

Carleton College Interlibrary Loan



Trans. #: 45678

Borrower: GDC

Lending String: *MNN,ORU,INT,MUB,PAU

Patron: ;dept; ;type; Amith, Jonathan

Journal Title: Written language and literacy.

Volume: 7 Issue: 2

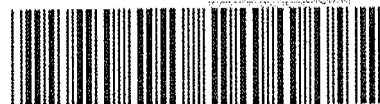
Month/Year: 2004 Pages: 139--63

Article Author:

Article Title: Venezky, Richard; In search of the perfect orthography

Imprint: Amsterdam ; Philadelphia ; John Benjamin

ILL Number: 15030662



Call #: Current Periodicals

Location:

ARIEL

Charge

Maxcost: \$25FM

Shipping Address:

Gettysburg College Library, ILL

Gettysburg College

300 N. Washington Street

Gettysburg, PA 17325-1493

Fax:

Ariel: ariel.cc.gettysburg.edu

In search of the perfect orthography*

Richard L. Venezky
University of Delaware

Philologists, linguists, and educators have insisted for several centuries that the ideal orthography has a one-to-one correspondence between grapheme and phoneme. Others, however, have suggested deviations for such functions as distinguishing homophones, displaying popular alternative spellings, and retaining morpheme identity. If, indeed, the one-to-one ideal were accepted, the International Phonetic Alphabet should become the orthographic standard for all enlightened nations, yet the failure of even a single country to adopt it for practical writing suggests that other factors besides phonology are considered important for a writing system.

Whatever the ideal orthography might be, the practical writing systems adopted upon this earth reflect linguistic, psychological, and cultural considerations. Knowingly or unknowingly, countries have adopted orthographies that favour either the early stages of learning to read or the advanced stages, that is, the experienced reader. The more a system tends towards a one-to-one relationship between graphemes and phonemes, the more it assists the new reader and the non-speaker of the language while the more it marks etymology and morphology, the more it favours the experienced reader. The study of psychological processing in reading demonstrates that human capacities for processing print are so powerful that complex patterns and irregularities pose only a small challenge. Orthographic regularity is extracted from lexical input and used to recognise words during reading. To understand how such a system develops, researchers should draw on the general mechanisms of perceptual learning.

1. Introduction

In times of high stress and anxiety, when the world order is threatened by menacing groups or new technologies, when financial markets act erratically, and public civility declines, some turn their attention to an imagined earlier and simpler time when man, woman, and nature were in perfect harmony.

The Industrial Revolution in England, for example, led to romanticising an earlier bucolic existence, what today is called the Pastoral Dream (Marx 1964). The Reformation in Europe led to a similar search into the past for a simpler, purer time, only this was a search for the perfect church that resulted, among other outcomes, in the preservation of important Anglo-Saxon documents that were thought to reflect the doctrines of the true faith before it was corrupted by indulgences and other theological aberrations.

According to Eco (1993), a similar search began among philosophers, poets, and Church fathers with the breakdown of Latin in the former Roman Empire, only this was a search for the perfect language. From the story of Babel was drawn an assumption of a single, perfect language that was spoken in the Garden of Eden. This was the presumed language that God spoke in commenting on the progress of his/her creation, the language that Adam spoke on first seeing Eve and in naming the animals, and the language that Eve spoke in cavorting with the Serpent. What this language was, however, was a matter of widely varying opinion. Augustine assumed it to be Hebrew. Dante, writing at the beginning of the 14th century, assumed it to be the form of Italian that he reserved for his own poetry, and Luther, writing in the first quarter of the 16th century, claimed this *Ursprache* to be German. Others claimed Chaldean, Phoenecian, and a host of other entries.

By the middle of the 17th century the search for a perfect language had shifted its focus to writing systems and, in particular, to a search for a universal writing system. With Sir William Jones' discoveries in comparative Indo-European philology at the end of the 18th century, the crusade leadership passed to missionary societies whose main interest was the translation of the Bible into previously unwritten languages, particularly in Asia and Africