled incorrectly were rated 79% at test and those originally presented spelled in their correct form were rated 81% at test. A Wilcoxon test revealed that there was no significant difference between these two results [$T = 154$ ($N = 24$), $p > 0.05$]. This is an important finding because it means that any decrease in spelling accuracy following the presentation of an incorrect item, or an increase in accuracy following presentation of a correct item, cannot be attributed just to a decrease or increase in confidence of the spelling.

Confidence ratings at test as a function of rated orthographic accuracy at study

This was further tested by investigating those words that subjects *thought* were spelled correctly and incorrectly at presentation, regardless of actual accuracy of the item. For the purpose of this analysis, any item that was given a rating of less than forty was deemed to have been considered incorrectly spelled and any item rated fifty or more was considered correct, despite the real accuracy of the spelling. It was found that for those words that were considered to be spelled incorrectly at presentation, the mean rating for the final test was 71.63%, and those words that were considered to be correctly spelled at presentation showed a mean rating at final test of 74.25%. Again, a Wilcoxon test showed no significant difference between these two ratings [$T = 46$ ($N = 12$), $p >> .05$]. This provides further support for the notion that a subject's confidence at spelling production does not vary as a function of their prior experience with a word.

From the preceding discussion it can be seen that subjects do not show differences in confidence of spelling following either exposure to a real correct or incorrect spelling, or to what the subjects consider to be a correct or incorrect spelling. Since the orthographic exposure effect relies upon the *actual* accuracy of the presented items and the subjects were unable to explicitly access the accuracy of the orthography, it implies that the orthographic exposure effect is mediated via implicit processes beyond the conscious control of the reader. Also, if the orthographic exposure effect was due to an explicit 'confusion' of the spelling of the item following presentation of a contradictory exemplar, a drop in confidence would be expected. Since there was no evidence of a drop in confidence following exposure to an incorrect item or, perhaps more relevant in this case, following what the subject considered to be an incorrect spelling, this provides further support that the orthographic exposure effect is mediated via implicit processes.

The Orthographic Exposure Effect

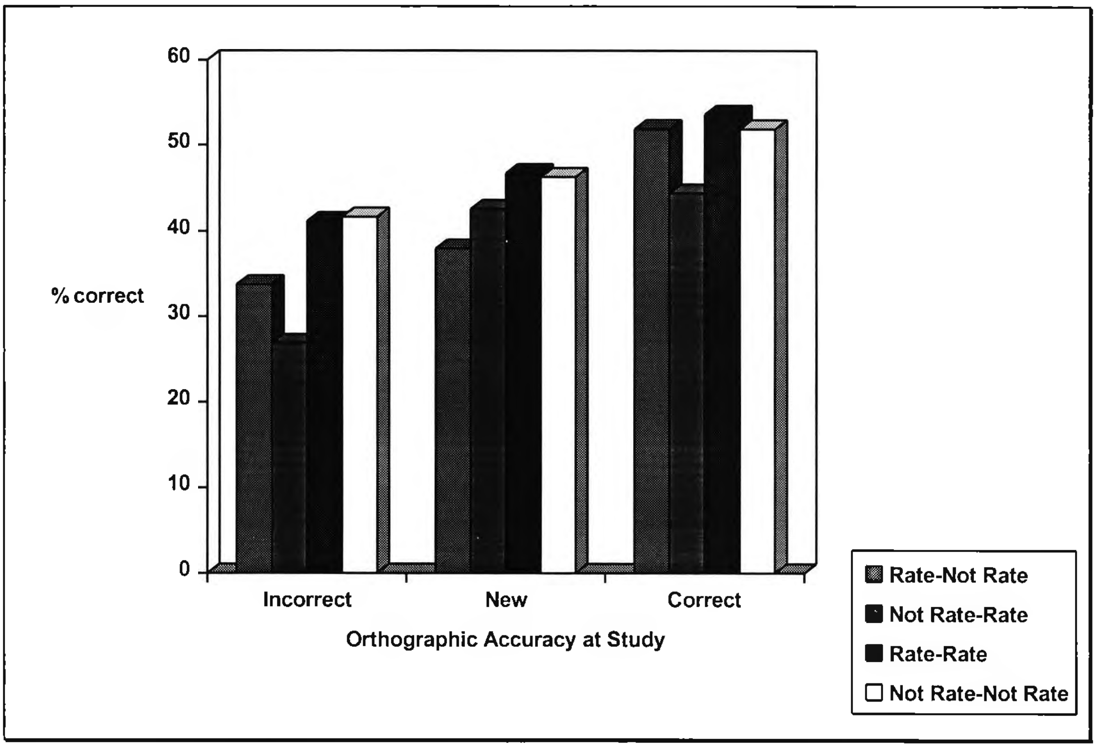
The main data of the experiment, in the form of percentage of correct spellings achieved at test, are shown in Table 6.2 (and in Appendix C).

Table 6.2 Means (and standard deviations in parentheses) of percentage of correct spelling at final test.

Rating		Orthographic Accuracy at Study			
Study	**Rate**	**Incorrect**	**New**	**Correct**	**Means**
Rate	Not Rate	**33.79** (13.51)	**37.95** (12.70)	**51.85** (24.19)	**41.20** (18.80)
Not Rate	Rate	**26.84** (14.17)	**42.57** (18.24)	**44.40** (21.17)	**37.96** (19.31)
Rate	Rate	**41.16** (18.25)	**46.74** (20.30)	**53.57** (13.81)	**47.17** (17.91)
Not Rate	Not Rate	**41.67** (18.43)	**46.31** (15.78)	**51.85** (22.40)	**46.61** (18.99)
Means		**35.86** (16.88)	**43.40** (16.83)	**50.44** (20.41)	

Inspection of the data of Table 6.2 reveals that the orthographic exposure effect is evident in all four conditions with the percentages of correct spelling always the smallest for Incorrect, medium for New and largest for Correct. This increasing trend in spelling accuracy from Incorrect to New to Correct is illustrated in Figure 6.2.

Figure 6.2 Mean percentage of correct spellings at final test.



These data were analysed using a mixed ANOVA, where conditions at study and test were between-subjects variables and accuracy of orthography at study was a within-subjects variable. There was a very strong within-subjects effect of orthographic accuracy at study [$F(2,88) = 18.73$, $MSe = 136.22$, $p < 0.0005$], showing that presenting correct and incorrect orthographies has a strong effect on subsequent spelling performance. The difference between Incorrect-New and Correct-New were analysed using planned comparisons and both of these differences were found to be highly significant [$F(1,44) = 11.209$, $MSe = 121.50$, $p = 0.002$ and $F(1,44) = 24.77$, $MSe = 150.94$, $p < 0.0005$ respectively]. These were analysed further to see if there was a linear trend from Incorrect to New to Correct. A Page's L trend test revealed a significant linear trend in the predicted direction [$L = 631.5$, $N = 48$, $p < 0.01$]. These results support those of Experiments 1 and 2 in demonstrating a robust orthographic exposure effect.

There was no significant main effect of conditions at study [$F(1,44) = 0.18$, $MSe = 711.93$, $p = 0.67$], indicating that asking subjects to rate explicitly the accuracy of each spelling did not affect their subsequent spelling performance. There was also no significant main effect of condition at test [$F(1,44) = 0.09$, $MSe = 711.93$, $p = 0.77$]. In Experiment 2, the difference between the single word and text spelling tests approached significance and this was interpreted as a possible difference in levels of anxiety on the different tests (the dictated single word spelling test was a more explicit and thus more anxiety producing test of spelling than the dictated passage). In the present experiment it was considered that asking subjects to rate their spellings for accuracy could be considered more anxiety provoking than a simple dictated spelling test. The finding of a clearly non-significant result in this study could imply one of three things. First, that the almost significant effect in Experiment 2 did not reflect a real underlying difference. Second, that subjects did not find rating their spellings for accuracy more anxiety provoking than a dictated spelling test. Or third, that the difference between accuracy of spelling in a traditional dictated spelling test and a dictated passage test was not caused by the difference in anxiety between the two testing conditions. However, at present it is impossible to distinguish between these explanations and only further explicitly directed testing would be able to disambiguate these alternatives.

The orthographic exposure effect was evident in all four between-subjects conditions and this was supported by an absence of two and three way interactions in the data. To further test that the orthographic exposure effect was as strong in conditions where the study and test conditions were matched as when they were not matched, a subsequent ANOVA was performed. This analysis consisted of the between-subjects variable of matching versus non-matching conditions and the within-subjects variable of orthographic exposure. The effect of orthographic exposure was very strong [$F(2.92) = 18.68$, $MSe = 136.5$, $p < 0.0005$], but there was no main effect of matching of study and test conditions [$F(1,46) = 2.8$, $MSe = 685.21$, $p = 0.10$] nor was there a significant interaction between the two variables [$F(2,92) = 1.01$, $MSe = 135.5$, $p = 0.37$]. This analysis provides strong support for the notion that the orthographic exposure effect is as strong in matched conditions as in non-matched conditions at study and test. This supports the results of Experiment 2 and provides converging evidence against an episodic account, and hence in favour of the alternative, an item-specific account of priming. This point will be discussed further in the General Discussion.

Analysis of Error Types

For purposes of derivation of percentage correct responses for the main analysis, subjects' responses were categorised as correct or incorrect. In the present, subsidiary analysis, responses were categorised into those that replicated an originally presented incorrect orthographic form, and those that were misspelled in some other way. This analysis was based only upon those words that had initially been presented incorrectly spelled and were also later misspelled in the final dictated spelling test. Responses were simultaneously categorised according to whether the incorrectness of the orthography had been recognised at exposure (the criterion for this being a rating of 40 or less) or not (ratings of 60 or more).

The data are in Table 6.3 below (and in Appendix C). Items that replicated the original incorrect orthography of the incorrect spelling have been named 'Primed', and items that were misspelled at test but did not replicate the presented incorrect orthography have been named 'Other'.

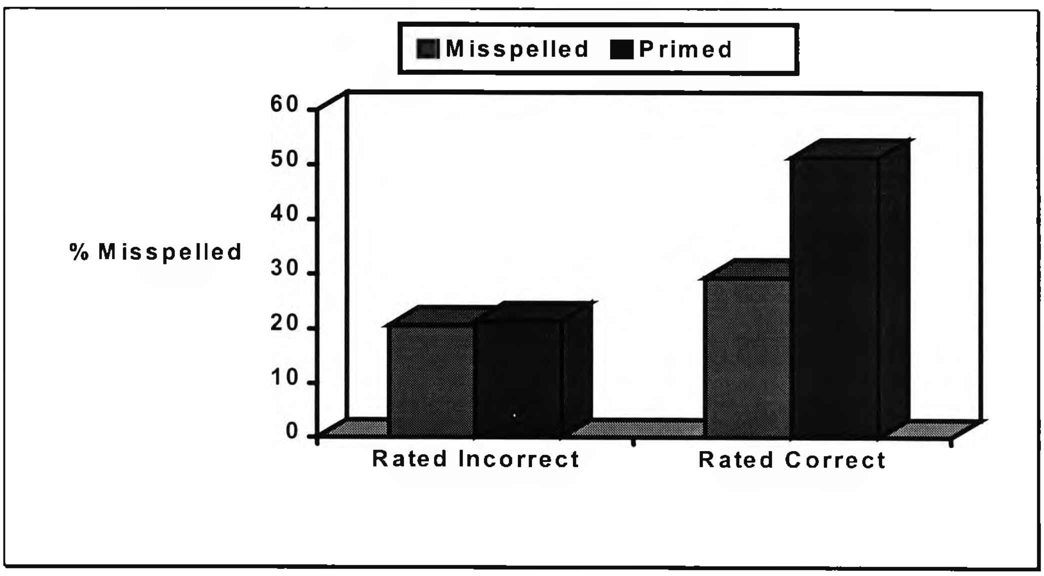
Table 6.3 Means (and standard deviations in parentheses) of percentage of misspellings replicating the presented misspelling and those spelled in another way.

	Rated Incorrect at Study	Rated Correct at Study	Means
Primed	**21.42** (20.72)	**51.37** (16.15)	**35.35** (24.29)
Other	**20.66** (14.30)	**29.36** (23.87)	**24.97** (19.92)
Means	**25.39** (22.47)	**36.02** (21.64)	

It can be seen from Table 6.3 that the tendency for misspellings at test to mimic the incorrect orthography presented at study varies according to whether the incorrectness of the original exposure was recognised or not. The percentage of misspellings at test which replicated the original incorrect orthography is approximately equal to the percentage of words which are misspelled in some other way at test, for words which were recognised as being incorrectly spelled at exposure (21.42 versus 20.66 in the category ‘Rated incorrect at study’). However, when the original incorrect spelling is not recognised, but perceived as correct, the percentage of words replicating the original misspelling far exceeds words which take on some other misspelled form (51.37 versus 29.36 in the ‘Rated correct at study’ category).

This effect is clearly demonstrated in Figure 6.3 where an apparent interaction between recognition of incorrect orthography at exposure and the likelihood of replicating the exposed orthography at test is illustrated. While the number of words taking on some ‘Other’ misspelled form is relatively unaffected by perceived orthographic accuracy of presented items, there is a marked increase in replication of the exposed form for those items judged to be correctly spelled at exposure.

Figure 6.3 Mean percentage misspellings spelled in the same direction as the presented misspelling and those misspelled with a different orthography.



This pattern of results was fully confirmed by using a repeated-measures ANOVA on the above data. A significant main effect of rating was found [$F(1,23) = 15.31$, $MSe = 177.01$, $p < 0.001$], where subjects were more likely to misspell an item if they thought that its misspelled presentation was, in fact, a correct spelling rather than a misspelling. There was also a significant main effect of type of misspelling [$F(1,23) = 5.46$, $MSe = 569.66$, $p = 0.029$], demonstrating that subjects were more likely to reproduce a presented misspelling than go on to misspell the item in a different way. Finally, there was a significant interaction between rating of spelling and type of misspelling [$F(1,23) = 22.84$, $MSe = 392.47$, $p < 0.0005$], showing that subjects were more likely to be primed by a misspelling that they actually thought was correctly spelled than one that they knew was incorrectly spelled.

The fact that a presented misspelling, which is thought to be correctly spelled, results in a higher probability of reproducing the same orthography at test than when the misspelling is recognised as such at presentation could suggest that two different processes are being used. It could be that recognition of a misspelled word results in explicit, rather than implicit, processing of the item. This is unlikely, however, since the data from the confidence ratings revealed that there was no significant difference between the confidence ratings of those words that the subjects knew were incorrectly spelled and those they thought were correctly spelled. If the effect of orthographic exposure in this case was explicit, it would be expected that there would be a drop in confidence for those words that the subjects thought were incorrectly spelled. Converging evidence that this is not an explicit effect comes from Experiment 1. Good spellers are more likely to recognise a misspelling as such when it is presented and since the orthographic exposure effect was comparable for good and poor spellers, it is unlikely that the effect was mediated by explicit processing for the good spellers and implicit processing for the poor spellers. A consideration of the nature of lexical representations underlying the observed effects could lead to an explanation of these results in terms of implicit processing.

It could be argued that there are two possible explanations of why a subject rates a presented misspelling as correct. One possibility is that a version of the misspelling could already be stored within the lexicon and thereby presentation of an identical misspelling would activate the already existing lexical item, leading the subject to assume that the presented misspelling is, in fact, the correct spelling. The second possibility is that the corresponding lexical item may be incompletely specified and therefore presentation of a misspelling may not contain any information that contradicts the incomplete lexical representation, so the subject is unable reject the presented item as a misspelling. In the former case, the result of reproducing the presented misspelling at test could be argued to be the consequence of direct priming of an incorrectly spelled lexical exemplar (for example, presentation of 'gullable' would strengthen the 'gullable' lexical exemplar and would result in a high probability of this orthography being produced at test). In the latter case, since the lexical exemplar is not sufficiently well specified to provide an accurate spelling of the item, specific information from the presented misspelling may be used, along with the already existing imprecise lexical information, either implicitly or as an explicit reference to guide spelling accuracy.

Correct identification of a misspelling, however, suggests either the existence of an orthographically correct representation (following Funnell, 1992, who argued that recognition of a misspelling can only occur in the context of correct orthographic information), or the existence of a well-specified lexical representation containing incorrect orthographic information which is different from that presented at exposure. In both of these cases, the exact orthography of the presented misspelling may not be lexically represented and therefore direct lexical priming would not be possible. There are two other possible ways in which the presented misspelling could exert an influence over subsequent spelling of the item. The first method consists of the presented incorrect spelling creating a new lexical entry which could create competition within the lexicon at output. However, the creation of a new lexical exemplar following a single presentation is unlikely to be strong, or well-defined, enough to be competitive with a pre-existing lexical representation (see Chapter 3 for a discussion of how lexical representations are created). This would mean that any priming resulting from this competition would be weak compared to the direct priming possible if the identical incorrect exemplar is already stored within the lexicon. The second alternative is that the exposed incorrect orthography could be superimposed upon the already well-defined lexical representation (either correctly or incorrectly spelled) producing dissonance within the lexical exemplar. However, this also is unlikely to produce an effect as large as that found with those incorrect spellings that subjects thought to be correctly spelled, since a single exposure to an incorrect exemplar would not produce as much dissonance in a well-specified lexical representation as one which is less well-specified. Therefore, it would be expected that if the presented misspelling is recognised as such, there would be far fewer misspellings at test that mimic the presented spelling than when the presented misspelling is thought to be correctly spelled.

The analysis of types of misspellings needs to be interpreted with some caution, however, since the baselines for the two conditions ('Rated incorrect at study' and 'Rated correct at study') were different: approximately two-thirds of the items were considered to be correctly spelled as opposed to one-third of the items that were considered to be incorrectly spelled. This introduces error variance into the variables and reduces the reliability of the data.

General Discussion of Experiments 2 and 3

The preceding two experiments have both shown a very strong effect of orthographic exposure, that is that presentation of a misspelling decreases spelling accuracy compared to new words and that presentation of a correct spelling increases accuracy compared to a set of new words. The finding of an orthographic exposure effect clearly supports the findings of Experiment 1, and those of previously published studies by Brown (1988) and Jacoby and Hollingshead (1990). The orthographic exposure effect was found in Experiment 2, even when the presented words and test words were encased in text, and in Experiment 3, when the presented words and test words were assigned confidence ratings as to the correctness of each word's orthography. Combining together the results of Experiments 2 and 3 clearly provide strong evidence that the orthographic exposure effect is robust and is pervasive across a variety of different conditions.

In addition to confirming the generality of the orthographic exposure effect, the findings have important theoretical implications for the question of episodic versus item-specific accounts of priming. An episodic account of priming would predict stronger priming under matching study and test conditions than where study and test conditions do not match, on the grounds that the former situation would at test represent a reinstatement of the encoding episode, generating more potent retrieval cues. The absence of a differential priming effect in matching and non-matching study-test conditions in the present experiments (with respect to provision of context for items in Experiment 2, and with respect to the requirement of rating the orthographic accuracy of items in Experiment 3), clearly do not support the predictions derived from episodic priming. Priming of spelling performance undoubtedly occurs, since the probability of a correct spelling at test is clearly related to whether a word was seen correctly or incorrectly spelled at exposure, but the level of priming is independent of study-test manipulations. The findings are more in line with those of Scarborough, Cortese and Scarborough (1977), Morton (1979) and

Dean and Young (1996), and therefore support an item-specific account of priming.

Since an item-specific account of priming dictates that priming represents a long-term alteration within the lexical representation, the findings of Experiments 2 and 3 imply that a single presentation of an item is sufficient to alter a lexical representation. In terms of priming of a correct spelling this is easy to explain. A single presentation of a correctly spelled item accesses the existing, matching lexical entry. This strengthens, or reinforces, the representation in some unspecified way which means that when the lexical entry is accessed again, this time for output, the correct spelling of the item is more likely to occur. This account is similar to accounts of repetition priming except that, instead of re-presenting the stimulus visually, the stimulus is presented auditorily and the subject outputs the spelling allowing the priming to be assessed via the accuracy of the spelling. It can be seen that this account assumes that the lexical representation underlies both reading and spelling processes (see Chapter 3), since alterations to the lexical representation following the reading of an item also influence subsequent spelling of the word.

However, the question becomes more complicated when attempting to explain priming of a misspelling. While there is only one possible orthographically correct version of a word which can mediate priming effects of exposure to a correct exemplar of a word, there is more than one possible incorrect version, and the particular incorrect version used experimentally as a prime may or may not have an existing representation within the subject's lexicon. If it has, then the explanation of priming can follow the same logic as that for correct spellings. If it has not, then an additional assumption has to be made - that the perceptual experience constructs a lexical representation which is then used as a basis for spelling output.

Alternatively, it may be assumed that the incorrect exemplar is somehow superimposed on the existing representation of the correct form of the word in the lexicon, where new experiences are superimposed on an existing core representation altering it in some way. These notions are elaborated in the following paragraphs.

In Experiment 3, the detrimental effect of exposure to a misspelling appeared smaller if the incorrect exemplar was recognised as such at presentation. This would suggest that a sufficiently well-defined lexical representation of the correct form of the word (or some other incorrect form believed by the subject to be correct and hence used as a basis for spelling generation) was in existence, mediating discrimination between itself and the exposed incorrect form and resulting in identification of the exposed form as incorrect. The fact that the exposed incorrect form has relatively little influence on subsequent spelling suggests that either its superimposition on an existing representation had little effect on that representation, or that a newly created representation was not effective in competing with the pre-existing one as an informational source at output.

For those misspelled items that were not recognised as such, a much larger detrimental effect occurred and in these cases the subsequent misspelling was also usually a replication of the orthography of the presented item. This priming effect of a lexical exemplar could also be explained in two ways. First, it could be argued that the exposed misspelling was accepted as a correct spelling because it had already acquired lexical status from previous encounters. This is a plausible possibility, since the misspellings used were popular misspellings of difficult-to-spell words. If this were the case, then presentation of a misspelled item serves to reinforce an existing incorrect lexical representation resulting in a greater possibility of subsequent misspelled output. Since priming would occur by activating the identical misspelled representation, it follows that the misspelled output would be a replication of the presented item.

An alternative explanation of why the presented misspelling is not recognised as such is that subjects may not have sufficiently clear or complete lexical information for that word to allow the misspelling to be detected. There seems adequate evidence that some form of representation existed for those words, in that the presented misspellings were read aloud as the intended word, indicating that the intended representation had been accessed. It is therefore possible that incorrect and correct orthographic information is stored within the same representation, producing internal dissonance and hence increasing the probability of a misspelling at output.

At present, it is difficult to distinguish between the aforementioned alternatives in explaining how misspellings that are not recognised as such at input, lead to a higher probability of generating misspellings at test. A possible way to investigate the differences between these two theories is to employ misspellings that people would never have encountered before. These would have no pre-existing lexical representation to prime and therefore a new representation would have to be created following a single exposure. There is some evidence that lexical entries require many presentations before a reliable entry is formed (see Chapter 3), so if priming occurred with these items, it would imply that the misspelling is superimposed on a correct lexical exemplar. This possibility is investigated Experiment 4, where phonologically implausible misspellings are presented which are unlikely to have been encountered before and in Experiment 5, where misspellings of simple words that are rarely misspelled are employed.

CHAPTER SEVEN

THE ROLE OF PHONOLOGY IN LEXICAL ACCESS

Experiment 4
Phonological Plausibility of Misspellings

The experiments investigating the orthographic exposure effect in previous chapters and those of Brown (1988) and Jacoby and Hollingshead (1990) have all shown a similar pattern of results; presentation of correct spellings enhance subsequent spelling performance and presentation of incorrect spellings has a detrimental effect, compared to spelling accuracy of non-studied (New) items. It therefore appears that the orthographic exposure effect is a real and robust phenomenon. However, in all the previous studies mentioned, the misspellings presented to the subjects were phonologically plausible, that is, although the orthography was incorrect, the item preserved the phonology of the target word (for example, 'deligate' was the presented misspelling of 'delegate'). The fact that the misspellings were all phonologically plausible could have important consequences for the orthographic exposure effect since there has been some evidence that phonology is an important factor in lexical access (Van Orden, 1987; Van Orden, Johnston and Hale, 1988; Van Orden, 1991; Lukatela and Turvey, 1994). If phonology is the major factor in lexical access and the orthographic exposure effect is mediated via subconscious priming within the lexical exemplar, it is possible that presentation of phonologically implausible misspellings may not exert a detrimental effect on subsequent spelling performance. This experiment, therefore, investigates the differential effect of presentation of phonologically plausible and implausible misspellings on subsequent spelling accuracy.

Introduction

The notion that phonology plays an important part in lexical access and hence that the phonological plausibility of misspellings could be an important factor in lexical activation has been discussed briefly in Chapter 1 in terms of the pseudohomophone effect. Previous work (for example Coltheart et al., 1977; Besner et al., 1985 etc.) has mainly concentrated on the use of priming using homophonic real words and nonwords, and non-homophonic spelling controls. It can be seen that a homophonic nonword (or pseudohomophone) is essentially the same as a phonologically plausible misspelling since its orthography does not map on to that of a lexical item, while the phonology does. Similarly the non-homophonic spelling controls that have been used in pseudohomophone experiments can be considered to be similar to phonologically implausible misspellings since they are visually similar, but not identical, to a pre-existing lexical item.

In Chapter 1, a series of experiments was reported that demonstrated that the presentation of pseudohomophones in a lexical decision task resulted in an increase in the time required to reject the item, compared to a nonword spelling control (Coltheart et al. 1977; Rubenstein et al, 1971; Besner and Davelaar, 1983). This increase in lexical decision time was argued to be due to the conflicting information from the phonology, which mapped onto a lexical exemplar, and the orthography, which was not represented in the lexicon. However, the use of lexical decision data to support the role of phonology in lexical access has been questioned on methodological grounds. First, it has been argued that the lexical decision task requires the subject to reject the pseudohomophone target item (i.e. to say 'No' the presented item is not a word).

Since it is generally considered that rejecting items takes longer than accepting lexical items (Coltheart, 1978), it is possible that the pseudohomophone effect occurs outside the time limit usually allocated for 'normal' reading processes (Henderson, 1982; McCusker, Hillinger & Bias, 1981). The other problem concerns the greater 'familiarity' of a pseudohomophone than a spelling control. Since a pseudohomophone is phonologically similar to a real word, it may appear more familiar to the subject without actually affecting lexical access at all, and it may be this familiarity that is responsible for the increase in decision time (Besner, Davelaar, Alcott & Parry, 1984).

Van Orden (1987) attempted to overcome the criticism that the pseudohomophone effect, and hence, the influence of phonology on lexical access, was derived from 'No' responses (rejection times) in a lexical decision task. He introduced a new task in which 'Yes' responses would provide the critical data. The task was a categorisation task involving discrimination between exemplars of the category and two types of non-exemplar foils. The paradigm consisted of the presentation of a category name, e.g. FLOWER, followed by one of three types of words: an exemplar of that category, e.g. ROSE; a homophone of the exemplar, e.g. ROWS, or a spelling control for the exemplar, e.g. ROBS. The non-exemplar foils were all lexical items, familiar to the subjects, and hence any findings would not be open to the criticism (Besner et al., 1984) that differential familiarity of pseudohomophones and other nonwords lay at the basis of the pseudohomophone effect in standard lexical decision tasks.

Van Orden (1987) found that false positive, 'Yes' responses to homophone foils (ROWS) far exceeded those of spelling control foils (ROBS), (18.5%

versus 3%, respectively), indicating a tendency to accept the foil as a real exemplar of the category (ROSE) on the basis of a shared phonology.

A second experiment in the Van Orden 1987 series utilised a similar procedure, but this time a pattern mask was presented immediately following the presentation of the target word to obliterate the effects of orthography (Johnston and McClelland, 1980). Similar results were found to those in Experiment 1, in that homophony still played an important role in the number of false positive responses. These results demonstrate that phonology is activated quickly enough to exert an influence on lexical activation, even when the exposure of the items was so short that subjects were unable to identify any of the target words that were not a member of the preceding category (that is, exposure times of the order of 150 msecs).

Van Orden suggested that phonology is the fastest route to lexical access and that the visual route is utilised as a spelling check after the lexical item has been activated. He suggests that only phonological processes rely upon bottom-up processing (that is deriving the phonological form from the orthographic representation, and this phonological representation activates the lexical entry) and that visual processes are top-down (orthographic information is used as verification solely after lexical access has been achieved). In order to test this hypothesis, Van Orden, Johnston and Hale (1988) examined differences between real word homophones and nonword homophones. They found more false positive responses on pseudohomophones (a part of the human body - 'brane') than spelling control nonwords (a part of the human body - 'blain'), with the levels of false positives to pseudohomophone (a part of a building - ‘sellar’) and homophone targets (a part of a building - ‘seller’) being very similar (21.3% and 21.8% respectively). Van Orden et al. argued that, since homophones and pseudohomophones demonstrated similar levels of false positives, and that the pseudohomophones are not orthographically represented in the lexicon, sub-lexical phonological processing must play the major role in activation of the lexical representation.

More detailed work in this area of automatic, pre-lexical computation of phonology by Lukatela and Turvey (1994) has revealed more complicated findings. Using an associative priming paradigm, where speed of naming a target word, FROG, could be influenced by priming with an associate, TOAD, Lukatela and Turvey investigated the effect of varying the phonological and orthographic relationship of the prime to the target. For example, they examined the effect of priming by a homophone of the associate (TOWED) and its spelling control (TOLD), and by a pseudohomophone of the associate (TODE) and its spelling control (TORD). They found significant associative, homophonic and pseudohomophonic priming effects at short (50 msec) stimulus onset asynchronies, with no priming effects by orthographic controls. That is TOAD, TOWED and TODE were effective primes, while TOLD and TORD produced no priming effects. At the longer stimulus onset asychronies (250 msec) priming was limited to real-word associates (TOAD) and pseudohomophones (TODE). Real word homophones (TOWED) failed to produce any priming effects.

Lukatela and Turvey argued that since the real word associative prime and the homophonic and pseudohomophonic items produced priming effects at the short onset asynchronies, and that the orthographic primes did not, this implies that phonology, and not orthography, is the most important factor in lexical access at these very brief time spans. However, when the time between presentation of the prime and target was lengthened to 250 msecs, the real word homophone failed to produce any priming. It appears from these results that the homophonic prime accessed the target lexical representation (TOAD) in a very short time (as shown by the priming evident at short onset asychronies) but this activation dissipated very quickly (demonstrated by the lack of a priming effect at longer onset asynchronies). Lukatela and Turvey interpret the dissipation of the lexical priming of homophonic items as being due to conflicting information processed from the orthographic components after lexical activation has taken place. This post-activation orthography does not influence the pseudohomophone prime since this is not stored within the lexicon and therefore cannot give rise to conflicting information. These experiments therefore provide evidence that phonology is the primary route to lexical access and that orthographic components are processed after activation has taken place.

The hypothesis that visual processes are only instigated to verify the already activated lexical representation is extremely contentious, especially in a deep orthography such as English, where the mappings between phonology and orthography are not regular. A possible method of addressing this question is to investigate the effects of frequency of the target item on pseudohomophones and spelling controls. If the pseudohomophone effect is due to influence at the level of the lexical representation then the frequency of the target item should be important and frequency effects should be evident within the pseudohomophone effect. If spelling controls also access the lexical entry, these too should demonstrate a frequency effect. If a frequency effect is found for the pseudohomophones and not for the spelling controls, this would provide further support for phonology as the primary route to lexical access, because only pseudohomophones possess the relevant phonology.

Van Orden (1991) investigated the effect of variation in frequency of pseudohomophones and orthographic controls in the context of a proof-reading task. Subjects were presented with a story which contained either twenty pseudohomophones or twenty nonword spelling controls (e.g., 'My best defence is my right 'elbo'/'elbot'). Half of these items were derived from high frequency words and half were based upon low frequency words. Van Orden found that error-detection rates were higher for high frequency-based items than for low frequency-based items. He argues that, since frequency effects are considered to be tied to lexical processes, the finding of a frequency effect associated with non-lexical items suggests that the nonwords used in the study were in fact capable of accessing the relevant representation in the lexicon. Closer inspection of the data revealed that the frequency effect for pseudohomophones was significantly greater than that for spelling controls, although there was a small, unreliable frequency effect for the spelling controls which was evident in the subject, but not the item, analysis. Since the frequency effect was based primarily within the pseudohomophones, this suggests that certain non-lexical items have the capacity to access the lexicon and activate a representation therein. The critical feature enabling this access appears to be the phonology of the presented item. The spelling controls, nonwords visually similar to the lexical item but not sharing its phonology, failed to exhibit a reliable frequency effect, and hence, were less able to access the lexical item, to the same extent

The above-outlined research on automatic and pre-lexical computation of phonology during visual word recognition, suggests that phonology plays a primary role in lexical access. Lukatela and Turvey (1994) argue that a word's phonology is the initial access code to the lexical representation and, hence, all those items with a phonology similar to the target item are activated within the lexicon. The orthographic code is, therefore, primarily responsible for producing confirming activation for the appropriate item and thus reducing the noise within the lexicon. Van Orden, Pennington and Stone (1990), however, describe the major role of phonology in terms of a computational model of 'phonologic coherence'. They argue that phonological codes are components of the lexical representation and that these codes are more coherent than other possible codes, for example, semantic and syntactic codes, by virtue of the precise covariance between an orthographic and a phonologic code. Hence, they argue that phonologic information is the primary constraint on lexical activation since it is the code that exhibits the greatest harmony, that is the phonologic information resulting from an initial activation is very similar to the resulting code following clean-up processing.

The importance of phonology in gaining access to a lexical representation is highly consistent with the findings of the effect of exposure to misspellings on orthographic information within the lexicon. All the research conducted so far on the exposure effect, both in previous research and that of the present studies reported here, has used misspellings which were phonologically plausible. That is, as far as phonological information went, the information provided by the exposed exemplar was correct. It would therefore gain access to and activate the intended lexical item either by virtue of lexical activation or phonologic coherence. Orthographic information, either activated at a later stage or becoming coherent at a later stage, would reach an already activated representation and this new information could be assimilated thus producing a change in the orthographic representation for that item.

It appears from the above argument that phonologically implausible misspellings whose phonology does not match that of the underlying word, should not have the same potency of access to the internal lexical representation, and hence not produce the same, or the same extent of, detrimental effect on subsequent spelling performance. This is because the critical lexical representation would not have received excitation from phonology even though some excitation could occur from the orthographic processes.

The role of phonology is also important in more traditional dual route theories of lexical access, which hypothesise simultaneous activation of lexical and sub-lexical systems, though in these theories phonology is not considered to be the primary route to lexical activation. If a detrimental effect on subsequent spelling accuracy is found following exposure to a phonologically plausible misspelling but is not evident following exposure to a phonologically implausible misspelling, this could also be interpreted in terms of traditional dual route theory. In this scenario, a phonologically plausible misspelling would provide some activation of the targeted item from its orthography and confirming information from the phonological route. A phonologically implausible misspelling, however, would only provide some activation resulting from possession of a similar orthography and no confirming information would be received from the phonological input. It is therefore possible that any activation following presentation of an implausible misspelling would decay very quickly and hence new orthographic information would not be assimilated.

Single route theories of lexical access, however, do not highlight a special role for phonology and therefore phonological plausibility of the presented misspellings should not be a relevant variable in terms of the detrimental effect on subsequent spelling ability.

The current experiment, therefore, investigates the effect of presenting phonologically plausible and implausible misspellings upon subsequent spelling performance. Since the orthographic exposure effect has already demonstrated a significant detrimental effect on subsequent spelling accuracy following exposure to a phonologically implausible misspelling and that this effect is deemed to be mediated via access and alteration of the lexical representation, the finding of a less powerful detrimental effect using phonologically implausible misspellings will provide confirming evidence of a major role for phonology in lexical access.

Method

Subjects

45 subjects participated in this experiment; 23 were assigned to the phonologically plausible group and the remaining 22 were assigned to the phonologically implausible group. All the subjects were first year psychology undergraduates who participated in the experiment as part of their coursework requirement. Subjects were tested in two groups and none of the subjects had participated in any of the other orthographic exposure experiments.

Design and Materials

A test-retest design was used, with exposure to different types of misspellings intervening between the two tests, and the effect of exposure being measured by the change in spelling accuracy from the pre-exposure test to the post-exposure test.

The initial test took the form of a dictated spelling test involving 36 words. The test was compiled from the bank of 'difficult-to-spell' words used in the experiments reported in the previous chapters. The plausible misspellings used were the same as those used in the experiments reported in the previous chapters. The implausible misspellings, however, were created by substitution of a phonologically implausible letter, in most cases this was achieved by altering the vowel sound within the target item and usually resulted in a misspelling that contained orthographic information closer to the target item than that found in the phonologically plausible misspellings. For example, the plausible misspelling for the target item 'dearth' was 'dirth', whereas the implausible misspelling for the item was 'deerth'. A full list of the materials used for this experiment can be found in Appendix B.

After completion of the spelling test, subjects were randomly assigned to one of two exposure conditions, 'Plausible' and 'Implausible'. In the former condition they were exposed to phonologically plausible misspellings of the original test items, while in the latter the exposed misspellings were phonologically implausible.

Immediately following exposure to the misspellings, subjects were re-tested on their spelling of the 36 items

Procedure

Initial spelling test

Subjects were auditorily presented with a list of 36 words and were asked to spell each word as accurately as possible. They were told that, if they were not sure or did not know the correct spelling of the word, they should write down their best guess as to how the word should be spelled. Subjects were allowed to take as much time as they required, and were permitted to make several attempts at each word before finally deciding on the preferred option.

Presentation of incorrect spellings

Subjects were presented with a list of either phonologically plausible or phonologically implausible misspellings. There were 36 in total and these were identical to the words the subjects were initially asked to spell. Subjects were instructed to read each word silently to themselves and were told that some of the items might be misspelled. The visual presentation of each word was accompanied by simultaneous auditory presentation by the experimenter reading the word aloud. This was to ensure that the intended word was perceived by the subject since, although, in the case of phonologically plausible misspellings, a subject will realise the intended word despite deviant orthography by virtue of the accurate phonological information, it is by no means certain that the same accurate lexical access will occur in the case of misspellings which are phonologically implausible.

Final spelling test

The final spelling test contained the same words and testing conditions as the initial spelling test, though in a random order. Following the final test, all the subjects were debriefed and were asked to read through the correct version of the words used in the experimental condition. This was included as an ethical consideration to help to overcome the possible detrimental effects of encountering a misspelling.

Results and Discussion

To ensure that random assignment of subjects to the two conditions had yielded comparable groups, an independent t test was performed on the initial spelling test data of both groups of subjects. This revealed that there was no significant difference between the two groups at the initial spelling test ($t_{43} = 0.63$, $p = 0.533$), and therefore that subsequent legitimate comparisons could be made.

The results reported here are the percentages of correct spelling (as defined by the Oxford English Dictionary) in the initial and final spelling tests, as a function of type of exposed misspelling.

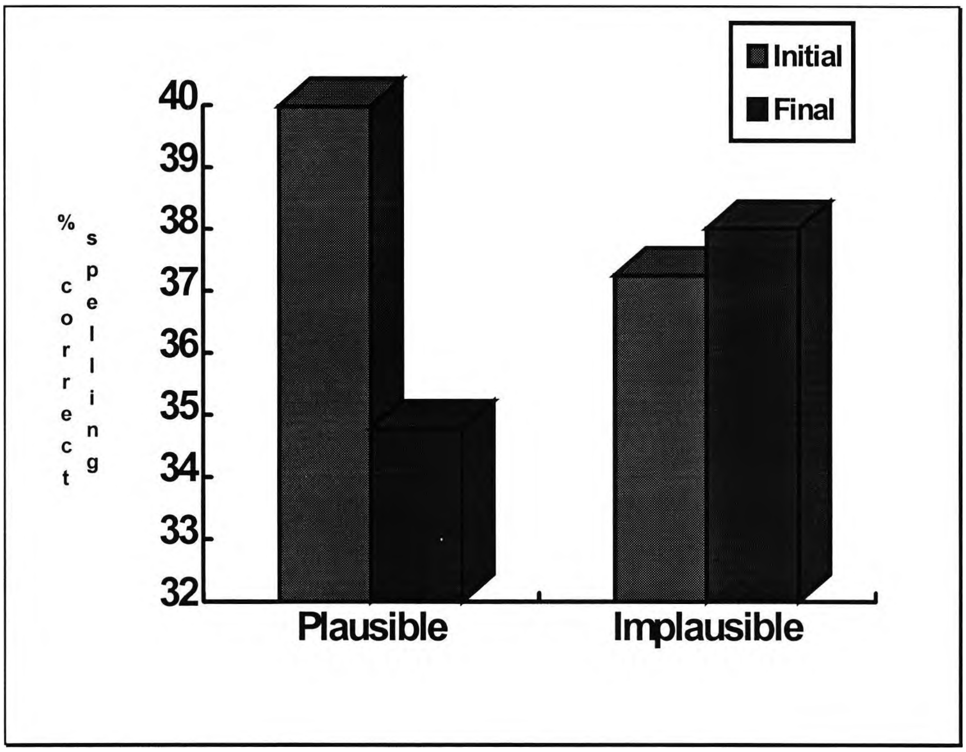
Table 7.1 Means (and standard deviations in parentheses) of percentage of correct spellings

	Initial spelling (% correct)	**Final spelling (% correct)**
Phonologically plausible	**39.98** (15.37)	**34.78** (16.54)
Phonologically implausible	**37.25** (13.63)	**38.01** (12.61)

An inspection of the data (as shown in Table 7.1 and Appendix C) reveals that there is a detrimental effect of encountering a phonologically plausible misspelling, demonstrated by a 5.20% loss in accuracy from pre- to post-test, but no detrimental effect of encountering a phonologically implausible misspelling. In fact, the data show a slight *increase* in spelling accuracy (less than 1%). The data were analysed using a mixed ANOVA, where time of testing (pre-test vs. post-test) was a within-subjects variable and phonological plausibility of misspellings (phonologically plausible vs. phonologically implausible) was a between-subjects variable.

The analysis revealed that there was no significant main effect of phonological plausibility [$F(1,43) = 0.00$, $MSe = 414.12$, $p = 0.95$], demonstrating that the subjects spelling accuracy was similar across the two conditions. There was, however, a significant main effect of time of testing [$F(1,43) = 7.38$, $MSe = 14.98$, $p = 0.009$], supporting the hypothesis that spelling accuracy was significantly worse following exposure to misspellings. There was also a highly significant interaction [$F(1,43) = 13.29$, $MSe = 14.98$, $p = 0.001$], reflecting the detrimental influence of exposure to a phonologically plausible misspelling compared to the slightly beneficial effect of exposure to a phonologically implausible misspelling. This interaction can be seen clearly in Figure 7.1 and was also supported by post hoc comparison of the two conditions. A Tukey's Honestly Significant Difference test (critical value = 3.1%) revealed that the difference between the pre- and post- test scores was significant for the phonologically plausible misspellings and not significant for the implausible misspellings. This demonstrates that the highly significant main effect of time of testing was carried completely by the phonologically plausible condition.

Figure 7.1 Mean percentage of correct spelling for initial and final spelling tests.



The fact that a phonologically plausible misspelling was found to exert a detrimental effect on subsequent spelling accuracy supports the earlier work of Brown (1988) and Jacoby and Hollingshead (1990), as well as Experiments 1, 2 and 3 reported in the previous chapters. However, the inclusion of phonologically implausible misspellings has revealed a condition in which the normal orthographic exposure effect is not evident, that is, the presentation of a phonologically implausible misspelling exerted no influence over subsequent spelling performance. This is a very important finding since it suggests that there is something critical about the phonology of the presented item in mediating the orthographic exposure effect.

It has previously been argued that the orthographic exposure effect is mediated via access to and alteration of the targeted lexical representation and that this process is beyond the conscious control of the reader. The finding that phonologically implausible misspellings do not exert a detrimental effect could, therefore, possibly reflect problems in accessing or altering of the lexical item. Both of these alternatives will be discussed below.

It is possible that the critical role of phonology in the orthographic exposure effect concerns gaining access to the lexical representation. The work described earlier in this chapter (Van Orden, 1987, 1991; Van Orden, Pennington and Stone, 1990; Lukatela and Turvey 1994) suggests that phonology is the primary route to lexical activation and that orthographic features of the presented item are only processed after the initial activation has taken place. This theory provides a feasible framework within which to interpret the data from the current experiment.

In terms of the phonologic mediation hypotheses, it would appear that presentation of a phonologically plausible misspelling would immediately activate the targeted lexical item, by virtue of the homophony of the presented and targeted item. Following activation, the orthographic components of the word would be processed leading to a possibility of conflicting orthographic information within the lexical representation. This orthographic conflict stored within the lexical representation could be the source of the decreased spelling accuracy consistently found in the orthographic exposure effect.

The presentation of a phonologically implausible misspelling, however, would not be able to access the lexical representation since although the auditory presentation provided accurate phonological information, the phonology derived from the orthography of the presented item is not concordant with the phonology of the lexical item. Since Van Orden et al. (1991) argue that consonance between a word's orthography and phonology is required to produce full activation of the lexical item, it is probable that the initial phonological activation derived from the visual presentation of the item does not occur and thus that any orthographic processing which subsequently occurs is not tied to the targeted lexical exemplar. This would mean that conflicting orthographic information would not be stored within the representation and therefore subsequent testing of the item would remain unaffected by the prior exposure of a phonologically plausible misspelling.

An alternative possibility is that the role of phonology is to prevent conflicting information being stored within the lexical representation even after lexical access may have occurred. This interpretation is more in line with traditional dual route theories which hypothesise that the visual and the phonological aspects of the presented item are activated concurrently.

In terms of this theoretical basis, it can be seen that the presentation of a phonologically plausible misspelling would provide two types of information. The orthographic aspects of the word would be processed and, although it is unlikely that there would be any lexical representations that would match completely (since the presented item is a misspelling), activation would occur within the lexical exemplars that are closest to the presented item. In this way, it is very likely that the target word would be activated, since the target word is likely to be the closest match to the presented misspelling. While this is occurring, phonological information is also being processed and activating the closest lexical entries. In terms of the phonologically plausible misspellings, this means that activation of the target word will occur due to the homophony of the presented and target item. Therefore, the target item will receive double activation from orthographic and phonological routes, thus providing confirming information. Since the targeted item is activated, the incorrect orthographic information is likely to be assimilated producing orthographic conflict within the lexical representation. It is therefore this conflict that causes the decline in spelling accuracy demonstrated clearly in this experiment and in the previous experiments investigating the orthographic exposure effect.

The presentation of a phonologically implausible misspelling would operate in the same manner. For the visual route, the orthographic aspects of the presented item would be unlikely to be identical to a pre-existing lexical exemplar, but the targeted item would be activated by virtue of it being a very close orthographic match. At the same time, the phonological route would be processing the item, despite the concurrent auditory input provided at study. The results of the phonological processing of the provided orthography would not yield a lexical exemplar, thus conflicting information would be provided for the already activated target item. It is therefore possible that conflicting information from the two routes to lexical access is not sufficient to activate the lexical representation properly and thus no conflicting lexical information would be stored.

A final model could also be postulated whereby the phonologically implausible item does access the lexical representation, by virtue of its visual similarity to the target word, and the alternative orthography is stored within that representation. It could, therefore, be argued that exposure to phonologically implausible misspellings failed to exert an effect on subsequent spelling because, at output, normal spellers are guided by phonology (Frith, 1980; Burden, 1992), and thus are unlikely to produce the phonologically implausible misspelling that is stored. However, if the implausible misspellings accessed the targeted lexical representation, introducing conflicting information, some detrimental effect on spelling accuracy arising from the disturbed representation would be expected, even though phonological guidance at output would be more likely to produce a phonologically plausible misspelling rather than a copy of the presented implausible misspelling. In fact there is no evidence of this. The data clearly show that exposure to phonologically implausible misspellings simply have no detrimental effect on subsequent spelling accuracy, indicated by an absence of a difference between pre- and post- exposure tests. Hence the implication is that an incorrect orthography which does not activate the appropriate phonology simply does not access the relevant orthographic representation in the spelling lexicon, and so cannot alter it and cause a change in spelling accuracy.

The results of this experiment, therefore, indicate that phonologically implausible misspellings either block access to the target representation or prevent the storage of conflicting orthographic information within the lexicon. Currently it is not possible to distinguish between these two hypothetical models. However, the results do provide support for the general notion of a fundamental role for phonology in terms of lexical activation. The findings of this experiment are, therefore, consistent with phonologic mediation theory and dual route models of lexical access, but they provide strong evidence against single route models of lexical access that deny the use of phonology (Glushko, 1979; Marcel, 1980; Seidenberg and McClelland, 1989).

CHAPTER EIGHT

RESPONSE TIMES IN SPELLING IN THE ORTHOGRAPHIC EXPOSURE EFFECT

Experiment 6

The Orthographic Exposure Effect on Easy-to-Spell words

Introduction

The preceding studies reported in Chapters 5 and 6 have demonstrated a detrimental effect of presenting a misspelling and a beneficial effect of presenting a correct spelling on subsequent spelling performance. It has already been argued (Chapter 6) that this implies that incorrect orthographic information is represented within the lexicon, either as a separate entity from the correct lexical entry or within a single lexical representation that contains discrepancies according to the misspellings that have been encountered. However, the stimuli that have been used in this thesis and in previous experiments (Brown, 1988; Jacoby & Hollingshead, 1990; Nisbet, 1939; Pintner et al., 1929) are all words that are considered to be difficult to spell. This has several implications. First, that in a wider-cross-sample of materials spanning a wider range of spelling difficulty, the orthographic exposure effect may not obtain statistically because spelling performance on only the more difficult words will be adversely affected by exposure to incorrect forms. This is because these items are probably less strongly represented and therefore may be more susceptible to priming. Second, there may be something special about these items (i.e. that misspelled versions of the word are stored prior to the experimental procedure) thereby restricting the generalisability of the results of the experiments. Indeed, Brown (1988) argues that "multiple spelling entry is probably restricted to those words that are of moderate difficulty or are moderately confusing" (p. 492).

In order to investigate whether the orthographic exposure effect is limited to a set of items that are considered to be difficult to spell, this experiment utilised a selection of words that most adults can spell quite easily and automatically. It was hypothesised that, since the orthographic exposure effect is beyond the conscious control of the reader, it is possible that even presentation of words that are considered to be easy to spell could be adversely affected by exposure to an incorrectly spelled item. However, it was expected that there would be less of an effect of orthographic exposure since it is very unlikely that adults would misspell words like ‘bottle’, ‘fox’ or ‘finger’ by virtue of encountering a misspelling. For this reason a different methodology from that of the preceding studies (Experiments 1 - 4) was used whereby timing of spelling, as well as accuracy, was investigated.

Spelling time has been used as a measure of performance in investigations of the orthographic exposure effect by Jacoby and Hollingshead (1990). In their first experiment, Jacoby and Hollingshead discovered that spelling time following presentation of a correct spelling was faster than that of spelling a non-studied item. However, this facilitatory effect of exposure to a correct spelling was only evident in the conditions where the subjects were asked to reproduce the presented orthography by either writing or typing the item, there was no facilitatory effect of *reading* a correctly spelled item. This finding was supported by a significant interaction between type of encoding at study and accuracy of the presented orthography.

In the second experiment, a similar facilitation was found for those items that had been exposed spelled correctly compared to a set of non-studied items. However, in this experiment those words that had been reproduced while the exposed word was still visible on the screen (identical to the reproduction condition in Experiment 1) did not produce a facilitation effect. Only those items that were correctly reproduced from memory after the exposed word had been removed from the screen showed a significant decrease in spelling time compared to the New items.

Thus, while both experiments indicate that exposure to a correct spelling may have a facilitatory effect on subsequent spelling time if the exposed word is reproduced, the findings are contradictory with respect to details of the exposure and reproduction conditions. The results of Experiment 1 indicate that spelling time is reduced if a correct spelling is reproduced by direct copying, while those of Experiment 2 suggest that the facilitatory effect only occurs if the reproduction is carried out post-exposure. In contrast, both experiments provide consistent data on the effects of exposure to an incorrectly spelled item. In both experiments there was no significant difference between the spelling times for the words previously seen spelled incorrectly and those words that were new at test regardless, of whether the exposed word was copied directly or reproduced from memory.

The inconsistency in the above data may reflect methodological problems in measuring spelling speed. For the final dictated spelling test, Jacoby and Hollingshead presented subjects with words on a tape. Following presentation of each item, an arrow appeared on the computer screen and subjects were requested to type the item into the computer and to press the return key when they had finished. Subjects were allowed to change the spelling of the item as much as they required until they had pressed the return key. There was no instruction to type as quickly as possible and indeed some of the scores were so large that the data had to be subjected to a logarithmic transformation. It therefore appears that the measurement of spelling speed in this experiment was not very accurate and therefore was probably not reflecting possible conflict within the lexical representation.

Other attempts to measure speed of spelling have also been problematic. Sloboda (1980) attempted to measure speed of spelling by presenting two alternative versions of a spelling and asking the subject to choose the correct one as quickly as possible. This is not an appropriate methodology to employ in the context of the current experiments, since it would involve presentation of a second misspelling whose effect on spelling performance is being explored. Also, it can be argued that this method does not reflect spelling processes, but rather those of reading, since the subject simply has to read both items and choose the one s/he considers to be correct.

Another paradigm of measuring spelling time was introduced by Kreiner (1992) by using a spelling probe test derived from a test originally used for short-term serial recall by Sternberg (1969). In this test, a target word was presented auditorily to the subjects followed by visual presentation of a single letter. Subjects were required to press a right-hand button if the probe letter was contained within the spelling of the auditorily presented word and to press a left-hand button if it was not. Spelling times were therefore calculated as reaction times following presentation of the letter probe. The legitimacy of claiming that this is a useful tool for measuring spelling time, however, can be debated since at no point are the subjects required to spell the target item. In addition, Kreiner himself points out that abnormal strategies may be utilised when a spelling probe test is used rather than measuring the duration of producing an orthography.

In order to overcome the problems of ecological validity of the spelling probe task, Kreiner conducted a second experiment using an oral spelling technique. In this task, the experimenter read the target word aloud and subjects were asked to spell the word aloud and to press the space bar on the computer upon completion. Reaction times to start and finish oral spelling were recorded. However, the time differences between finishing the spelling and pressing the space bar introduce a large amount of error variance.

A more controlled method of measuring spelling speed was devised by Glover and Brown (1994). They used an oral spelling test coupled with a spectrographic recording of the sound waves. From this diagrammatic representation, they could gain a very accurate measure of the amount of time taken to spell each word. This method also afforded very detailed information concerning the time delay between offset of the stimulus word and onset of spelling and between the vocalisation of each letter. The only drawback of this particular method is that it assumes that oral spelling and written spelling are based upon the same mechanism.

Evidence that oral and written spelling are not comparable procedures have been discovered in cognitive neuropsychological cases, where a double dissociation between oral and written spelling has been found. Patients have been reported who possess good or moderate written spelling whilst being poor at oral spelling (JP - Kinsbourne and Warrington, 1965; JC - Bub and Kertesz, 1982), contrasting with those patients who demonstrate a superiority for oral spelling over written spelling (CM - Kinsbourne and Rosenfield, 1974). Margolin (1984) has argued that although these cases reflect the possibility of suffering from impaired output routes, both oral and written spelling derive from a single graphemic buffer. Lesser (1990), however, has provided some evidence that oral and written spelling may not even utilise the same graphemic output buffer. She describes a patient, CS, who demonstrated different effects of written and oral spelling which appear to exert influence prior to the graphemic output stage. For example, CS appeared to be a surface dysgraphic in written spelling, displaying a clear advantage for spelling words than producing plausible spellings for nonwords and yet this was not found in his oral spelling. Conversely, he could also be described as a phonological dysgraphic for oral spelling since a clear regularity effect was discovered, but this was not evident in his written spelling. Since regularity and lexical status are variables which are considered to affect spelling performance at a level prior to graphemic output, it appears that written and oral spelling may be two separate processes entirely and thus generalisation of data concerning oral spelling times is seriously questioned.

For the present experiment, it was decided that measuring spelling times using typing would be preferable to using oral spelling. In order to minimise individual differences, and to make the task appear naturalistic, subjects were recruited on the basis that they were proficient at typing. It was considered that using typists would reduce the large amount of variance found in the scores of Jacoby and Hollingshead (1990) and thus would be more likely to reflect lexical conflict time. The technique involved auditory, computer-generated, presentation of stimulus words, with words being typed onto the computer keyboard by subjects. The interval between stimulus onset and completion of typing response (pressing of space-bar), was timed by the computer and taken as the measure of spelling speed. Stimulus word onset, rather than offset, was chosen as the signal for timing to begin, because there is some evidence from speech processing research that words are processed from the onset of the voiced stimulus (Marslen-Wilson and Tyler, 1980). Space-bar press was chosen as the signal to end timing since it is almost automatic for a typist to press the space bar after typing a word and thus constituted an ecologically valid task.

If the orthographic exposure effect observed in previous research and in the experiments reported in the preceding chapters is a general phenomenon, and not limited to difficult-to-spell words, then the easy-to-spell words used in the present study should also show the effect. That is, exposure to a correct spelling should decrease subsequent spelling time relative to new words and that exposure to a misspelling should increase spelling time compared to new words. This is because, for the correct spelling, the lexical representation will have been accessed recently and therefore subsequent access should be faster. This prediction is in line with data from repetition priming where reaction time measures have been shown to be facilitated on subsequent presentation of the target item (Scarborough, Cortese and Scarborough, 1977). However, it is contradictory to those of Jacoby and Hollingshead where there was no facilitatory effect of spelling speed following the *reading* of a correctly spelled item. For the incorrect spelling, however, although the lexical representation will probably have been accessed, the orthography is likely to be contradictory to the information already stored and it is, therefore, hypothesised that spelling times will be longer for these items due to conflict at the lexical level.

Method

Subjects

30 clerical and administrative staff from City University, London, participated in this study. All had good keyboard skills and spoke English as their first language. All subjects were paid for their participation and were tested individually. None of the subjects had previously participated in any of the other orthographic exposure experiments.

Design and Stimulus Materials

Three lists of 18 words were compiled, ranging from 3-7 letters in length. All the words were considered to be rarely misspelled by skilled adult spellers (for example, ‘war’, ‘carpet’ etc.) and were matched for frequency and letter length across the groups. (A full list of stimuli can be found in Appendix B). Each list was produced in a Correct version, where the words were spelled in standard English, and an Incorrect version, where a phonologically plausible misspelling of the word was produced (for example, the word ‘bottle’ was presented spelled incorrectly as ‘bottul’). The design involved presentation of two of the three lists, one in Correct, and the other in Incorrect, form. The two lists of words were randomly selected for each subject by the computer programme and the items from both lists were mixed and presented one at a time on the screen in a random order.

In the test phase of the experiment, subjects were presented aurally with all three lists of words: a list they had seen spelled correctly, a list they had seen spelled incorrectly and a list of words that they had not seen previously. Once again, items from all three lists were presented in a random order by the computer. The subjects were required to type each word into the computer upon hearing it and then press the space bar to proceed onto the next item.

Apparatus

An IBM compatible 386 computer equipped with a soundblaster card was used for visual and aural presentation of the stimuli. The software employed was 'Monologue for Windows' driven by a Visual Basic programme.

Procedure

Study Phase

Subjects were told that they would see a series of words displayed on the screen and that some of these words would be correctly spelled and some would be incorrectly spelled. They were asked to read each word aloud to verify correct perception of incorrectly spelled items, and to proceed to the next word by pressing the space bar on the keyboard. There were no time limits in this part of the experiment and any misperceptions were corrected by the experimenter.

Test Phase

Subjects were instructed that the computer would present them with a spoken word and that they should type the correct spelling of this word as quickly and accurately as possible. At the end of typing an item, subjects were instructed that they must press the space bar as quickly as possible which would signify the end of the timing and would bring the next item to the screen. If an item was difficult to recognise, subjects were instructed to either produce their best guess or to omit the item and press the space bar to proceed. The computer recorded the responses made and the time from the onset of the presentation of an auditory stimulus to the space bar press at the end of typing of that word was also recorded automatically by the computer.

Debriefing followed the test phase and included asking the subjects to read through a list of correctly spelled words that had been used in the experimental condition. This was performed to help to counter any possible detrimental effect following exposure to a misspelling.

Results

Two aspects of spelling performance were collected - spelling times, and spelling errors. The means and standard deviations as a function of type of prior presentation (Incorrect, Correct and New) are shown in Table 8.1 (the raw data can be found in Appendix C).

Table 8.1 Means (and standard deviations in parentheses) of spelling times and spelling errors at final test.

	Orthographic Accuracy at Study		
	Incorrect	**New**	**Correct**
Spelling Time (secs.)	**3.72** (1.29)	**3.71** (1.22)	**3.46** (1.05)
Spelling errors	**0.27** (0.64)	**0.07** (0.25)	**0.00** (0.00)

Spelling time was analysed using a repeated measures ANOVA which revealed that there was a significant effect of orthographic accuracy at study [F (2,58) = 5.17, MSe = 0.129, p = 0.009]. Inspection of the means shows that this effect was carried by the Correct condition, where spelling times appear to be shorter (3.46 seconds) than in either the New or Incorrect conditions (3.71 and 3.72 seconds respectively), with little difference between the two latter conditions. This was supported by the results from planned comparisons which demonstrated that there was a significant effect of priming for the words that were presented correctly spelled, as shown by a significantly faster spelling time for correctly spelled words than that of new items presented at test [F(1,29) = 12.84, MSe = 0.10, p = 0.001). The difference in speed of spelling in the final test between the incorrectly spelled items and new items, however, failed to reach significance [F(1,29) = 0.01, MSe = 0.15, p = 0.92). This does not support the initial prediction. A further post hoc comparison was performed using a Tukey's Honestly Significant Difference test (critical value = 0.246) which revealed that the difference between Incorrect and Correct was significant at the $p < 0.01$ level.

Analysis of the errors was not possible due to the very small numbers of misspellings produced at test. However, an inspection of the results in Table 8.1 reveals that the pattern of results is similar to those found in the other experiments in this thesis. The total number of spelling errors made for those words that had been seen misspelled was 8, compared to 0 for those words seen correctly spelled and 2 for the new words. This provides some evidence that even exposure to misspellings of simple words can cause a detrimental effect on subsequent spelling performance.

Discussion

The results of this study provide partial support for the original prediction in that there was a significant decrease in spelling time following the exposure to correctly spelled words. This result is contrary to those of Jacoby and Hollingshead (1990), who found that spelling time only decreased following reproduction of the spelling while it was on the screen (Experiment 1, but not Experiment 2), or following reproduction of the spelling after it had been removed from the screen (Experiment 2). The reason for these contradictory results could lie in the difference in spelling times between the present experiment and the experiment by Jacoby and Hollingshead. The spelling times in the Jacoby and Hollingshead study were generally much longer than those reported in this study (means for all conditions in the Jacoby and Hollingshead study were greater than 5 seconds) and they were also subjected to a logarithmic transformation to take large outliers into account. This means that any small time differences due to a facilitation effect of presenting a correct spelling could remain unnoticed due to the relatively large time involved in actual typing. In the present experiment, typing times were relatively quick and the typing was performed by subjects who had good keyboard skills, providing more opportunity for facilitation effects to emerge.

The prediction that there would be an increase in spelling time following the presentation of an incorrectly spelled word, compared to spelling time for a New item, was not supported by the data. The mean spelling time for the New items was 3.71 seconds compared to the spelling time for the Incorrect items of 3.72 seconds. There is, however, a possible methodological reason for this apparent lack of an effect.

The computer generated words sounded rather artificial and were not always easy to understand; introspective comments of the subjects indicated that they had considerable difficulty in identifying the words, and frequently resorted to conscious retrieval of words seen during the exposure phase as an aid to deciphering the auditory stimulus at test. This would suggest that words which had been seen in some form, be it orthographically correct or incorrect, should be processed more rapidly at test than New, unexposed words, simply because they would be perceived more easily. In other words, spelling times for New words would be artificially elongated, relative to Correct and Incorrect words. This would increase any underlying facilitatory effect for Correct words, magnifying the Correct-New difference, but reduce any real Incorrect-New difference. Hence the absence of a significant difference between spelling times for Incorrect and New words may, in fact, be an artefact arising from the shortcomings of the experimental hardware.

To test this hypothesis the data were analysed in terms of missing cases for Incorrect, New and Correct conditions, on the basis of the following rationale. When a subject was unable to perceive the presented stimulus at test, they had been instructed to move on to the next item by pressing the space bar. These unperceived items therefore presented as missing cases. If New items were indeed more difficult to perceive at test than Correct and Incorrect items, which had already been processed during the visual phase of the experiment, this should show up as a greater number of missing cases in the New condition. In other words, the response rate should be lower in the New condition. This was found to be the case where the response rate for the New items was 62.9%, compared to the mean for Incorrect which was 70.2% and Correct which was 65%. These response rate data were analysed using a repeated measures

ANOVA and a highly significant main effect of accuracy of orthographic exposure was found [$F(2,58) = 5.44$, $MSe = 2.48$, $p = 0.007$]. Planned comparisons revealed that although the Correct-New difference did not reach significance [$F(1,29) = 0.80$, $MSe = 2.02$, $p = 0.38$], the Incorrect-New difference in baseline responding was highly significant [$F(1,29) = 8.63$, $MSe = 2.94$, $p = 0.006$]. It appears, therefore, that New items did present a higher level of perceptual difficulty at test than items which had been seen during the exposure phase of the experiment. This difficulty would have increased response times for New items relative to Correct and Incorrect items, leading to a spuriously high baseline response latency. Hence a real effect of an increase in spelling time for Incorrect items would be masked by an artificially long baseline measure derived from New items, lowering the chance for an Incorrect-New difference to emerge. Conversely, of course, the artificially high baseline time would increase the apparent facilitatory effect of prior exposure to correct items.

In view of this possible confounding factor, the most relevant test for the orthographic exposure effect is a comparison between spelling times Correct and Incorrect items, since both types of items will have been seen at exposure and be comparable in perceptual difficulty at test. This comparison in fact revealed a significant difference between Correct and Incorrect words. Thus spelling times following exposure to a correct orthography are shorter than spelling times following exposure to an incorrect orthography. This represents the essence of the orthographic exposure effect. It seems that even in very simple words prior exposure to a spelling can affect internal spelling procedures, with this influence emerging in response times.

In fact, the orthographic exposure effect in these simple words can also be seen to some extent in the spelling error data, an index of performance which was originally considered unlikely to yield observable differences between exposure conditions because of the simplicity of the words used. Inspection of the error data, which were too small for reliable statistical analysis, shows an overall pattern similar to those of previous studies, with the greatest number of errors for those items that had been presented spelled incorrectly, a smaller number of errors for those items that were new at test and a relatively smaller number of errors for those items that were presented spelled correctly at test.

Although the data in this experiment must be interpreted with caution, they provide some evidence that the orthographic exposure effect was evident in words that are considered to be easy to spell. This has important theoretical implications. First, it provides support for the results of experiments reported in previous chapters which used a different methodology. This provides good evidence that the orthographic exposure effect is a real phenomenon and cannot be considered to be a consequence of a particular methodology. Second, any conclusions derived from the previous experiments can be generalised, with caution, across a range of lexical items and cannot be considered to be a curious phenomenon specific to a small subset of words.

Third, the fact that misspellings appeared to produce a detrimental effect on subsequent spelling in terms of both spelling times and accuracy, provides important information concerning the location of spelling disruption; that is whether misspellings are stored separately from the correct spelling or within a single representation with the correct orthography. It has already been argued (see Chapter 3) that the creation of a new lexical representation requires multiple presentations of the item. It follows, therefore, that in this experiment lexical competition is unlikely to have occurred as a result of the creation of a new competitive lexical exemplar following a single presentation. An alternative could be that the exposed misspelling was already stored within the lexicon as a separate lexical item. On presentation of this item at study, the existing representation would be activated and thus the disruption would be caused by competition between the newly activated incorrect version and the orthographically correct lexical representation. However, the items used in the present experiment were all words that were considered to be easy to spell and thus were unlikely to have been encountered spelled incorrectly. This means that for these items, it is unlikely that the incorrectly spelled versions were already represented within the lexicon.

The only possible mechanism to mediate the orthographic exposure effect with these simple words would be storage of conflicting information within a single lexical exemplar. It therefore seems that the detrimental effect of presenting a misspelling is due to intra-lexical, rather than inter-lexical competition. That is orthographic information may be ‘absorbed’ into a pre-existing lexical representation, modifying its orthographic information in some way. In weak or ‘hazy’ representations of more difficult words, this modification may emerge as a change in actual orthography generated at spelling. In stronger representations of simpler words the modification may simply alter the time course of retrieval of the correct orthography without producing an actual change in the orthographic form.

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This thesis has, so far, provided data that supports the existence of the orthographic exposure effect in skilled adult spellers. The following chapter investigates whether the same effect is evident in children who are still in the process of learning to spell.

CHAPTER NINE

THE ORTHOGRAPHIC EXPOSURE EFFECT IN CHILDREN

Experiment 7

An investigation into whether orthographic exposure affects children's spelling accuracy

Introduction

The effects of exposure of incorrectly and correctly spelled items on skilled adult spellers are now clear. It appears that the presence of an incorrect item has a detrimental effect on subsequent spelling performance (Brown, 1988) whereas correct spelling has a beneficial effect (Jacoby and Hollingshead, 1990). The results of Experiments 1, 2 and 3 reported in previous chapters also support the orthographic exposure effect and Experiment 4 has shown that the orthographic exposure effect disappears when the presented misspellings are phonologically implausible. It therefore appears that the orthographic exposure effect is quite robust. It is therefore somewhat surprising that, Bradley and King (1992) apparently failed to observe a comparable effect in children.

Bradley and King (1992) used a proof-reading task as a means of achieving visual exposure of the target items, since they argued that proof-reading tasks were often used in spelling procedures in the school environment to improve spelling ability. They presented children (mean age 11 years) with sentences containing a target word which was spelled either correctly or incorrectly. In each case, the target word was underlined to draw attention to the item. The children's task was to read the sentence (or to listen to it since the experimenter also read the sentences aloud) and to decide whether the target word was misspelled or not. It could therefore be argued that this was not a true proof-reading task since separate sentences were created for each word, the target word was underlined, and the children were asked to make an explicit decision as to the accuracy of the spelling. The children were randomly assigned to one of three groups controlling orthographic exposure of the target items. One group was exposed four times to the misspelling, another group was exposed twice to the misspelling and twice to the correct spelling, and the final group was exposed four times to the correct spelling. Each presentation of the orthography was presented in a different sentence context, for example, 'My aunt and uncle came to dinner' and 'My uncle is a pilot'. Bradley and King also implemented three different times of testing of spelling as a within-subjects manipulation; a pre-test, an immediate post-test and a delayed post-test.

Bradley and King expected to find that proofreading of misspellings would increase the number of spelling errors made. However, this was not supported by the data. They discovered that exposure to misspellings had no significant effect on subsequent spelling accuracy, whereas exposure to the correct orthographies improved spelling accuracy even in the condition where the target items were presented twice misspelled and twice correctly spelled. Further inspection of the data showed that some subjects (but very few) were adversely affected by the presentation of incorrect spellings but that most of the children greatly improved their spelling after presentation of a correctly spelled item.

Bradley and King (1992) claimed that, in some cases, the presentation of an incorrect spelling actually *improved* subsequent spelling. They cite the example of a child who wrote 'bredfast' as their initial spelling of 'breakfast', but then changed to 'brekfast' after the presentation of this incorrect spelling of the item. The latter orthography rendered a better approximation of the spelling than the initial attempt since, not only was it phonologically plausible, it was also only one letter away from the correct spelling rather than two letters away as was the initial attempt.

There were, however, several flaws in the Bradley and King (1992) study. First, there was no control group to establish how the error scores varied over the period of testing when no versions of the target word were presented. This is important, since the difference in error scores from pre-test to post-test was rather small (approximately 5%) and may not differ significantly from the natural fluctuation of spelling accuracy. Second, there was a problem in the ANOVA analysis concerning the use of the test-retest variable as two levels of a within-subject variable. Huck and McLean (1975) argue that using this test greatly increases the probability of a type II error (the incorrect acceptance of a null hypothesis) since the variation of type of spelling presentation can only affect one level of the time of testing variable (i.e. the post-test) and therefore the variation within this can only be half the potential amount it should be. This means that the inability to find a significant detrimental effect of presenting misspellings could be due to the type of analysis performed rather than a true reflection of the data.

Ehri, Gibbs and Underwood (1988) also investigated the impact of incorrect spellings on subsequent spelling performance in children. In their study (Experiment 1), they asked children (mean age of 8.75 years) to produce spellings for auditorily presented pseudowords. The subjects were then told that this spelling was incorrect and were shown the 'correct' version. Ehri et al. found that asking children to create 'incorrect spellings' in this way did not affect their subsequent ability to learn the 'correct' spellings of these items as defined by the experimenter. However, the use of pseudowords, rather than real words, in this experiment provides a number of problems. First, there is no orthographically 'correct' spelling of the word other than that dictated by the experimenter. In this case the 'correct' spellings were chosen on the basis that they were difficult to guess and therefore a subject's invented spellings were probably quite different from the 'real' spelling. Since Brown (1990) suggests that confusion may arise only when an incorrect spelling is similar to the correct version, it could be argued that the large difference between the spellings used by Ehri et al. and those created by the children resulted in a lack of confusion. Second, unlike a real word, the pseudoword has no lexical representation. Since, in adults, the negative impact of encountering a misspelling is thought to be mediated via the lexical activation, the presentation of an item with no lexical representation would not be expected to have any effect. There is some support for this notion from Experiments 2 and 3, where Ehri et al. investigated the effect of misspelling pseudowords in the adult population. Under these conditions, they found no detrimental effect of inventing a misspelling, thus supporting the argument that the technique using pseudowords is not comparable to that of using real words.

Previous studies investigating the effects of presenting misspellings to children have therefore produced different results from those with adults. This could be due to the methodological difficulties, as in the Bradley and King study, or could reflect a real underlying difference. A possible difference between adult and child spelling is that children may have not yet established, or have less well specified, lexical representations. However, there is evidence from other areas of research that lexical information can influence the spelling processes of children, the implication being that lexical representations have been established.

One example of such research is in the area of lexical priming of nonword spelling. It was found that children's spelling of nonwords could be influenced by the orthography of real word primes, under conditions of direct priming where prime and target nonword share phonology (for example, using 'soap' to prime the spelling of the nonword 'boap', Campbell, 1985), and under conditions of associative priming, where prime and target do not share phonology, but where priming is mediated by a covert close associate of the overt prime (for example, 'vatican' to prime the spelling of the nonword 'bope' via 'pope', Seymour and Dargie, 1990; Dixon and Kaminska, 1994). The fact that significant levels of priming were found in each case suggests that lexical information was available and able to influence spelling for primed nonwords, and hence that lexical representations containing specific orthographic information have already been established. On the other hand, the levels of priming, although significantly above zero, were rather low. A comparative study of direct and associative priming in adults and children (Dixon and Kaminska, 1994) revealed that levels of priming were slightly lower for children than for adults.

Another area of research providing support that children are able to use some sort of lexical knowledge in spelling production comes from investigating the role of spelling-to-sound contingency in children. Both Barry and Seymour (1988) and Goulandris (1994) report that children are sensitive to the frequency with which they encounter sound-to-spelling patterns in their reading vocabulary. Children are more likely to produce high contingency, (frequently occurring sound-to-spelling) than low contingency, spelling patterns in free spelling. However, whether this can be considered to be a truly lexical phenomenon depends upon whether contingency patterns are abstracted from the orthographic lexicon (Barry and Seymour, 1988) or are derived from feedback between the presented stimulus and the phonological output lexicon (see Chapter 3 for a further discussion on this point).

It appears from the research outlined in the preceding paragraphs that, at least in some cases, children are able to utilise lexical information, suggesting that they have well-developed lexical representations. However, the current teaching techniques in this country (which were employed by the school where children from the present experiment were tested) emphasise the role of inventing spellings from the sound of the word. This teaching technique may neglect the role of lexical information in spelling and may lead to less well-developed lexical representations than children who are taught to spell in more formal ways. At this point it seems appropriate to consider current teaching practice within the UK, since this has a bearing on the information and procedures which children may or may not have available to them when attempting to spell.

Current Teaching Practice

Present teaching practice in this country is strongly influenced by developmental writing. Developmental writing has emerged mainly from Charles Read's (1971; 1975; 1986) work on invented spelling and from Bissex's (1980) longitudinal case study of her son's creative spellings. Invented, or creative, spellings are those spellings produced by children when they do not have access to the standard spelling of a word. In this case, a child spells a word in the only way that he/she knows how, by transcribing the sounds in the word onto paper. Since these alphabetic spellings differ from standard English orthography they offer insight into the way in which children perceive spoken language. A number of researchers (Read, 1971, 1975; Chomsky, 1971; Treiman, 1985, 1993) have studied the way in which these spellings differ from standard spelling. One such deviation from standard spelling is the representation of short vowels by a phonetically similar letter. Read (1986) cites an example where the spelling of /ɛ/, for example the 'e' in 'bed', is spelled using an 'a'. He argues that children use an 'a' since phonetically the sound /ɛ/ falls between the sound and the name of the letter 'a' (as found in 'bat' and 'bait' respectively). Children also have a tendency to omit preconsonantal nasals, for example the 'ng' in 'ring', since, not only is there no clue from the nasal sound that it can be represented by a consonant, but also children may regard the nasalisation sound as a property of the vowel. Another common finding is that words beginning with 'tr' and 'dr' and often represented by 'chr' and 'jr' respectively, since the /t/ in 'trip' is affricated and therefore more closely approximates 'ch' - 'chrip'. All of these above deviations from standard spelling, and many that have not been reported here, are based upon the perceived physical aspects of the spoken language which are often no longer attended to when standard spelling has been achieved. Much of the initial research into invented spelling was aimed at providing insights into the categorisation of speech sounds rather than investigating the nature of spelling development. Read (1975) does, however, suggest that the research provides a solid framework within which to understand the nature of the misspellings produced by children and Treiman's (1993) development of his work aims to do this.

From the above data and the longitudinal study by Bissex (1980), who charted the development of her son's spelling in the absence of any formal teaching, a theory of developmental spelling was devised (Gentry, 1981, 1982; Henderson and Templeton, 1986). This was a stage theory of spelling within a Piagetian framework, whereby each stage represents 'a different conceptualisation of English orthography' (Gentry, 1982). It is assumed that all children pass through the same stages in the same order until standard (or correct) spelling is achieved. The five proposed stages of development are: prephonemic (where meaningless scribbles are used), early phonemic (words are often represented by one or two appropriate letters), lettername spelling (children's attempts at spelling are longer but they tend to overuse letter names in spelling, e.g. 'R' for 'are'), transitional (where some knowledge of the orthographic rules of English becomes apparent) and the final stage where correct spelling is achieved. This developmental theory of spelling has been widely accepted and has been adapted into a teaching model known as developmental writing. Developmental writing, it is claimed, allows a child to create uninterrupted writing and flow of ideas unburdened by having to spell correctly. Proponents of this theory believe that emphasis on correct spelling at the beginning of writing inhibits creative flow, since words may be chosen on the basis of whether they can be spelled correctly rather than for their suitability to the writer's intention. Teachers are encouraged to help children progress through these natural stages and to tailor instruction to the particular stage a child is at. This model of teaching is now advocated in many teachers training manuals (e.g. Flood & Salus, 1984; Fisher & Terry, 1977; Hennings, 1982; Mudd, 1984; Norton, 1980; Quandt, 1983; Temple & Gillet, 1984; Temple et al, 1988 etc.) and is also stressed in the National Curriculum (DES, 1990) where it is stated that 'Teachers should help children to develop from invented spelling towards conventional accuracy'.

It can be seen that this method of teaching encourages children to spell by concentrating on the sound of the word, that is, the phonological route, and that the sophistication of their phoneme-to-grapheme conversion will be dictated by the developmental stage they have reached. For example, a child who has some knowledge of the orthographic rules (i.e. is at the transitional stage) may know that the letters 'ough' sometimes map onto the sound 'uff', as in 'enough', and could incorrectly apply these letters to the word 'buff'. Developmental spelling, therefore, heavily stresses the role of phonological information in children's spelling, even though the words being written have usually been encountered in print many times before and should, according to most developmental reading theories, have some type of lexical representation.

This present study sought to investigate the effects of presenting correct and incorrect spellings to children. A test-retest design was used whereby children were exposed to correct and incorrect spellings as an interpolated task between an initial spelling test and a post-exposure spelling test. Real words were used and several different conditions were implemented to present the target items. In one condition, children were presented with each word separately. The reasons for this were twofold. First, presenting the words singly, rather than as a proof-reading task, allows a direct comparison between children and adults since the previous published studies (Brown, 1988; Jacoby and Hollingshead, 1990) have used an item-by-item presentation format. Second, many of the techniques or tests used to help spelling accuracy utilise multiple choice testing, where the child is shown several orthographies of the item and is asked to pick the correct spelling. It is therefore important to know that this kind of presentation designed to aid spelling is not, in fact, detrimental to children's spelling accuracy.

In a second condition, the target words were hidden in a story. This condition enabled direct comparison between the effects of presenting target words in text with adults (Experiment 2, Chapter 6). The inclusion of this condition served also to provide further information concerning whether children are susceptible to implicit priming or whether they rely upon explicit information at study. An effect similar to that found with adults would be expected if children are susceptible to implicit priming. If, however, children rely upon explicit orthographic information at study then a much smaller effect would be expected since orthographic information is less likely to be explicitly noticed when the target words are embedded in a story. Furthermore, the inclusion of this condition provides a more realistic proof-reading task than that used by Bradley and King (1992), where each target word was embedded in a different sentence and the target word was highlighted by being underlined.

A third condition included in this experiment concerned copying of the spelling of each presented target item. The reason for including this was to investigate further the nature of the priming process. If children are explicitly trying to recall the previous encounter, rather than priming occurring at an implicit level, then copying the items (rather than reading them) should result in a stronger effect.

Finally, a control condition was included to investigate the consistency of children's spelling when no interpolated task is given.

It was hypothesised that, if children have a well developed lexicon by the age of 10-11 years, the results of this experiment should mirror those of adult studies in which the presentation of a misspelled word has a detrimental effect on subsequent spelling performance and a correct spelling has a beneficial effect. It would also be expected that the influence of presenting the orthographies would not vary across the three experimental conditions (Spell words vs. Read words vs. Read story) supporting the findings that degree of effortful processing does not affect the orthographic exposure effect (Jacoby and Hollingshead, 1990; Experiments 2 and 3, Chapter 6 in this thesis). If, however, children rely more upon phonological processes than lexical information in order to spell, it would be predicted that they should be less affected by lexical influence from the visual form of an orthography. It is possible, however, that children may be helped by the presentation of a correct spelling (or even sometimes by a misspelling if it is closer to the real spelling of the item than the child's initial attempt) as an explicitly remembered reference rather than as a lexical influence. If this is the case then this should present in three different ways:

First, the beneficial effect of presenting a correct spelling would be very small, since the presentation of 40 items far exceeds the usual short term memory span of approximately seven items (Miller, 1956), and so only a few items would be available for explicit recall.

Second, there should be a gradually increasing effect of presenting *correct* orthographies as the nature of encoding becomes more effortful - that is, from asking children to spell the words, to reading the words individually to reading the words in text. This is because the more effortful the encoding, the more likely they will be remembered on a future occasion (Craik and Lockhart, 1972). How the encoding will affect *incorrect* items is unclear since these could either help or hinder subsequent spelling, depending on the pre-existing spelling knowledge of the children. If a child's spelling is very bad then it could serve to improve the spelling since it might well be closer to the correct orthography than the child's initial attempt. If, however, the child has appropriate knowledge to spell the word correctly then presentation of an incorrect item could have a detrimental effect.

Third, the number of different alternatives used to spell the words within the group of children may also indicate the use of explicit recall. If children are explicitly trying to recall the items, then, regardless of spelling accuracy of the presented item, the number of alternative spellings of a word at pre-test should be greater than the number used to spell the word after presentation of an item. This is because all the children will have recently seen one of two possible orthographies of the item (spelled correctly or incorrectly) and will therefore be starting to recall the spelling from the same fixed reference point and not trying to create a spelling individually. Furthermore, on the basis of the premise that constriction is based on explicit memory processes, any constriction of alternatives should be related to the condition of encoding, with more effortful encoding leading to a greater degree of constraint on alternative spellings at post-test (i.e. Spell words > Read words > Read story).

Thus if the children are affected by orthographic exposure in the same way as adults, a strong orthographic exposure effect should be found in all three of the experimental conditions. If, however, children use the presented misspellings as an explicitly remembered reference point, then there should be very little effect of orthographic presentation and any effect should be more noticeable in the conditions which require more effortful processing.

Method

Subjects

A total of 93 children, all of whom were attending a primary school in North London, participated in this experiment. The children were taken from four parallel classes, each of which contained an equal mixture of Year 5 and Year 6 age groups. The number of children in each condition was not equal, there were 21 children in the control group, 22 in the 'Spell words' condition, 26 in the 'Read words' condition and 24 in the 'Read text' group. The mean age of the total group of children at the time of testing was 10 years and 10 months (standard deviation = 7 months). It should also be noted that the children's ages across the four classes did not differ significantly [$F(3,92) = 1.25$, $p = 0.295$). The children were pre-tested in their respective classes, but were generally post-tested in smaller groups.

Design

A test-retest design was used for this experiment with each subject serving as his/her own control. This particular design was chosen for several reasons. First, each of the four classes participated in a separate condition. Although the classes were randomly assigned to the four conditions, the original assignation of children to classes may not have been on a random basis and therefore the groups may not have been comparable. To overcome this limitation, the scores that were used in the analysis were the difference between each child's post-test and pre-test spelling score. This method of analysis legitimised comparison between the groups. To further validate the legitimate comparison of the four classes, children's pre-test scores were analysed using an ANOVA to investigate whether the groups performed significantly differently from one another. The pre-test scores for the groups were very similar and this was supported by the analysis that revealed no significant differences between the groups [$F(3,92) = 1.068$, $MSe = 1233.985$, $p = 0.367$].

Second, it was considered that investigating the difference between the number of alternative spellings used for the same word at pre-test and post-test across the group of children could provide a useful insight into the mechanism underlying any possible effect of presenting spellings to children. These data could therefore only be collected by implementing a test-retest design. Finally, using a test-retest design allowed a direct comparison between the results obtained from the present experiment and those obtained by Bradley and King (1992).

The basic design involved an initial dictated spelling test consisting of 40 items, followed by a final dictated spelling test consisting of the same 40 items. In the intervening period the main experimental manipulation of exposure to spellings of the test items took place. Four exposure conditions were employed. In one condition (Read words), the children were presented with individual words on cards and were asked to read these words aloud. In another condition, (Spell words), children were presented with the same cards but were asked to copy the spelling of the words onto a separate piece of paper. In a third condition, (Read story), children were given a story to read aloud in which the target words were placed, but were not highlighted in any way. The fourth condition was a control condition, with no exposure to the target items. In the three conditions which involved exposure of items, half the items were spelled correctly, and the other half were presented incorrectly spelled. The items were counterbalanced across subjects within each of these conditions so that those items shown incorrectly spelled to half of the children were shown correctly spelled to the other half.

The exposure manipulation took place after the lapse of one week from the initial spelling test. The final spelling test was given immediately after visual presentation of the target items.

Materials

The items used for this experiment were 40 words and their respective misspellings selected from the original list of 90 items used by Bradley and King (1992). From these forty items, two lists were compiled. In order to counterbalance the items, the words presented in their incorrect form to one set of subjects were presented in their correct form to the other set of subjects and vice versa. For the 'Read words' and 'Spell words' condition, the words were typed in lower case letters (font size 24) onto individual cards and these cards were shuffled to randomise presentation for each group. For the 'Read story' condition, the words were put into the context of a story of less than 500 words, which was typed in font size 15 onto A4 paper. The basic set of 40 items, their misspelled versions, and the context providing stories are shown in Appendix B.

Procedure

Initial and Final Dictated Spelling Tests

The procedure for the two spelling tests was identical. In each, forty words were read aloud by the experimenter at a pace appropriate for the class. A new word was presented only when the whole class had finished writing, and any items not heard properly were always repeated upon request. The children sat at individual desks to reduce the possibility of copying. The children were encouraged to attempt to spell all the words and were told not to worry unduly about whether their attempts were spelled correctly or not. Any items that could be considered ambiguous, or that the children found difficult to grasp, were presented in the context of a defining phrase (for example, 'island', which might be mistaken for 'Ireland' was clarified to, 'as in a tropical island' - 'island').

'Spell Words' Condition

Children were tested in groups of approximately five. A card was presented to them and they were asked to read the word aloud and then copy it down onto a separate piece of paper letter by letter (even if they knew that the word was spelled incorrectly). Exposure to each new item occurred when the whole group of children had accurately recorded the presented item. In the event of an incorrect replication of the item, the experimenter asked the child to write the word again.

'Read Words' Condition

Children, also tested in groups of five, were shown a card on which a word was printed and were asked to read the words aloud. On the majority of occasions the children read the word out together. The experimenter only intervened when the children were unable to decipher a particular item (which happened surprisingly rarely) or when it was necessary to correct any wrong attempts at the word.

'Read Story' Condition

In this condition, children were tested with others of similar reading ability (as estimated from their spelling scores and some advice from the teachers). Each child was given a copy of the story on a sheet of paper and was asked to read the story aloud. Those children who found reading easy, read the story aloud together. The experimenter read aloud the story for the children who found reading more difficult and asked the children to follow the story along with their fingers to ensure that they had seen the target words.

Debriefing

In order to overcome ethical considerations of a possible negative effect of encountering a misspelling, all the children who participated in this study were asked to read through a correct version of the list of words they had encountered in the experimental situation, before they returned to their class work.

Results

A comparison of spelling performance at pre- and post- exposure testing

The results reported here are the differences between the percentage of correct spellings achieved in the post-test condition and the percentage of correct spellings in the pre-test condition. (This method of accounting for pre-test scores was used, rather than an ANOVA using pre- and post-test as two levels of a within-subjects variable, in order to reduce the possibility of a type II error, Huck and McLean, 1975). A spelling response was only considered to be correct if the child spelled the word in standard English; phonologically plausible spellings or close approximations to the correct orthography were not counted. The control group had a mean gain percent of 2.62 and a standard deviation of 6.25, showing a slight increase in accuracy of spelling from pre-test to post-test. The mean scores (and standard deviations) for the experimental conditions are shown in the table and graph below (Table 9.1, Figure 9.1 and the raw data can be found in Appendix C).

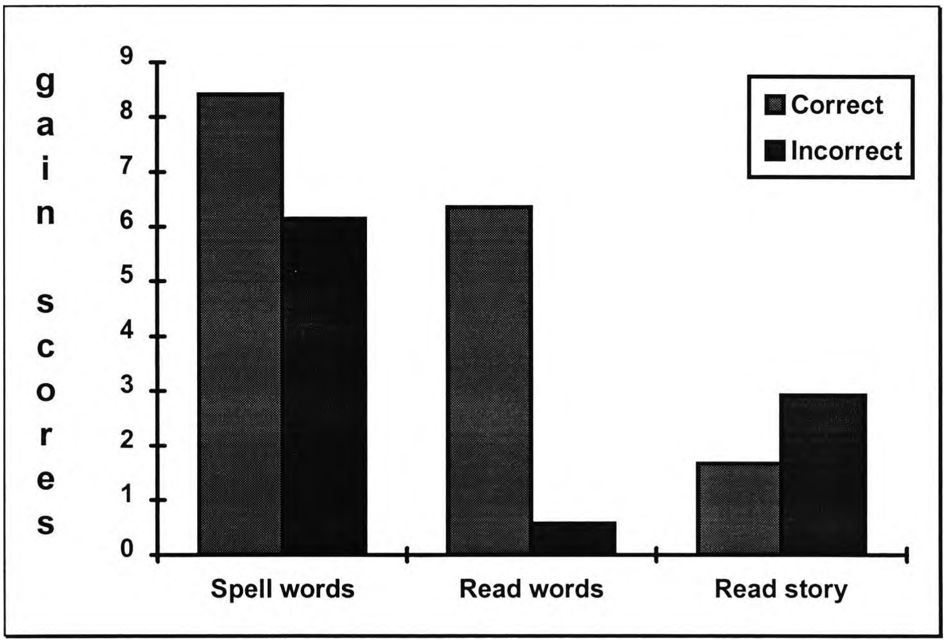
Table 9.1 Mean percentage gain scores of correct spelling (and standard deviations in parentheses) as a function of type and condition of exposure.

	Spell words	Read words	Read story
Correct	**8.41** (12.47)	**6.35** (7.94)	**1.67** (8.30)
Incorrect	**6.14** (10.57)	**0.58** (7.79)	**2.92** (9.88)

A series of independent t tests were carried out to investigate whether the scores for the different exposures and conditions were significantly different from the control group. Since six t tests were performed the $\propto$ level was set at 0.01 (Howell, 1992). No significant differences were found, although the two closest to significance were the 'Spell words' condition for the correct followed by the 'Read words' condition for the correct items. This lack of significant difference shows that the presentation of an orthography has had very little effect on the subsequent spelling accuracy of the children.

A mixed ANOVA was performed on the data to investigate differences between the experimental groups, where encoding group was a between-subjects variable and accuracy of presented orthography was within-subjects. The main effect of encoding group (Spell words vs. Read words vs. Read story) was not significant [$F(2,69) = 2.41$, $MSe = 129.99$, $p = 0.097$], neither was that of accuracy of presented stimuli [$F(1,69) = 3.72$, $MSe = 52.173$, $p = 0.058$] although this did approach significance. The interaction between encoding group and accuracy also approached significance [$F(2,69) = 3.11$, $MSe = 52.173$, $p = 0.051$]. This interaction can be seen in Figure 9.1 where, for the correct items, there appears to be a decline across the three conditions, while the incorrect items show no linear relationship. A decline across encoding conditions was expected for the correct items if children were using an explicit recall procedure from the words presented earlier, since explicit retrieval of the correct orthography is more likely following an effortful encoding procedure, and spelling words represents a more effortful process than reading. A linear trend was significant when polynomial contrasts were used ($t_1 = 2.09$, $p = 0.04$), thus providing support for the trend.

Figure 9.1 Mean percentage gain scores in correct spelling as a function of type and condition of exposure.



Number of alternative spellings

An analysis was also performed on the number of different alternatives generated by each group of subjects for each item. The data used for the analysis were the difference between the number of different alternatives produced in the post-test condition and the number of different alternatives produced in the pre-test: hence a negative score indicated a reduction in the number of alternatives from pre-test to post-test. The number of alternatives were calculated as a percentage of the total number of possible alternatives in order to overcome problems of different sample sizes in the different groups. For example, in the group containing 21 children, it is possible that each child produced a different version of the spelling from one another, thus resulting in

21 different alternatives. So if only 10 different alternatives were produced, the test score would be 10/21, i.e. 47.62%. The control group showed a mean percentage gain score of -1.43 and a standard deviation of 7.87 (i.e. a small tendency for the group to produce more homogenous spellings in the post-test group than the pre-test group). The mean percentage gain scores in number of alternative spellings (and standard deviations) for the experimental groups are shown in Table 9.2 (the raw data can be found in Appendix C).

Table 9.2 Mean percentage gain scores in number of alternative spellings (and standard deviations in parentheses) as a function of type and condition of exposure.

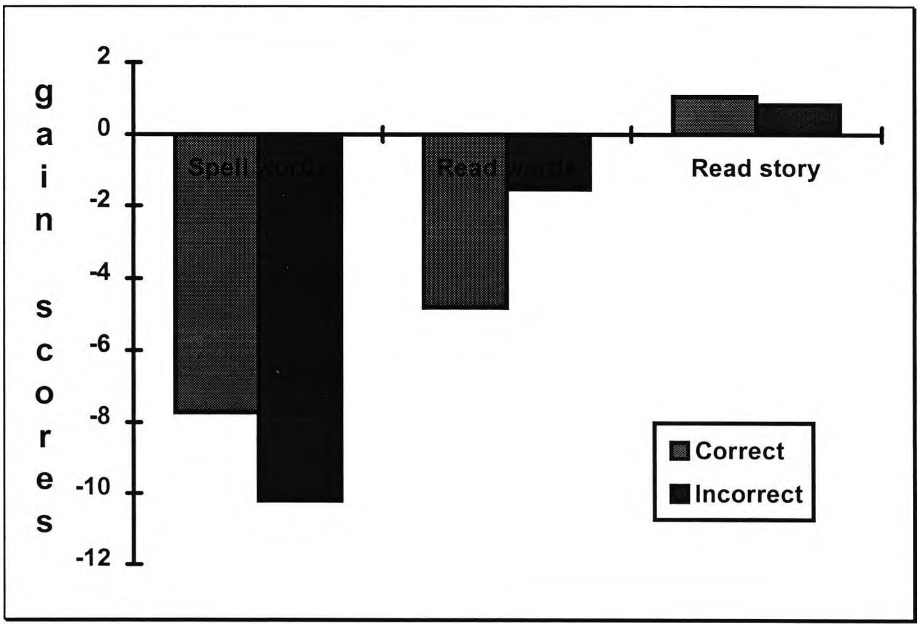
	Spell words	Read words	Read story
Correct	**-7.73*** (12.46)	**-4.81** (10.12)	**1.05** (14.52)
Incorrect	**-10.21*** (13.15)	**-1.54** (14.19)	**0.83** (11.13)

*** significantly different from the control group**

The data of Table 9.2 show that, for the 'Spell words' condition, there appears to be a strong effect of presentation of both correct and incorrect items, in that their presentation has constricted the subsequent number of alternative spellings produced. This is also evident to a lesser degree for the 'Read words' condition but is not at all evident in the 'Read story' condition. It was expected that the effect would be largest for the most explicit encoding condition and progressively smaller for the less explicit conditions if the children were trying to explicitly recall the presented items. In order to see if this trend was significant, a series of statistical tests was used.

First, a series of independent t tests were performed to investigate whether the gain scores achieved for the experimental groups were significantly different from the gain scores in the control groups and, once again, the probability criterion was reduced to 0.01 to account for the number of t tests performed (Howell, 1992). Two of the results were significantly different (as marked by an asterisk in Table 9.2); the correct and incorrect items in the spelling condition (correct: $t_{78} = 2.707$, $p = 0.008$; incorrect: $t_{78} = 3.625$, $p = 0.001$). The gain scores in the other conditions were not significantly different from the control group.

Figure 9.2 Mean percentage gain in number of alternative spellings from pre-test to post-test as a function of type and condition of exposure.



A repeated measures ANOVA was also performed on the gain scores and this yielded a significant effect of encoding group [$F(2,78) = 14.08$, $MSe = 140.852$, $p < 0.0005$] and no significant effects for the accuracy of item at presentation [$F(1,39) = 0.02$, $MSe = 147.102$, $p = 0.91$] nor a significant interaction [$F(2,78) = 0.89$, $MSe = 187.87$, $p = 0.42$]. Page's L tests were used to test whether there was a significant trend in the encoding group variable on both correct and incorrect items. A highly significant linear effect was found when both correct and incorrect items were presented (correct - $L = 4.25$, $p < 0.05$; incorrect - $L = 4.75$, $p < 0.05$).

Summary of Results

Although the data do show some influence of exposure to orthographies on subsequent spelling, the effect does not parallel that found in previous studies on adults, in that it appears to be mediated by explicit memory processes. Explicit mediation is revealed in a number of ways:

- It was hypothesised that, if children were using explicit memory recall, the effect of exposure of spellings on subsequent spelling accuracy would be very small since only a few items would be able to be explicitly remembered. The data were consistent with this, in that the positive effect of presenting a correct spelling was never significantly different from the control group.

- Explicit retrieval would predict a 'levels of encoding' effect for mean gain scores of spelling accuracy for the correct items only, with the largest gain for the 'Spell words' condition, followed by the 'Read words' condition, followed in turn by the 'Read story' condition. Some support for this hypothesis could be seen in the mean percentage gain scores as illustrated in

Figure 9.1. The analysis also revealed an almost significant interaction which demonstrated that, for the correctly spelled items, the increase in accuracy was greater for the 'Spell Words' condition than the 'Read Words' and in turn for the 'Read Story' condition, whereas the incorrectly spelled items did not demonstrate this trend. This highlighted the differential effects of the encoding conditions following presentation of correct and incorrect items.

- It was hypothesised that, if explicit recall of the exposed orthography was responsible for the data, the number of different alternative spellings in the post-test condition would be lower than in the pre-test by virtue of the children trying to recall the same recent exemplar. This effect was expected to be present for both correct *and* incorrect exemplars and, once again, to be related to the type of encoding condition: the more explicit the encoding, the larger the effect. Evidence of this was found. For the 'Spell words' condition (the most explicit encoding task) there were significantly fewer alternatives produced at post-test than at pre-test, following exposure of both correct and incorrect items. This was demonstrated by the significant difference between these conditions and the control group. Further support that levels of encoding exerted an influence on the constriction of alternatives at post-test was found in the ANOVA analysis. There was a significant main effect of type of encoding and, when tested further, it was revealed to be a highly significant linear effect in the predicted direction. The fact that correct and incorrect items exerted the same influence can be seen in Figure 9.2 and was supported by a lack of an interaction between encoding group and accuracy of presented items.

Discussion

Looking at the data from this study, it can be seen that they are quite comparable to the data reported by Bradley and King (1992). In this experiment, the gain scores following the presentation of a correct item were larger than those following presentation of an incorrect item (although this difference did not quite reach significance). If the present data had been analysed in the same way as in the Bradley and King (1992) study, and had not been compared to a control group, it might also have been concluded that correct spellings exert a beneficial effect and that misspellings have no effect over subsequent spelling accuracy. However, although a positive gain score was obtained for the items that had previously been presented spelled correctly in the present study, this did not differ from that of the control group who had been presented with none of the target words between pre-test and post-test. It can therefore be concluded that neither exposure to a correct spelling nor an incorrect spelling exerted any significant influence over the accuracy of spelling the item in a subsequent spelling test.

Exposure to correct and incorrect spellings did, however, have *some* effect over subsequent spelling performance. In the pre-test condition, it was noticeable that the group of children generated a large number of different orthographies for the spelling of an item. In the control group the mean number of alternatives of spelling the same word was 7.28 (standard deviation = 4.24). For example, the word 'sugar' was spelled in three different ways 'sugar', 'suger' and 'suga', while 'bicycle' was spelled in 17 different ways. Alternative spellings of 'bicycle' ranged from close attempts such as 'bycicle', 'bicicale' and 'bisecal' to more obscure attempts such as 'buskal', 'biyecle' and 'bikeskall'. The fact that such a wide range of spellings was given for a great many of the words suggests that children were 'creating' spellings rather than referring to precise lexical information. At post-test, children tended to produce a much narrower range of orthographies and this was most noticeable for the group of children who were asked to copy the spelling of the items at presentation. The fact that the size of the reduction in the number of alternatives produced at post-test was dependent upon the nature of encoding (the more explicit the encoding, the larger the reduction) suggests that children were consciously trying to recall the item they had previously seen in order to help their current spelling attempt. This result is contrary to that found by Jacoby and Hollingshead (1990) where the orthographic exposure effect in adults was not affected by degree of effortful processing at study.

The effect of presenting an orthography is, therefore, different for adults than for children. In adults, the presented word appears to act at a sub-conscious level on the lexical representation and subsequently alters future spelling accuracy of those items. This sub-conscious process is not dependent upon degree of effortful processing at study. In children, however, there is very little effect of presenting an item on subsequent spelling and any effect that is discernible appears to be mediated via explicit memory which is enhanced by degree of effortful processing at study. The interesting question therefore is why children are not affected in the same way as adults. There are several possibilities.

It could be that, although children's representations are similar to adults, exposure to orthographies does not significantly affect children's lexical representations since the lexical items might not have been accessed. This explanation, however, seems unlikely since, children were able to read the words aloud and many of these words were irregularly spelled. Under these conditions it would seem reasonable to assume that lexical access had occurred. If children's representations are similar to adults and lexical access had occurred, it is difficult to see why the orthographies do not affect children in the way that they do adults.

Alternatively, if children's lexical representations were less well specified than adults, then reading could occur quite efficiently, but spelling could still be a problem. This is because word identification in reading may be achieved on the basis of incomplete lexical information, with the word being matched to the closest lexical entry. For example, the word 'elephant' could be matched quite successfully to the incomplete lexical representation of 'el --- ph -- t'. However, spelling is a task that requires very detailed information concerning the identity and order of letters, and therefore an incomplete lexical entry would only be of limited use in spelling. If children possess only limited lexical information, they would tend to 'fill in the gaps' using any other information, such as phonological information or anything that can be explicitly remembered from a previous encounter with the word. This could account for the findings of the apparent use of explicit memory in the study.

Further evidence to support the notion that children rely on information other than lexical information when spelling, comes from a study by Stuart (1990), who investigated the use of orthographic strategies in spelling in children with an average age of nine. She found that when children were divided into good and poor spellers on the basis of whether their results fell above or below the mean on a spelling test, poor spellers were no better at spelling words than creating a plausible spelling for nonwords. This means that, for over half of the children in the study, either no information from a lexical representation was used or that, at the age of nine, no lexical representations had started to form. In either case this was quite surprising since, at the age of nine, most of the children will have been reading for approximately four years and will have frequently encountered the words they have been asked to spell. The good readers did, however, show a significant advantage for spelling words over nonwords, but this difference was quite small (a mean of 10 spelled correctly for words rather than 8.7 spelled 'correctly' for nonwords). It is also possible that this small, but significant, difference in good spellers reflects partial orthographic knowledge rather than a reliable lexical representation.

The difference between good and poor spellers in the Stuart (1990) study could be explained in several ways. First, it could be due to the fact that good spellers rely more upon a lexical route in order to spell. This would make sense since many English words are irregularly spelled and the only reliable way of reproducing them is via specific lexical information. Second, it could be due to the fact that good spellers have more reliable lexical information. This is also plausible since good spellers are usually also good readers and good readers will probably have encountered the words more often in their reading vocabulary than poor readers. Finally, it could be that good and poor spellers have similar representations and use the lexical route to the same extent, but, for both groups of children, the lexical representations are not fully specified. It could therefore be possible that the good spellers are those with good phonological skills and knowledge of orthographic constraints and are therefore able to use the incomplete lexical information in a more constructive way than poor spellers.

These possibilities may be explored through a comparison of good and poor spellers within the present sample. If differences between good and poor spellers reflect more general differences either in the completeness of lexical information, or in reliance on a lexical route in spelling, then good spellers, with superiority in this area should show the same effects of exposure to orthographic information as do adults. If poor spellers have worse lexical representations than good spellers, or are less inclined to use the lexical route, exposure to orthographic information should have little influence on subsequent spelling in terms of the standard implicit effect operating on lexical representations, but there may be a small effect mediated by explicit memory, where children may consciously attempt to recall the examples they have seen.

The children in this study were therefore divided on a post hoc basis into two groups: those children who scored below the mean on the pre-test (52.5% correct) were considered 'poor' spellers (N = 39) and those who achieved a score of 52.5% or above were allocated to the 'good spellers group (N = 33). A mixed design ANOVA, including spelling ability of child and encoding group as between-subjects variables and accuracy of presented orthography as a within-subjects variable, showed no significant main effect of spelling ability [$F(1,66) = 0.02$, MSe = 133.47, $p = 0.878$] and no significant interactions of spelling ability with encoding group [$F(2,66) = 0.59$, MSe = 133.47, $p = 0.56$] or with accuracy of the presented orthography [$F(1,66) = 0.15$, MSe = 50.27, $p = 0.695$].

Since no differential effects between good and poor spellers were evident, the division into good and poor spellers was made more stringent, with those children who scored below 37.5% allocated to the poor spellers group (N = 28) and those children who scored above 62.5% allocated to the good spellers group (N = 26). This excluded the middle range of scores, providing a clear separation of the two groups. However, the outcome of analysis by ANOVA of the resulting data repeated the patterns found in the preceding analysis on the basis of the less stringent decision [main effect of ability $F(1,48) = 0.08$, MSe = 133.73, $p = 0.78$; interaction between ability and encoding group $F(2,48) = 0.01$, MSe = 133.73, $p = 0.99$; interaction between ability and accuracy of presented orthography $F(1,48) = 0.36$, MSe = 40.41, $p = 0.55$]. These results support those of Bradley and King (1992) who also conducted a similar post hoc examination of spelling accuracy and failed to find any differential effects as a function of spelling proficiency of the subjects. Since there were no differences between good and poor spellers following exposure to an orthography, it would seem that the two groups do not differ in terms of possession of lexical representations and inclination to use lexical procedures in spelling. This leaves incompleteness of lexical representations (in both groups) as the most likely cause of the failure of the orthographic exposure effect, with differences in actual spelling proficiency stemming perhaps from different degrees of incompleteness, or from differences in ability to make use of what lexical information there is.

The fact that these children appear to rely on other methods of spelling rather than complete lexical information, could either be the *result* of possessing an inadequate lexical representation (i.e. since lexical information is not yet at a stage where it is useful, other information is utilised) or it could possibly be the *cause* of inadequate lexical information (i.e. the reliance on creative spelling could possibly be hindering the creation of a fully specified lexical representation). The encouragement of creative spelling in school may have several impacts which will be of relevance here. First, children encouraged to create spellings may form the habit of relying upon phonological information and may therefore undervalue lexical information. Second, it has been argued that reading an item does not appear to be useful in creating a fully specified lexical entry which is a prerequisite of accurate spelling. Evidence by Dixon, Stuart and Masterson (in preparation) shows that beginning readers shown words up to 40 times still do not possess anything approaching a lexical representation that is useful for spelling. Even those children who were phonologically aware, and were therefore able to make more meaningful links between the letters in the word and the sounds, were unable to spell the words they had learned to read. Funnell (1992) argues that fully specified lexical entries cannot be created from reading processes, they can only arise from the process of generating correct spelling. Therefore reliance on 'creating' a spelling may actually inhibit the process of establishing a useful lexical entry.

In conclusion, it appears that the orthographic exposure effect does not occur in primary school age children which is probably due to a difference in the maturity of lexical representations. This may be a consequence of the teaching method employed at the school, or may reflect a more general lack of orthographic experience.

PART III

OVERVIEW AND DISCUSSION

This chapter provides an overview of the experimental work reported in the preceding chapters. The first part of this chapter focuses on the results of the adult studies. It will cover questions such as whether the orthographic exposure effect is a real and replicable effect, whether the effect is pervasive and generalisable, what processes underlie the effect and what conclusions can be drawn about the nature of underlying lexical representations. Following an overview of the experimental work, the findings will be used to propose a possible model of lexical representations underlying spelling. This will include a consideration of single versus dual lexicons for reading and spelling, inter- versus intra- representational lexical conflict and an outline of exactly how the orthographic exposure effect might occur. The findings of the study using children are discussed separately, in the second part of the chapter, since these followed a completely different pattern from those of adults. This part of the discussion will cover the processes used by children following presentation of an orthography and the differences between adults and children's lexical representations will be dealt with.. The final part of this chapter will discuss implications for further research and the main achievements of this thesis.

Skilled Adult Spellers

An Overview of the Main Experimental Findings

The aim of this thesis was to explore the effect of visual exposure of correctly and incorrectly spelled words on subsequent spelling performance. Previous research has reported that exposure to an incorrectly spelled word can decrease subsequent spelling accuracy for those words (Brown, 1988; Jacoby and Hollingshead, 1990; Nisbet, 1939; Pintner et al. 1929), and there was some support in the literature for the notion that exposure to correctly spelled words can improve subsequent spelling performance (Jacoby and Hollingshead, 1990). The orthographic exposure effect was a term coined to encompass the decrement in spelling accuracy following exposure to incorrectly spelled words and the enhancement of spelling accuracy for those words which had previously been seen spelled correctly. Since there had been very little previous research into the effect of exposure of orthographies, the first priority was to establish the orthographic exposure effect as a real and replicable phenomenon.

This question was directly addressed by Experiment 1, which included a study phase where correctly and incorrectly spelled words were visually presented to the subjects, and a test phase where a dictated spelling test, including all the words seen at study and a further set of words that were new to the experimental situation, was administered. Two other variables were included in this experiment in order to investigate the possible generalisability of the orthographic exposure effect. These variables included a division of the subjects into good and poor spellers and a between-subjects manipulation of time of test, which occurred either immediately following the study condition or after the delay of a week. The findings of this experiment provided strong support for the orthographic exposure effect. A highly significant main effect of orthographic accuracy at study was found, and further testing revealed that there was a significant trend in spelling accuracy in the predicted direction (Incorrect < New < Correct) and that both the Incorrect-New and Correct-New differences were found to be significant. There were no significant interactions between orthographic accuracy at study and the other two variables, indicating that the orthographic exposure effect was evident in good and poor spellers and could also be found using both immediate and delayed testing. The results of this experiment therefore revealed that the orthographic exposure effect is highly robust and can be generalised to good and poor spellers.

Experiments 2 and 3 also provided confirmation of the orthographic exposure effect and, in addition, established that the effect is not confined to the conditions in which the item is initially exposed. This was investigated by a 2 x 2 design of between-subjects conditions which allowed conditions at study and test to be matching or non-matching. Experiment 2 used the manipulation of embedding the target words in text to achieve this, thus, the four conditions consisted of words presented in text at study and test, presented in isolation at study and test, presented in text at study and in isolation at test, and in isolation at study, in text at test. Experiment 3 achieved the matching and non-matching conditions by either presenting words in isolation or presenting the words in isolation and then asking the subject to rate the items for confidence in accuracy of spelling. The rating variable was on a scale of 0 to 100, where 0 was certainty that the spelling was incorrect and 100 was certainty that the item was correctly spelled, and this variable was also manipulated at study and test.

The findings of these two experiments were very similar. In both cases there was a strong effect of orthographic exposure and a significant trend in spelling accuracy in the predicted direction, from Incorrect to New to Correct. There were also no significant interactions between this variable and any of the other variables, again indicating that the orthographic exposure effect was evident in all the experimental conditions. These findings therefore support the notion that the orthographic exposure effect can be generalised beyond the conditions in which the item was initially encountered.

Perhaps the most interesting support for the orthographic exposure effect was found in Experiment 5 where a different methodology was employed. In this experiment the stimuli chosen were words that were considered to be easy to spell, as compared to the previous work which had only used words that were difficult to spell. Since it was deemed unlikely that subjects spelling accuracy would be adversely affected by the presentation of a misspelling of these easy words, a more sensitive index of performance, spelling time, was employed. In this experiment, a computer was used to present the items in the study phase, and subjects were required to type the spellings of auditorily, computer-presented words at test using the computer keyboard. For this reason, all the subjects who participated in this experiment were highly competent in keyboard skills. Although the findings were not conclusive, they provided tentative support for the orthographic exposure effect from a different perspective. A significant effect of orthographic exposure was found but planned comparisons revealed that although the difference between Correct and New items was significant, the difference between Incorrect and New items did not reach significance. This was considered to be due to the difficulty that subjects appeared to have in understanding the computer voice, so that those words that they had seen spelled earlier may have aided recognition of the auditory stimulus at test. To support this argument, it was discovered that there were more missing cases for the New items than the Incorrect items, demonstrating that the subjects found the New items more difficult to perceive and it was therefore concluded that the spelling times were confounded with time taken to recognise the stimulus. As further support for the orthographic exposure effect occurring in simple words, the accuracy of the spelling responses was also investigated. Although the number of errors was too small to analyse, they did reveal the same pattern of results found in Experiments 1, 2 and 3, that is the greatest number of errors occurred for those items that had been presented incorrectly spelled, a smaller number of errors for those items that were new at test and a relatively smaller number of errors for those items that were presented spelled correctly at test.

Experiment 4 was the first experiment where the manipulation of variables resulted in an attenuation of the detrimental effect following exposure to misspellings. Experiment 4 employed phonologically plausible and implausible misspellings of difficult-to-spell words. The previous experiments had only utilised phonologically plausible misspellings. Since the effect of presentation of correctly spelled words had already been strongly supported by the previous data, Experiment 4 was designed to compare the effect of presenting phonologically plausible misspellings and implausible misspellings using two separate groups of subjects. A test-re-test design was employed whereby subjects were asked to spell 36 words at pre-exposure test, were exposed to the incorrect versions of the words and then asked to spell the same words again at post-exposure test. A decline in spelling accuracy was expected in the post-exposure test. This effect was in fact only observed when the presented misspelling was phonologically plausible; the implausible misspellings exerted no influence over subsequent spelling performance. The full implications of these results will be discussed later, with reference to the role of phonology in lexical access, but for the meantime it is worth noting that although the phonologically implausible misspellings did not exert a detrimental effect on subsequent spelling performance, the results from the phonologically plausible misspellings provide further converging evidence for the orthographic exposure effect.

It is clear that the results of the experiments outlined in the previous paragraphs provide a wealth of evidence supporting the replicability of the orthographic exposure effect in skilled adult readers. The effect is evident across good and poor spellers, for simple words and words that are difficult to spell, when target items are presented singly or in text and is even evident when adults are writing text. Since the effect is also known to be long lasting, there are serious implications for the use of misspellings in advertising. It appears that they can access and alter the already existing lexical representations of adults regardless of the type of words and the situation in which they were encountered.

The second question to be considered was the nature of the processes that could be mediating the orthographic exposure effect. Jacoby and Hollingshead (1990) discovered that the orthographic exposure effect was independent of recognition memory and, on this basis, suggested that it was mediated via implicit, rather than explicit, processing. Further support that the orthographic exposure effect is mediated via implicit processing is described below.

Experiment 1 investigated the longevity of the orthographic exposure effect and the findings revealed that the influence of orthographic exposure was still evident up to a week after the experimental presentation. The duration of this effect was found to be very similar to other long lasting priming effects which are also considered to be mediated via implicit processes (Kolers, 1979; Tulving, Schachter & Stark, 1982). Furthermore the results of Experiment 1 demonstrate there was a significantly greater number of misspellings replicating the presented misspelling than those misspelled in some other way. If the orthographic exposure effect was deemed to be caused by explicit 'confusion' about the spelling following presentation of an incorrectly spelled word, then few of the subsequent misspellings would be expected to be replications of the exposed incorrect spelling. These two findings therefore provide some indication that the orthographic exposure effect is mediated by implicit processing.

The experimental manipulation of embedding the target words in text in Experiment 2 revealed findings that also provide support for the implicit nature of the orthographic exposure effect. If the effect relied upon explicit retrieval of the presented item from the study episode, a stronger effect would be expected when the words were presented in isolation because more elaborative processing could be performed. For example, Schindler (1970) discovered that misspellings were more difficult to spot when placed in meaningful text, suggesting that explicit processing of the letter information is easier to achieve when the words are presented in isolation. The fact that the orthographic exposure effect was evident when the exposed items were embedded in text, as well as when they were presented singly, indicates that explicit processing of the presented item does not play a major role in the effect.

Finally, asking subjects to rate confidence in spelling accuracy, a variable employed in Experiment 3, also provided some supporting evidence for the implicit nature of the effect. Subjects were not only asked to rate the presented spellings for accuracy at study but also asked to rate their own spellings at test. An investigation of these ratings revealed that although presentation of misspellings decreased spelling accuracy and exposure to correct spellings enhanced spelling accuracy, neither of these exerted any influence over the subjects' rating of their own spellings. Hence, even though a subject spelled a word incorrectly following an incorrect exposure, he/she experienced no drop in confidence of their own spelling accuracy for that item. This finding was identical when the ratings were compared to the items that subjects *thought* were correctly or incorrectly spelled at study, regardless of the actual orthographic accuracy of the presented item. Thus, even when subjects considered that they had been exposed to a misspelling, they were not less confident of their own subsequent misspelling of that item. These findings suggest that the subjects were unaware of the effect that was being produced and, therefore, the orthographic exposure effect could not be considered to be due to explicit processing of the exposed orthographies.

The evidence from the above-mentioned experiments, therefore, provide strong support for Jacoby and Hollingshead's (1990) claim that the effect of exposing orthographies is implicit and, as such, is beyond the conscious control of the reader. On a practical note, this could mean that exposure to misspellings in everyday life is even more dangerous than was already thought since, if the effect of orthographic exposure is mediated at an implicit level, the effect cannot be attenuated by conscious processes.

Since the orthographic exposure effect appears to be mediated by implicit priming, it makes sense to consider exactly how this priming might occur. There are two possible types of priming. The first is known as episodic priming (Jacoby, 1983) where the whole study episode is considered to be stored and then retrieved at test. Jacoby and Hollingshead (1990) postulated that this type of priming might be responsible for the orthographic exposure effect. The second is known as item-specific priming (based upon Morton's logogen model, 1969, 1979) whereby presentation of a word at study causes a long-lasting change within the representation of that item.

Monsell (1985, 1987) has argued that episodic information decays very quickly and that priming over long time periods requires the item to have lexical status. This assertion was supported by relatively long-lasting and stable priming effects with words as compared to very short-lived or non-existent priming effects found with nonwords, which are not represented within the lexicon. It therefore appears that although episodic information has been found to be responsible for priming effects over short time periods of two to three minutes (Humphreys, Besner and Quinlan, 1988; Ratcliff, Hockley and McKoon, 1985), any priming effect lasting longer than this relies upon item-specific priming. Since the results of Experiment 1 demonstrated that the orthographic exposure effect was as strong after the delay of a week as when immediate testing took place, it follows that this effect is likely to be mediated by item-specific priming, because any episodic information would have decayed over the time period between the study condition and delayed post-testing.

Another major difference between episodic priming and item-specific accounts is that the context in which the item is studied is an important factor in strength of episodic priming. This is because since the whole episode is stored at study, reinstatement of the same conditions at test provides very strong retrieval cues and thus the priming effects are stronger. If the conditions at test differ from those used at study, the retrieval cues are weaker and the priming is less effective. Support for this notion comes from the fact that studies of priming where conditions at study and test do not match have shown less priming than those where conditions at test reinstate those at study (Kolers, 1975; Winnick and Daniel, 1970; Roediger and Blaxton, 1987).

This notion of matching and non-matching conditions at study and test was implemented in Experiments 2 and 3 by using text presentation and rating of spellings respectively. Analysis of the priming scores revealed that the orthographic exposure was as evident in matching conditions at study and test as when the conditions did not match. Since an episodic account of priming would hypothesise a decrease in priming in the non-matching conditions compared to the matching conditions, the results of these two experiments provide converging support for the item-specific account of priming as suggested by Dean and Young (1996).

It is interesting to note that although the orthographic exposure effect can be explained using an item-specific account of priming, this effect is not directly comparable to traditional studies of repetition priming. In repetition priming the conditions at test usually reinstate the conditions employed at study, that is, if a word is presented visually at study it is also usually presented visually at test. This means that it is impossible to identify whether the priming occurs via the input pathways to the representation or actually within the representation itself. The orthographic exposure effect, however, consists of visual presentation of the item at study and auditory presentation of the item at test. Since the orthographic exposure effect appears to be mediated by item-specific priming, and there is no overlap between input conditions due to the different modality of input at study and test, the locus of priming in these studies must be within the lexical representation itself.

The other implication that arises due to the orthographic exposure effect being mediated by item-specific priming is that the item to be primed must be stored within the lexicon. Hence misspellings, as well as correct spellings, must have some form of lexical representation. There are two possible alternatives of how a misspelling could be represented; either the misspelling could have a separate lexical representation from the correct spelling, and so the detrimental effect of exposure to a misspelling would occur due to inter-lexical conflict, or the misspelling could be superimposed on the correct lexical representation producing intra-representation competition. Although it is difficult to distinguish between these alternatives, some data from the experimental work appear to support the latter alternative.

In Experiment 1, it was found that good and poor spellers were equally affected by a single presentation of a misspelling. This appears to contradict previous work by Burt and Butterworth (1996), who demonstrated that poor spellers were much worse at storing and retrieving a presented nonword than good spellers. The difference between these two findings was interpreted in terms of the possible difference in lexical status between the nonwords in Burt and Butterworth's (1996) experiment and the misspellings used in Experiment 1. It is possible that poor spellers are less able than good spellers at creating a new representation (as was required following presentation of a nonword), but that they may be as effective as good spellers at amending an already existing representation. Thus, a visually encountered misspelling is either transposed onto the pre-existing 'correct' lexical exemplar, or the presented misspelling has been seen so often that a reliable lexical entry for the misspelling had already been formed. Since the establishment of a lexical representation requires repeated exposure of the item in question, the chance of a representation of the identical misspelling to the one that was presented in the experimental situation is quite small and, thus, perhaps the notion that the misspelling was superimposed onto the existing 'correct' lexical representation is more plausible.

Experiment 3 provided information concerning whether the subject was aware of the original misspelling of the words and whether, when a misspelling was produced at test, that it was a direct copy of the presented item. It was found that, for those subjects who were unable to identify the original exposed misspelling as such, subsequent misspellings were likely to take the same form as the prime. When the misspelling was explicitly recognised as such, subsequent spelling performance was still detrimentally affected, but the misspelling produced at test was less likely to be in the form of an exact replica of the exposed item. There are two possible reasons why subjects may not be able to identify a misspelling as such: either a representation of the exposed misspelled version of the word is already stored as a potential 'correct' version, so that the incorrectness of the exemplar is not recognised, or that the lexical representation is not sufficiently well-specified to make a firm decision about its accuracy (that is, the lexical representation could contain dissonant information). Again, it seems relatively unlikely that a fully established separate lexical representation of the particular incorrect exemplar selected for use in the series of studies was in existence, and hence more likely that the locus of priming lay within a single lexical representation.

Further support for the notion that dissonant information is contained within a single lexical entry rather than stored as separate lexical representations, comes from the results of Experiment 5. In this experiment, misspellings of very simple words were presented. Since these items are rarely misspelled in everyday writing, it is extremely improbable that these misspellings could have a separate lexical representation to the correctly spelled version. Although the results of the experiment were not totally unambiguous, they provided some indication that accuracy of spelling was detrimentally affected by presentation of a misspelling and that timing too may also be affected. If this is so, the only possible way to create competition would be to superimpose fresh orthographic information on the correct version of the item, or to create a new, reliable, competitive representation on a single presentation of the word. Since the creation of a new lexical representation is considered to require multiple presentations, the only reasonable conclusion is that a misspelled exemplar accesses and alters the existing 'correct' lexical representation.

A Possible Model of Lexical Representations

Combined together, the results of the experiments reported here provide the beginnings of a picture of how words are represented in the spelling lexicon and how these representations are accessed. Throughout this thesis it has been assumed, on the basis of evidence discussed in Chapter 3, that a single orthographic lexicon exists that subserves both reading and spelling processes. The orthographic exposure effect is a detrimental effect of exposure to a misspelling and a beneficial effect of exposure to a correct spelling on subsequent spelling accuracy. All the experiments reported here, and also the previous experiment by Jacoby and Hollingshead (1990), have relied upon a single visual exposure to the target item to produce this effect. From this single reading of the orthography, a substantial effect occurs on the spelling performance of that same word which lasts for a considerable time. It therefore appears reasonable to assume that a single presentation of an orthography accesses and alters the lexical representation, which is also accessed when the subject is required to spell the same item. Although it is possible to postulate the existence of two separate but linked lexicons which transmit information freely from the input lexicon to the output lexicon, this assumption appears to be an unnecessary complication in the interpretation of this effect. The evidence from this thesis, therefore, seems to support the assumption of a single lexicon that subserves input from reading and output for spelling.

Likewise, although there was no explicitly directed testing to investigate whether misspellings are represented separately from the correct orthography or as a dissonant example within the 'correct' representation, the evidence points towards the notion of a single representation. This single representation would store orthographic information from each encounter with the item. In addition, the notion of a single representation has the advantage that connections between the representation and phonology and semantics already exist. If a phonologically plausible misspelling needed to be created following orthographic exposure, the representation would require the forging of new links with the same phonological form as the correctly spelled version and also links with the same semantic information. Since it would seem unreasonable for these links to be made following a single exposure to the item, it is more parsimonious to suggest that orthographic differences are stored within a single lexical exemplar.

The results of Experiment 4 are also relevant at this point. In this experiment, subjects were exposed to either phonologically plausible or phonologically implausible misspellings. The results of the experiment showed that exposure to phonologically plausible items demonstrated the same detrimental effect on spelling accuracy as was found in the other experiments which produced the orthographic exposure effect. The phonologically implausible misspellings, however, produced no such effect. It is possible that phonologically implausible misspellings are also stored within the lexical representation and are not produced on subsequent output due to a phonological check on orthographic output. This is unlikely, however, since conflicting information stored within a lexical representation is likely to produce some detrimental effect on subsequent spelling output even if a phonological guide at output means that the misspelling is phonologically plausible. Since phonologically implausible misspellings clearly did not exert any influence over subsequent spelling performance, this suggests that the phonological component of the implausible misspelling has somehow blocked access to the lexical exemplar and has not been stored within it. These results are, therefore, highly consonant with the notion that the already existing link between phonology and the lexical representation is a major factor in lexical access.

It is difficult to tell from the results of this experiment exactly how phonologically implausible misspellings may be blocking lexical access. It is possible that phonology is processed independently of the orthography, as proposed by the dual route theory of lexical access, and that both of these processes activate the lexical representation. In this scenario, a presented item which is orthographically similar to an already existing lexical item would activate that lexical exemplar and, in addition, other items that share components with the presented misspelling. The incoming phonological information, however, would provide disconfirming evidence for the already activated representations and thus lexical activation could be tempered and the assimilation of new orthographic detail ameliorated.

The alternative is that phonology could be the primary factor in lexical activation as expounded by the phonologic mediation hypothesis (Van Orden, 1987, 1991; Van Orden, Pennington and Stone, 1990; Lukatela and Turvey, 1994). On the basis of this theory, phonology is deemed to be the quicker, and perhaps the only, route to lexical access and orthographic information acquires the role of a spell check after activation of a representation has taken place. This can be seen in terms of two separate processes, as proposed by Lukatela and Turvey (1994), or in terms of the subsymbolic units of phonology being more harmonic than those of the orthographic units, as proposed by Van Orden, Pennington and Stone, 1990. Application of the phonologic mediation hypothesis to this experiment would mean that the phonologically plausible misspellings would access the lexical representations and then orthographic information would be accumulated and stored within the representation. The phonologically implausible misspellings, however, would not even access the targeted representation within the lexicon and thus the incoming orthographic information could not be assimilated.

Although, the results of Experiment 4 are unable to differentiate between the dual route and phonologic mediation accounts of lexical access, they both stress the importance of the already existing links between phonological and orthographic representations. Since this link appears to be important for the mediation of the orthographic exposure effect, this provides confirming evidence that the effect is due to intra-representational, rather than inter-representational lexical conflict. This is because, regardless of whether the orthography is correct or not, the phonological process will activate the targeted lexical representation for phonologically plausible misspellings. When the orthographic information is assimilated it will necessarily be connected with the target lexical item by virtue of phonological activation and thus is likely to be stored within the activated representation. A phonologically implausible misspelling, however, does not activate the targeted lexical item even if the orthographic information does. This means that the new orthographic information could not be stored within the targeted lexical item, but a new lexical exemplar would have to be created. Since there was no detrimental effect on spelling following exposure to an implausible misspelling, it appears that either a new lexical item was not created or that an item was created but that it was not sufficiently competitive with the existing lexical item to produce an effect.

If correct and incorrect orthographic information is stored within a single lexical exemplar, this somewhat changes existing notions of a lexical representation. It is usually considered that a lexical representation contains the correct specific information required to achieve perfect reading and spelling. However, evidence from skilled adult readers suggests that they are often able to read words that they cannot necessarily spell correctly. If the lexical representation contains conflicting information within it, it can be seen that it would be much more effective for reading than for spelling, since reading can occur using a matching technique whereas spelling requires precise letter and order information. It would therefore seem that lexical information may not be a major factor in spelling ability and that, therefore, the difference between good and poor adult spellers may not be in adequacy of lexical information, but rather in phonological, orthographic and morphological rules as Burt and Butterworth (1996) suggest. The results of Experiment 1 provide some empirical evidence to support this claim.

In Experiment 1, subjects were divided into a group of good spellers and a group of poor spellers based on the results of a single dictated spelling test. All the subjects were then exposed to correct and incorrect orthographies to discover what effect this had on their subsequent spelling accuracy. Although the poor spellers obviously obtained a much lower percentage of correct responses overall than the good spellers, the effect of orthographic exposure was the same for both groups. This result demonstrates several important points. First, the fact that the orthographic exposure effect was evident in both good and poor spellers demonstrates that they were both able to instantly access the detailed letter information from a single presentation. Second, this information was stored equally well for the poor spellers as for the good spellers. A further investigation of the misspellings produced by the two groups of spellers provides support for these notions. If poor spellers were worse at accessing detailed letter information and storing it for future use, then, although they may be detrimentally affected by the presentation of a misspelling, the final spelling response would be less likely to be an exact replica of the presented item. However, the data from the experiment revealed that for both good and poor spellers approximately two-thirds of the spelling errors following presentation of an incorrect orthography were replications of the exposed misspellings. The fact that the orthographic exposure effect was also evident following a week's delay in both groups of spellers provides converging evidence that the stability of lexical representations is similar for good and poor spellers.

It therefore appears that the notion of a single representation that stores conflicting orthographic information, providing the phonological constraints are satisfied, can be applied to good and poor adult spellers who are proficient in reading skills.

It is perhaps now possible to outline a final model of how the orthographic exposure effect occurs. Exposure to a correct spelling accesses the already existing lexical representation of that word, because both the phonological and orthographic aspects of the word provide a complete match. The orthographic information within the presented item is assimilated and provides reinforcement resulting in a stronger lexical representation (this might be in terms of a higher resting activation level or stronger links between sub-lexical units depending upon the theoretical framework adopted). Since the correct representation of the word has become stronger, there is a higher probability of subsequently spelling this word correctly, hence a significant increase in correct spelling is evident following exposure to correctly spelled items. This beneficial effect following exposure to a correctly spelled item is identical to the effect of repetition priming except that the beneficial effect is demonstrated in accuracy of spelling output, rather than speed of subsequent visual processing.

Exposure to a misspelling, however, is slightly more complicated. If the misspelling has a phonological representation that is identical to the targeted word (for example, dirth - dearth), activation of that lexical representation will occur. The fresh orthographic information will be assimilated into that representation, resulting in dissonant orthographic information within the lexical exemplar. The spelling output from this altered representation is more likely to be incorrectly spelled than prior to the exposure, since the newly-stored incorrect orthographic information results in intra-representational conflict and hence possibly in output of an incorrect orthography.

Presentation of a misspelling that differs in phonology from the targeted item (for example, deerth - dearth) has difficulty in accessing the lexical representation of that item. This is because, although the orthography is similar to the target item and thus activation may occur, the information from phonology is not close enough to the target item to provide confirming activation. Without accurate phonological information it appears that the orthographic information cannot be assimilated into the lexical representation. Alternatively, on the view that phonology is the primary route to lexical activation, the phonology of the phonologically implausible exemplar simply does not activate the target representation, and so the incorrect orthography cannot influence the existing orthographic information.

The Effect of Orthographic Exposure in Children

The investigation of the orthographic exposure effect, which was based on skilled adult spellers in the initial series of studies (Experiments 1 - 5), was extended to children in Experiment 6. The motivation was primarily to explore whether relatively unskilled spellers, with perhaps weak or unstable lexical representations, were similarly susceptible to the effect, and secondarily, to assess the findings of Bradley and King (1992) who had reported that although children displayed an enhancement of spelling accuracy following exposure to a correctly spelled item, exposure to a misspelling did not affect spelling performance.

In order to build upon the findings of the experiments of skilled adult spellers, a number of conditions were employed that were designed to show not only whether the orthographic exposure effect was evident but also to investigate the processes underlying any possible effect. A test-retest design was used where children (mean age 10 years 10 months) were asked to spell 40 words, were then exposed to 20 of these spelled correctly and 20 spelled incorrectly and finally were asked to spell the 40 words again. Three different exposure conditions were employed. In one, the children were presented with the orthographies on an item-by-item basis and were asked to copy the presented orthography. In another, the children were asked to read the presented words aloud and in a third condition the target words were embedded in text and the children were asked to read the text aloud. A final condition, where no orthographies were exposed between pre-test and post-test, was employed as a control condition.

The results of this experiment revealed that there was no evidence that the subsequent spelling accuracy of the children was affected by the presentation of either the correctly or the incorrectly spelled items. That is, the results obtained for the three experimental conditions did not significantly differ from the control condition where no orthographies were exposed. This result was, therefore, contrary to all the experiments which showed a strong orthographic exposure effect in adults and, also, did not support the previous findings of Bradley and King (1992) who argued that children were aided by the presentation of a correct spelling. The absence of an orthographic exposure effect indicates that the implicit priming found in skilled adult spellers is not operating in these young and relatively inexperienced spellers.

The presentation of the target items did, however, exert some effect. An increasing trend in spelling accuracy was found across degree of elaborative processing of exposed correctly spelled words at study, from reading the words in text, to reading the words in isolation, to copying the orthography of the presented items. Since the accuracy was greater for the items which required more elaborative processing, this indicates that the effect of presentation of orthographies is likely to be mediated explicitly and is linked to recognition memory processes. The spellings were further analysed by investigating the difference in number of alternative spellings of the same word produced by the whole group of children at pre-test and at post-test. The tendency was for the total number of alternative spellings to be lower following exposure of the orthographies, but this was most significant in the experimental group who were asked to copy the orthographies at study. This effect was again found to decrease in size across processing conditions from spelling the words, to reading the words in isolation to reading the words in text, but did not vary across presentation of correct and incorrect spellings. The fact that the size of the reduction in the number of alternatives produced at post-test was dependent upon the nature of encoding (the more elaborative the encoding, the larger the reduction) suggests that children were consciously trying to recall the item they had previously seen as an aid to spelling accuracy.

The results of exposure to orthographies has therefore shown both a different pattern of results and a different underlying mechanism for children than was found in the previous experiments with skilled adult spellers. It appears that in adults, the presented word acts at a sub-conscious level on the lexical representations and subsequently alters spelling accuracy for those items. In children, however, there is very little discernible effect on subsequent spelling and any effect that is discernible appears to be mediated by explicit memory.

It is possible that the differences underlying the different processes for adults and children could be due to the nature of the lexical representations at differing levels of reading experience and spelling expertise. It has been argued that the skilled adult spellers had some sort of orthographic representation for all the items that were presented and that misspellings were superimposed upon the correct spelling. Hence for adults, it is assumed that the information within the lexical representation is relatively stable and noise-free prior to the experimental procedure and that presentation of an incorrect orthography creates competition and thus increases the noise within the representation, whereas presentation of a correct spelling retains the status quo. Since the children in this study were actively encouraged to spell by concentrating on the phonology of the word, it could be that the lexical information was not yet at a stage where it was specified adequately to provide a useful tool for spelling. It therefore appears that the children were trying to refer explicitly back to the previous salient example of that word, whether correctly or incorrectly spelled, as a strategy to fill in the gaps in their lexical knowledge.

The investigation of the orthographic exposure effect in children, therefore, has yielded very important results. First, it has demonstrated that children of this age are not adversely affected by exposure to a misspelling nor is there a beneficial effect of a single presentation of a correct spelling. This implies that multiple-choice spelling tests are not harmful to a child's spelling and may, indeed, prove useful by ensuring that the children attend to detailed orthographic information at input. This attention to detail could help to create a more detailed lexical entry that could be useful for spelling as well as for reading. Second, it reveals that the lexical representations that are used by skilled adult spellers are qualitatively different from those of less experienced readers. This difference has been interpreted as a lack of detailed orthographic information, possibly resulting from a particular teaching technique employed currently in Britain. And finally, it reveals that children of this age are attempting to use explicit information about a word's orthography in order to spell these words. Although this may be due to the lack of adequate lexical information mentioned above, it has serious implications for the teaching of explicit rules for spelling. If, for example, children are taught to spell 'autumn' by referring to the derivative 'autumnal' where the silent 'n' is voiced, this could be an explicit cue that children can recollect and use to their advantage when spelling. It might also suggest why euphemisms for difficult-to-spell words (for example, Rhythm Has Your Two Hips Moving - rhythm) are so popular, since this is a highly memorable piece of information which can easily be retrieved to aid spelling attempts.

Suggestions for Further Research

The experimental work reported in Part II has built upon the work of Brown (1988) and Jacoby and Hollingshead (1990) by investigating the effect of exposure to correct and incorrect spellings on subsequent spelling performance in a variety of different situations. It has been discovered that the orthographic exposure effect is mediated by implicit, item-specific priming in adult skilled spellers and that this has major implications for theoretical modelling of the storage of misspelled representations within the orthographic lexicon. Children, however, were not affected in the same way as adults by exposure to orthographies. It appears that children only utilised the presented information as an explicit guide to aid spelling performance. Although the main findings are quite clear, there are some points which would benefit from a second examination, and some issues which have been uncovered which require further clarification.

The experiment which most obviously requires replication is Experiment 5, where words that are considered to be easy to spell were exposed to the subjects. The methodology for this experiment differed from the others in that spelling times, as well as spelling accuracy, was measured. The difficulty was that in order to gain accurate spelling times a computer programme was used to present words auditorily at test, but the speech synthesiser did not produce clear stimuli. In particular, the consonants were very difficult to understand, hence, for example, the word ‘carpet’ could not easily be distinguished from the word 'target'. In terms of the results of the experiment, this difficulty in computer speech perception meant that the subjects found it easier to understand the words that had already been presented visually at study compared to the words that were new to the test condition. This resulted in a possible confounding of the spelling times for the New items and was the likely cause of a non-significant difference in spelling times between Incorrect and New words. In order to investigate the effect of presenting misspellings of simple to spell words more accurately, this confounding variable needs to be reduced by using a computer package with better speech sounds or by using an accurate timing device coupled with a tape recorded version of the words. Unfortunately, neither of these options were available at the time of running the experiment, though advances in technology should enable a more valid procedure to be employed in future research of this type.

The results of Experiment 2, where the target words at study and test were either presented individually or embedded into text, revealed a slight tendency for spelling accuracy to be better using a dictated passage spelling test than a more traditional dictated single word test. Although, this tendency was not quite significant, the sample size of the subjects was quite small and it would be useful to see if the finding is reliable using a larger sample size. It could be that adult spelling is more accurate in the more usual context of writing than in the 'artificial' task of producing spellings on their own. This would provide some interesting data to add to the current debate about teaching of spelling to children. In the developmental spelling model, currently adopted by many schools in Britain, there is an emphasis on teaching spelling within the context of writing and on the notion that the content of, and the audience for, the writing should be primary concerns. Hence, spelling 'lessons' should be initiated by the teacher following issues arising from an individual's piece of writing. If it was found that adults were better at spelling when placed in its usual context of writing, it would provide some tentative support for the developmental spelling model in that spelling and writing are linked processes and, as such, it might be educationally better not to separate them.

The results of Experiment 4 also provided information that requires further investigation. In this experiment, phonologically plausible and implausible misspellings were presented and it was found that implausible misspellings did not exert a detrimental effect on subsequent spelling performance. It was concluded that the implausible misspellings did not exert a detrimental influence because the role of phonology in activating a relevant representation meant that the incorrect phonology blocked access to the targeted lexical item. Thus, any competing orthographic information would have to be input via the creation of a new lexical item of the misspelling. It would therefore be interesting to establish whether implausible misspellings could exert a detrimental effect by repeated exposure, since it is assumed that this is what is required to create a new lexical entry. The results of this experiment could provide useful information concerning how lexical entries are created. It has been argued (Stuart and Coltheart, 1988) that phonological information is crucial for the establishment of a new lexical entry. Stuart and Coltheart argue that children who are aware of the links between phonology and orthography can anchor the beginning and end letters and thus begin to create an orthographic representation, while those children unaware of these links can only establish a new entry by arbitrary links between the shape of a word and its meaning. Since the phonologically implausible misspellings used in

Experiment 4 do not map onto existing phonological representations, it is possible that even repeated exposures to these misspellings would not create an orthographic representation.

Further research arising from this thesis could concern the testing of the model of the orthographic exposure effect outlined earlier in the discussion. For example, if the detrimental effect of a misspelling is due to conflicting information being stored within the representation, multiple presentations of the same misspelling should result in a greater probability of that word being misspelled and it is likely that the misspelling produced would be an exact replica of the original presented misspelling. If, however, different incorrect orthographies of the same word are presented then, although the probability of misspelling the word on subsequent output should be increased, the nature of the misspelling produced would be less likely to be a replica of the last presented misspelling. This is because if, for example, 'sosages', 'sausadges', 'sausidges' are exposed and stored within the 'correct' representation, there is conflicting orthographic information at the point of the first vowel, the second vowel and the penultimate consonant sound. Hence it is possible that a misspelling that was not presented, for example 'sosiges' could be produced from the choice of conflicting information stored in various positions within the word. It could also be hypothesised that across a number of different spelling attempts, the subjects who were exposed to a single orthographically incorrect exemplar would produce more consistent spellings than those who were exposed to a variety of misspellings.

However, there are important ethical considerations to take into account before exposing multiple presentations of incorrect orthographies. Although in the previous experiments investigating the orthographic exposure effect, exposure to a misspelling was found to have a significant detrimental effect on subsequent spelling performance, there was also a significant beneficial effect following exposure to a correct orthography. Hence, any detrimental effect that occurred would be overwritten quite quickly following the next one or two encounters with the correct orthographic form of the word. Multiple presentations of a misspelling, however, would be less likely to be overwritten. As anecdotal support for this, although I was able to spell all the words used in the experiments before I started this research, currently I have difficulties with these words and although I am nearly always able to remember the two versions used (correct and incorrect) I am unable to tell which is the correct version. It can therefore be seen that any testing using multiple presentations should utilise already occurring situations, for example, the presentation of misspellings used in advertising, or the misspellings that are exposed to teachers on a daily basis.

Other research questions that have been highlighted by this thesis include the notion of single versus dual lexicons for input and output of spelling, intra- versus. inter- representational lexical competition following presentation of a misspelling, how lexical entries are created in children and adults, and the possible differences between adult and children's lexical representations. The way in which these functions or structures may best be conceptualised and modelled is currently an important area of theoretical debate, with process theory and connectionism as the main protagonists, and addressing the outlined research questions has the potential to make an important contribution to such debate.

Concluding Comments

To conclude, it appears that the orthographic exposure effect is a robust effect in skilled adult spellers and an exploration of this phenomenon has revealed some interesting insights into the nature of lexical representations. Incorrect orthographic information can be assimilated into the 'correct' lexical exemplar from reading processes and this information can then be utilised in spelling processes at a later date. This direct effect of reading on spelling provides some support that a single orthographic lexicon subserves reading and spelling processes. It also demonstrates that orthographic representations are not necessarily stable and consistent, but are flexible and constantly change according to incoming information.

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APPENDIX A

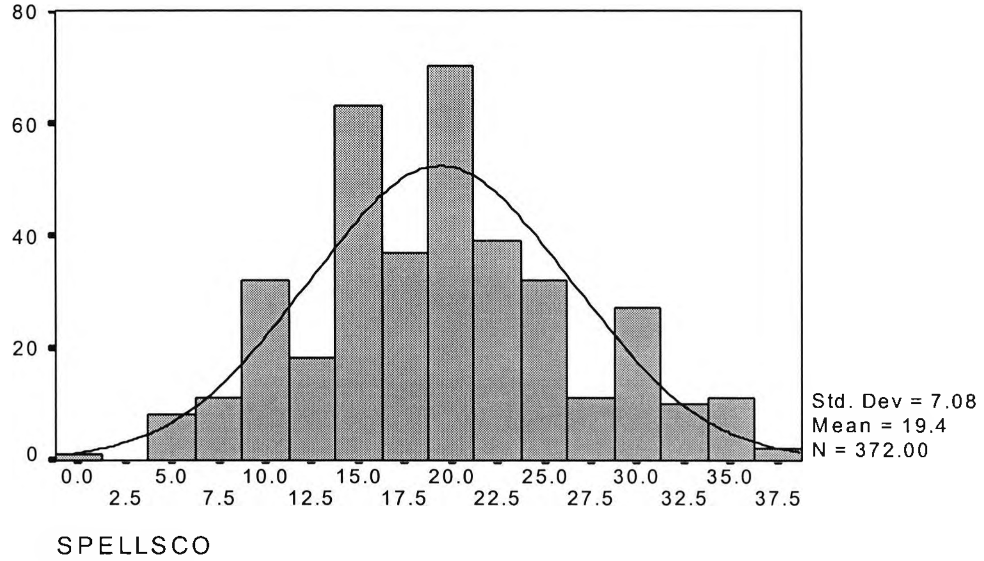
ADVANCED SPELLING SCREEN

Advanced Spelling Screen

A dictated spelling test which would produce a wide range of results in the undergraduate population was devised. The 38 words included in the test were picked from 'The Awful Spellers Dictionary' (Krevisky and Linfield, 1990) on the basis of being difficult to spell for educated adults. This test was piloted on 372 undergraduates and produced scores ranging from 1 to 38. The mean of the scores was 19.43 (standard deviation = 7.09), which was not very different from the median (19) or the mode (20). The fact that the three measures of central tendency are very similar suggests that the scores are normally distributed A graph showing the frequency distribution can be seen below.

From the graph it can be seen that the frequency distribution is indeed approaching a normal distribution. A further investigation of the Skewness (0.231) and Kurtosis (-0.261) scores shows that neither of these is significantly different to a normal distribution.

Figure A The distribution of spelling scores on the advance spelling screen



APPENDIX B

MATERIALS

Words used in Experiment 1

Sub-set 1		Sub-set 2		Sub-set 3	
Correct	**Incorrect**	**Correct**	**Incorrect**	**Correct**	**Incorrect**
boundary	boundry	abstinence	abstinance	absence	abscence
commitment	committment	anoint	annoint	category	catogory
conceive	concieve	believed	beleived	cemetery	cemetary
consistent	consistant	berserk	berzerk	delegate	deligate
corduroy	corderoy	consensus	concensus	desperate	desparate
crystal	chrystal	diarrhoea	diarrhea	disappear	dissappear
duly	duely	existence	existance	dormitory	dormatory
exercise	exersise	genius	genious	ecstasy	ecstacy
fluorescent	flourescent	isosceles	isoseles	forty	fourty
frolicking	frolicing	miniaturised	minaturised	harass	harrass
haemorrhage	haemorrage	omitted	ommitted	hieroglyphics	hyeroglyphics
imitation	immitation	primitive	primative	inoculate	innoculate
misspell	mispell	privilege	priviledge	primeval	primevil
nauseous	nausious	rarefied	rarified	proceed	procede
plagiarise	plagerise	remembrance	rememberance	questionnaire	questionaire
repetition	repitition	separate	seperate	recommend	reccommend
roommate	roomate	silhouette	sillouette	sesame	seseme
supersede	supercede	tonnage	tonage	stodgy	stodgey
supplement	suppliment	truly	truely	unravelled	unwravelled
visible	visable	withheld	witheld	zany	zaney

Words used in Experiments 2 and 3

Sub-set 1		Sub-set 2		Sub-set 3	
Correct	**Incorrect**	**Correct**	**Incorrect**	**Correct**	**Incorrect**
unforeseeable	unforseeable	warranty	warrantee	tendency	tendancy
supersede	supercede	tariff	tarif	subsistence	subsistance
serviceable	servicable	shriek	shreik	stodgy	stodgey
resuscitate	resusitate	reducible	reduceable	rhythm	rythm
rarefied	rarified	privilege	priviledge	remembrance	rememberance
pneumonia	pnumonia	omitted	ommitted	pumice	pummice
occurrence	occurrance	nauseous	nausious	pronunciation	pronounciation
ninetieth	nintieth	millennium	millenium	piccolo	piccollo
moccasin	mocassin	irrelevant	irrelevent	necessarily	neccessarily
isosceles	isoseles	hieroglyphics	hyeroglyhics	mistakable	mistakeable
independent	independant	gullible	gullable	minuscule	miniscule
impeccable	impeccible	feasible	feasable	liaison	liason
ecstasy	ecstacy	embarrassment	embarrasment	irreversible	irreversable
definitely	definately	desiccate	dessicate	inoculate	innoculate
contemptible	contemptable	consensus	concensus	fluorescent	flourescent
coercion	coersion	appalled	appauled	dearth	dirth
broccoli	brocolli	annihilate	anihilate	commemorate	commemmorate
acquitted	aquitted	absence	abscence	accessible	accessable

Text used in Study Phase of Experiment 2 (sub-sets 1 and 2)

She came back from the trip with **pneumonia**, although it was **unforeseeable**, they were **appalled** by the **absence** of any **serviceable** medical care. The parents **consensus** was that inclusion in the party was considered too much of a **privilege**, and that the organisers were too backward looking. They had taken a decision three years ago that it would not be **feasible** to give any **warrantee** on illness, and they refused to take any **independent** medical advice, and maintained that the **occurrence** of illness was so rare that it was a waste to plan too much around it. They even hinted that such an approach was **contemptible**, and that their own standards were **impeccable**.

The atmosphere on the mountain was indeed **rarefied**, which meant that attempts to **resuscitate** her were not successful. It was also coming up to the **ninetieth** anniversary of the society, and the plan to mark the **millennium** with the Himalayan trip was already in the planning stage, the **tariff** for that was as yet unknown, and there was a chance that it could be an **embarrassment** and that only the **gullible** would go. That trip was actually **reducible** to rather a **nauseous** exercise, and it was likely that people would only let their children go under **coercion**. When the new leader **supersedes** the old tyrant, they would **definitely** see a more open approach. One oddity was his insistence that all children wear a special hard **moccasin** for walking. The leader regarded these almost with **ecstasy**. One of his other passions was creating **isosceles** triangle routes covered with his own kind of **hieroglyphics** on their walking maps. He was convinced that this kind of route imparted deep navigational principles to the children. At best, people thought that this was **irrelevant** and it would indeed be easier to navigate if these triangles were **omitted**. He also ensured that they ate a great deal of **broccoli** on the tip, but they never found out why. They also knew he had been charged one with causing the death of some children on an outing, and that he had been **acquitted**, although his defence had been **annihilated**, they had to **desiccate** the evidence. He had left the court with a **shriek** of triumph.

Text used in Study Phase of Experiment 2 (sub-sets 2 and 3)

The **gullible** archaeologist didn't want to appear **stodgy**. There was, after all, a **dearth** of discoveries at the moment, and he was looking for anything **feasible** to get his teeth into, as long as it wouldn't offend the academic **consensus** amongst the **hieroglyphic** specialists. He wondered whether this chance discovery might even provide the substance for a **remembrance** conference to **commemorate** his old professor. It would be a great **privilege** for him to usher in the new **millennium** in this way.

He was **appalled** by the guilty feeling of pride that already assailed him. The only way to **annihilate** this, to **inoculate** himself against it, to overcome the **nauseous** wave of pride, was to throw himself into the **minuscule** detail of decipherment under the strongest, harshest **fluorescent** light he had. He would have to try and get rid of his **irreversible tendency** to **desiccate** his prose and maintain interest by sustaining the **rhythm** of the translated prose.

An almost **irrelevant** thought **occurred** to him. He had **omitted** to consider **liaison** with the museum. What would their **tariff** be for help? A lot more than **subsistence** level, he didn't doubt. And they'd look for some kind of **warranty** on his translation. Then there was the **embarrassment** of asking for their help. Would they appear **accessible** to him? He gave a little sigh like a **piccolo** tuning up, and started to clear his work desk of the Roman **pumice**. There was the question of clearing up the **pronunciation** of the trans-literated words, and this would necessarily require personal help, in the **absence** of good reference books. It was possible that this work was not **reducible** to reference book level anyway.

He looked up and opened his mouth in a **shriek** of triumph. None of this evidence could be **mistakable**. On that fact his reputation would rest.

Text used in Study Phase of Experiment 2 (sub-sets 1 and 3)

The **stodgy** interrogator blinked momentarily under the harsh **fluorescent** light, then gave a **rarefied** grin at his assistant as they remembered the **occurrence**. He nodded at the prone and soaked form of the spy on the table.

Coercion, I think, he said and added, we'll **resuscitate** him first, and if all else fails there is legal redress for the break-in. It's unlikely that he will be **acquitted** by any court.

This is **definitely** our lucky day, said the assistant, as long as he doesn't die from **pneumonia**.

This is my **ninetieth** attempt to catch him, said the interrogator, and added, but always there is the **unforeseeable** circumstance, the **contemptible** ruse, the **minuscule** detail that escapes me, the **tendency** for fate to play tricks. But not this time.

Notice, said the assistant that his right foot is bare, yet on the left he has a **moccasin**. What do you think that means?

We shall learn when he awakens, said the interrogator, He then lent forward and lifted one of the spy's eyelids experimentally. Looking down at the dark green-blue pupils he grinned and murmured, his eyes always remind me of **broccoli** spears, I've always said that.

For a moment he sighed with **ecstasy**, then turned to his assistant with a serious glance. We have three of them now, he said, all arranged in a neat **isosceles** triangle. All we need now is a **serviceable** confession from him, on that will **supersede** the garbage from his predecessor. It has to be **impeccable**, I tell you, whatever the cost. We must necessarily **inoculate** it with choice facts that he doesn't know, that's if there is a **dearth** of useful detail. Even little cues from his **pronunciation** may hold information we need. Remember, he always talks and talks about his **mistakable** hobby of playing the **piccolo**, his passion for collecting Roman **pumice** and his necessity to **commemorate Remembrance** Day.

We know he was is **liaison** with the **independent** agent, and that he paid him **subsistence**. There is an **irreversible rhythm** to his work which finally makes it **accessible** to us.

Text used in Test phase of Experiment 2 (sub-sets 1, 2 and 3)

He felt **nauseous**, and the **absence** of anything to drink did not help. Maybe a touch of **pneumonia** was coming on, perhaps the **broccoli** at lunch was to blame. It was too much of an **embarrassment** to ask for something to drink and there was the risk it would be treated as an **irrelevant** request. Anyway he had **omitted** to bring any drink with him, so his predicament was **reducible** to bad planning and this he could only **annihilate** with a plea for **subsistence**. He would have to overcome his **tendency** to only concentrate on the **accessible** things and give thought to more **stodgy** matters although this would take a degree of **coercion** and so would be less **independent**. His friends **consensus** was that he had been unwise not to **inoculate** himself.

The feeling of **ecstasy** he had before now seemed **contemptible** and it had given way to a **rarefied** sense of enjoyment. This **occurrence** was **unforeseeable** but quite **definite**. Luckily he did not require anyone to attempt to **resuscitate** him. On further thought he realised that this was the **ninetieth** time he had felt ill in this way and being under a **fluorescent** light only made a **minuscule** difference. It was, in fact, a **privilege** for him to be taken to the medical centre since it was built to **commemorate** Charles I and was usually where the famous used for private **liaison**. Last time he had noticed that when he was **acquitted** his **pronunciation** had suffered particularly if he had tried to say the words **dearth, hieroglyphics**, **piccolo**, **pumice**, **millennium** and **remembrance**. Although this appeared to be **irreversible**, it did not **necessarily** cause problems since they were not words he used frequently.

His breathing soon settled into an **impeccable rhythm**. This was not **mistakable**, but he was **appalled** at the length of time it took. He began to feel that he was **desiccated**, then he suddenly looked down at his left moccasin. On it there was a strange **isosceles** pattern of fungal growth. There was little doubt it would remain **serviceable** despite what his more **gullible** friends said. Anyway, there was no **warranty** on it and if you wanted to **supersede** it with the new model, he had no idea of the **tariff**. The pain in his chest made him **shriek** out suddenly. It would not be **feasible** to try to reach the medical centre on his own.

Words used in Experiment 4

Target Item	Plausible Misspelling	Implausible Misspelling
accessible	accessable	accessoble
acquitted	aquitted	acuited
annihilate	annihilate	annuhilate
appalled	appauled	appailed
coercion	coersion	coerson
consensus	concensus	censensus
dearth	dirth	darth
desiccate	dessicate	dessicute
fluorescent	flourescent	fluirescent
gullible	gullable	gallible
hieroglyphics	hyroglyphics	hayeroglyphics
impeccable	impeccible	impiccible
independent	independant	independant
isosceles	isoseles	isaseles
liaison	liason	laison
minuscule	miniscule	minascule
mistakable	mistakeable	mestakable
moccasin	mocassin	mocausin
nauseous	nausious	naiseous
necessarily	neccessarily	necessorily
ninetieth	nintieth	ninteeth
omitted	ommitted	omiteed
piccolo	piccollo	piccilo
pneumonia	pnumonia	pneamonia
pronunciation	pronounciation	pronainciation
rarefied	rarified	rorified
reducible	reduceable	reduceoble
serviceable	servicable	sarviceable
shriek	shreik	shriak
stodgy	stodgey	stogdy
subsistence	subsistance	subsastence
supersede	supercede	supershede
tariff	tarif	tareff
tendency	tendancy	tindency
unforeseeable	unforseeable	unfirseeable

Words used in Experiment 5

Sub-set A		Sub-set B		Sub-set C	
Correct	**Incorrect**	**Correct**	**Incorrect**	**Correct**	**Incorrect**
war	wor	circus	circuss	ahead	ahed
watch	wotch	chain	chane	always	allways
fox	focks	monk	munk	bowl	boul
bottle	bottul	number	numba	carpet	carpit
bucket	buckit	proof	prufe	carrot	carrott
heavy	hevvy	store	stoar	castle	casstle
finger	finga	hostel	hostal	coat	cote
depress	dipress	because	becaws	convert	convirt
choose	chooze	assist	asist	field	feeld
half	harf	speak	speke	issued	ishued
rival	rivel	heaven	hevven	knife	knief
down	doun	parrot	parot	onion	onyon
trouble	trubble	really	reelly	should	shood
rubber	rubba	currency	curency	skate	skait
promise	promice	curtain	curten	smoke	smoak
sheep	sheap	winter	wintur	train	traine

<u>**Words used in Experiment 6**</u>

Correct	Incorrect
sugar	suger
chocolate	choclate
enough	anough
kitchen	kichen
fresh	fersh
left	lift
chicken	chiken
juice	juise
between	betwene
tomato	tomatoe
pumpkin	pumken
empty	emty
terrible	terrable
awful	awfull
entire	intire
fear	feer
expecting	especting
everyone	evryone
breakfast	brekfast
uncle	unkel
whispered	wispered
bicycle	bycicle
often	ofen
about	abaut
knife	knief
next	nekst
napkin	napken
teeth	teethe
middle	middel
finger	fingur
unable	unabel
explain	explane
although	allthough
pardon	parden
build	bild
mouse	mowse
island	iland
fountain	fountin
feather	fether
many	meny

Text used in study phase of Experiment 6

Jim was a boy who just loved eating **sugar**. He didn't care if it was in cakes, biscuits, **chocolate** or even just off a spoon, he couldn't get **enough**. Early one Saturday morning, Jim tiptoed into the **kitchen** to see if there was a piece of **fresh** cream cake **left** over from the night before. He opened the fridge to find **many** exciting things to eat. There was a **chicken**, some orange **juice** and nestling **between** a **tomato** and a **pumpkin** was a huge cream cake. Jim's tummy was **empty** and suddenly made a **terrible** rumbling sound. It was **awful**! He thought that he might have woken up the **entire** household. He waited in **fear**, **expecting everyone** to come running down the stairs to see what he was doing. He thought that he would have to say that he couldn't sleep and he had come downstairs for his **breakfast**. Suddenly he heard a noise.

"Is that you **uncle**?" he **whispered**. There was no answer.

"It must have been the sound of the postman on his **bicycle**" he thought "he is **often about** at this hour."

Jim took out the cake and a big **knife** and put them both on the table. **Next** he pulled out a **napkin** and tucked it under his chin. He had just cut a slice of cake and was about to sink his **teeth** in when he felt somethinr bite him in the **middle** of his **finger**.

"Ouch!" he cried and dropped the cake. Jim looked around, but was **unable** to find anything to **explain** what had just bitten him. Perhaps I was dreaming he thought, **although** I'm sure I wasn't. Jim walked slowly around the table.

"**Pardon** me" said a small voice "I didn't want to bite you but I was afraid that you would eat my house and it has taken me ages to **build**." Jim looked down to see a small **mouse** standing beside the cream cake.

"It was you?" asked Jim "but why did you make your house in a cake?"

"Well I had tried making a house on a tropical **island** and that was nice but a bit too hot. So then I tried living in a **fountain**, that was very pretty but rather wet. I thought a cake would be perfect but I had forgotten that people eat them."

"Come with me" said Jim kindly "and I'll show you how to make a warm, dry house on a bed of **feathers**."

APPENDIX C

RAW DATA

Experiment 1

Percentage of correct spellings at final spelling test.

Immediate testing - Good Spellers			Delayed testing - Good Spellers		
Incorrect	New	Correct	Incorrect	New	Correct
58	85	70	75	78.9	80
70	80	80	65	85	90
65	55	75	50	55	70
80	75	80	65	65	90
35	55	65	40	35	50
60	70	65	65	55	80
55	55	70	75	80	85
50	60	70	70	90	90
60	55	70	70	35	70
60	70	65	50	55	40
55	60	55	65	65	55
85	85	90	75	80	85
Immediate testing - Poor spellers			**Delayed testing - Poor Spellers**		
Incorrect	**New**	**Correct**	**Incorrect**	**New**	**Correct**
45	50	65	35	40	35
40	45	50	45	35	55
60	45	40	25	35	70
50	50	60	60	55	60
25	60	60	20	35	25
45	55	60	40	75	80
40	55	50	25	55	60
20	30	25	40	40	65
45	65	50	40	45	65
40	55	40	60	55	45
45	75	75	45	35	55
45	30	55	40	75	80

Experiment 1 continued

Percentage of misspellings at final spelling test for the 'Incorrect' condition

Immediate testing - Good spellers		Immediate testing - Poor spellers	
Prime	**Other**	**Prime**	**Other**
31.58	10.52	45	10
20	10	40	20
25	10	25	15
15	5	115	35
40	25	50	25
20	20	30	25
35	10	40	20
15	35	40	40
25	15	35	20
30	10	45	15
25	20	35	20
10	5	10	45
Delayed testing - Good spellers		**Delayed testing - Poor spellers**	
Prime	**Other**	**Prime**	**Other**
20	5	45	20
10	25	20	35
30	20	45	30
35	0	30	10
25	35	5	75
30	5	50	10
15	10	40	35
25	5	35	25
25	5	40	20
35	15	15	25
15	20	20	35
15	10	50	10

Experiment 2

Percentage of correct spellings at final test

Text-Text			Word - Text		
Incorrect	New	Correct	Incorrect	New	Correct
44.40	50.00	55.60	11.10	38.90	61.10
61.10	61.10	55.60	55.60	27.80	38.90
33.30	72.20	61.10	77.80	66.70	72.20
61.10	83.30	72.20	55.60	61.10	77.80
44.40	55.60	33.30	61.10	50.00	77.80
61.10	44.40	5.00	11.10	50.00	72.20
66.70	55.6	72.20	44.40	61.10	72.20
33.30	11.10	38.90	72.20	66.70	77.80
72.20	72.20	66.70	50.00	72.20	72.20
22.20	16.70	55.60	72.20	72.20	94.40
50.00	33.30	50.00	44.40	61.10	50.00
33.30	55.60	61.10	38.90	50.00	44.40
Text - Word			**Word - Word**		
Incorrect	**New**	**Correct**	**Incorrect**	**New**	**Correct**
66.70	55.60	61.10	44.40	22.20	55.60
50.00	50.00	44.40	50.00	50.00	61.10
44.40	27.80	38.90	50.00	61.10	83.30
33.30	38.90	66.70	33.30	38.90	33.30
38.90	27.80	38.90	44.40	55.60	44.40
22.20	50.00	44.40	16.70	27.80	11.10
50.00	50.00	77.80	33.30	50.00	55.60
27.80	22.20	44.40	5.60	33.30	33.30
44.40	22.20	44.40	66.70	66.70	77.80
16.70	27.80	16.70	55.60	66.70	61.10
61.10	72.20	72.20	66.70	55.60	77.80
72.20	72.20	77.80	33.30	27.80	27.80

Experiment 3

Percentage of correct spellings at final test

Rate - Rate			Not rate - Not rate		
Incorrect	**New**	**Correct**	**Incorrect**	**New**	**Correct**
44.40	66.70	50.00	44.40	22.20	55.60
33.30	61.10	38.90	50.00	50.00	61.10
5.60	00.00	33.30	50.00	61.10	83.30
61.10	50.00	66.70	33.30	38.90	33.30
61.10	44.40	66.70	44.40	55.60	44.40
27.80	16.70	38.90	16.70	27.80	11.10
55.60	44.40	72.80	33.30	50.00	55.60
38.90	55.60	66.70	5.60	33.30	33.30
61.10	44.40	55.60	66.70	66.70	77.80
55.50	50.00	64.70	55.60	66.70	61.10
27.70	72.20	38.90	66.70	55.60	77.80
22.20	55.60	50.00	33.30	27.80	27.80

Rate - Not rate			Not rate - rate		
Incorrect	**New**	**Correct**	**Incorrect**	**New**	**Correct**
27.80	27.80	27.80	22.20	44340	44.40
66.70	55.50	66.70	27.80	77.80	66.70
50.00	50.00	77.80	44.40	55350	50.00
22.20	44.40	88.90	44.40	44.40	66.70
38.90	50.00	88.90	11.10	38.90	50.00
38.90	33.30	16.70	22.20	33.30	33.30
33.30	44.40	38.90	38.90	33.30	44.40
27.80	44.40	50.00	50.00	72.20	77.80
22.20	33.30	44.40	11.10	16.70	5.50
22.20	16.70	27.80	22.20	38.90	11.40
33.30	38.90	55.50	11.10	22.20	44.40
22.20	16.70	38.90	16.70	33.30	38.90

Experiment 3 continued

Percentage of misspellings at final spelling test for the 'Incorrect' condition

Rated Incorrect at Study		Rated Correct at Study	
Primed	**Other**	**Primed**	**Other**
00.00	83.30	58.30	8.40
00.00	00.00	64.70	17.70
12.50	12.50	70.00	10.00
50.00	25.00	57.40	6.90
50.00	50.00	62.50	31.30
11.10	22.20	44.40	00.00
00.00	11.10	55.60	11.10
00.00	25.00	28.50	21.50
00.00	25.00	70.00	20.00
50.00	00.00	56.25	25.00
11.10	55.60	22.20	55.50
9.09	27.30	28.57	28.53
00.00	50.00	50.00	35.70
25.00	44.20	70.00	00.00
69.20	30.80	80.00	20.00
50.00	12.50	57.14	14.26
12.50	44.60	40.00	50.00
28.60	46.40	45.40	36.40
25.00	8.30	57.14	14.26
00.00	40.00	33.30	8.30
20.00	46.70	38.46	15.34
33.30	46.70	53.30	26.70
40.00	6.70	23.08	30.72
16.70	45.80	66.70	8.30

Experiment 4

Percentage of correct spellings

Phonologically Plausible		Phonologically Implausible	
Initial test	Final test	Initial test	Final test
30.56	25.00	13.89	19.44
19.44	11.11	22.22	27.78
52.78	52.78	25.00	30.56
47.22	47.22	25.00	22.22
41.67	30.56	50.00	61.11
33.33	27.78	47.22	38.89
47.22	44.44	38.89	38.89
13.89	11.11	47.22	47.22
19.44	13.89	47.22	44.44
33.33	36.11	38.89	38.89
30.56	25.00	47.22	52.78
38.89	33.33	16.67	19.44
36.11	30.56	38.89	44.44
58.33	50.00	36.11	41.67
27.78	27.78	19.44	25.00
41.67	38.89	44.44	33.33
30.56	22.22	16.67	13.89
63.89	61.11	36.11	41.67
52.78	38.89	52.78	44.44
77.78	72.22	55.56	52.78
47.22	52.78	41.67	44.44
25.00	8.33	58.33	52.78
50.00	38.89		

Experiment 5

Mean spelling times at final spelling test

Orthographic Accuracy at Study		
Incorrect	**New**	**Correct**
3.48	3.79	3.56
3.12	3.29	3.15
2.41	1.97	2.23
2.48	2.96	2.96
3.32	2.89	2.65
2.09	2.87	1.94
2.81	2.93	2.49
2.92	2.69	3.31
3.27	3.04	2.57
2.39	2.56	3.02
3.16	3.01	2.76
3.05	2.80	3.12
3.77	3.62	3.68
3.32	3.61	3.35
3.08	2.76	2.76
4.93	4.11	4.15
5.25	5.41	4.41
3.20	3.79	2.92
4.46	3.78	3.59
5.01	4.83	4.71
7.49	5.47	5.08
6.19	6.89	6.17
2.48	2.45	2.33
2.66	2.43	2.34
5.88	6.41	5.55
3.15	3.74	2.89
4.64	4.87	4.89
4.30	4.41	4.07
4.50	5.03	4.43
2.94	3.03	2.78

Experiment 6

Percentage gain scores (final test - initial test)

Spell words		Read words		Read story		Control
Inc.	**Cor.**	**Inc.**	**Cor.**	**Inc.**	**Cor.**	
-5	10	0	10	-15	-10	2.5
0	10	5	15	15	5	12.5
10	5	-20	15	0	0	0
10	-15	0	0	20	10	5
25	35	5	0	10	0	7.5
0	10	5	20	5	10	-2.5
10	5	5	10	0	5	12.5
0	5	-5	-5	0	5	0
0	0	-5	15	0	0	-5
20	0	5	0	10	20	-5
25	30	10	20	20	-5	2.5
-10	-5	5	0	0	0	-7.5
10	0	-5	15	-5	-10	2.5
0	5	20	20	-5	5	-7.5
-5	0	10	0	5	25	5
-5	5	-5	5	0	0	0
25	35	-5	5	10	0	5
0	5	0	5	5	-5	7.5
10	10	5	5	-15	-5	15
0	5	0	0	-10	0	2.5
0	5	5	5	15	-5	2.5
15	25	0	5	5	0	
		-10	-5	10	-5	
		-5	10	-10	0	
		-10	-5			
		0	0			

Experiment 6 continued

Percentage gain scores in number of different alternative spellings produced (final test - initial test)

Spell words		Read Words		Read Story		Control
Inc.	Cor.	Inc.	Cor.	Inc.	Cor.	
0.00	-18.20	7.70	7.70	-8.30	-8.30	4.76
-18.20	-27.30	0.00	7.70	-16.70	-8.30	0.00
-44.50	9.10	0.00	-7.70	8.30	-8.30	0.00
-27.30	-9.10	-7.70	-23.10	16.70	8.30	-19.05
-9.10	0.00	7.70	15.40	-8.30	0.00	4.76
-9.10	9.10	0.00	-7.70	8.30	0.00	0.00
-9.10	9.10	15.40	-15.40	0.00	33.30	9.52
-18.20	-18.20	-15.40	-7.70	-8.30	0.00	-4.76
-18.20	-9.10	7.70	-15.40	-16.70	16.70	4.76
-9.10	0.00	0.00	-23.10	-8.30	-16.70	14.29
0.00	0.00	7.70	0.00	16.70	-16.70	-4.76
9.10	0.00	-15.40	-15.40	16.70	0.00	-4.76
-18.20	0.00	-7.70	-7.70	8.30	0.00	0.00
-9.10	-9.10	15.40	0.00	16.70	-16.70	-14.29
-9.10	0.00	-15.40	7.70	8.30	0.00	0.00
-9.10	9.10	7.70	0.00	0.00	-8.30	-4.76
-9.10	-18.20	15.40	-7.70	8.30	8.30	4.76
-9.10	-27.30	15.40	-7.70	-8.30	16.70	4.76
-18.20	-9.10	-15.40	7.70	-8.30	16.70	14.29
9.10	0.00	7.70	7.70	8.30	-25.00	-4.76
-54.50	-18.20	-30.80	-7.70	8.30	0.00	-14.29
-18.20	-27.30	-23.10	-7.70	8.30	8.30	-14.29
0.00	-9.10	0.00	-15.40	-16.70	0.00	-4.76
-18.20	0.00	-7.70	0.00	8.30	-8.30	-9.52
0.00	-36.40	-23.10	7.70	0.00	-8.30	-4.76
0.00	-27.30	0.00	0.00	0.00	16.70	0.00
0.00	0.00	-7.70	7.70	-8.30	-8.30	0.00
-9.10	-18.20	-30.80	-7.70	-8.30	16.70	-9.52
0.00	-9.10	0.00	-7.70	-8.30	0.00	-9.52
0.00	0.00	7.70	0.00	8.30	-8.30	4.76
18.20	-9.10	-7.70	-15.40	-16.70	0.00	-9.52
-9.10	18.20	-15.40	7.70	0.00	25.00	4.76
-9.10	9.10	38.50	-15.40	25.00	0.00	-4.76
-27.30	0.00	7.70	-23.10	16.70	-8.30	0.00
-9.10	-18.20	7.70	-15.40	0.00	33.30	9.52
0.00	-9.10	-15.40	-15.40	-16.70	0.00	9.52
-9.10	-9.10	0.00	7.70	0.00	33.30	-4.76
-9.10	-18.20	15.40	0.00	-8.30	-16.70	-9.52
-18.20	-18.20	0.00	0.00	0.00	-8.30	0.00
-9.10	0.00	-7.70	-7.70	8.30	-16.70	4.76

APPENDIX D

ITEM ANALYSIS

Experiment 1

An item analysis was performed on the data reported in Table 5.1 to investigate whether the orthographic exposure effect was robust across items as well as subjects. A repeated measures ANOVA was performed where time of testing (immediate vs. delay), proficiency of spelling (good vs. poor) and type of prior presentation (incorrect vs. new vs. correct) were entered as within-items variables.The main effect of orthographic accuracy at study was highly significant [$F (2,118) = 10.76$, $MSe = 719.07$, $p < 0.0005$] and also showed a significant linear trend in the predicted direction [$F(1,59) = 22.8$, MSe 655.02, $p < 0.0005$]. This clearly shows that the orthographic exposure effect obtains across items as well as subjects.

The main effect of proficiency of spelling was also found to be highly significant [$F(1,59) = 82.2$, $MSe = 836.83$, $p < 0.0005$] thus supporting both the subject analysis and the initial division of the subjects on the basis of the advanced spelling screen. There was no significant effect of time of testing [F(1,59 = 0.019, $MSe = 461.96$, $p = 0.89$] and none of the 2- or 3- way interactions were significant. These results fully replicate the results of the subject analysis and therefore show the orthographic exposure effect to be very robust.

Experiment 3

As an additional test of the robustness of the results in Experiment 3, an item analysis was performed on the data reported in Table 6.2. A repeated measures ANOVA was employed where the three variables were conditions at study (rate vs. not rate), conditions at test (rate vs. not rate) and orthographic accuracy at study (incorrect vs. new vs. correct). A very strong effect of orthographic accuracy at study was found [$F(2,106 = 26.82$, $MSe = 0.80$, $p < 0.0005$] as was a strong linear effect across conditions from Incorrect to New to Correct [$F(1,53) = 49.67$, $MSe = 0.86$, $p < 0.0005$]. These results replicate those of the subject analysis and demonstrate a very significant orthographic exposure effect.

The main effects of conditions at study and test were not significant [study $F(1,53) = 0.83$, $MSe = 0.75$, $p = 0.7$; test $F(1,53) = 0.12$, $MSe = 0.82$, $p = 0.73$] and there were no significant 2- or 3- way interactions. These results demonstrate that the orthographic exposure effect is evident in all four of the experimental conditions and that the effect is robust across both subject and item analysis.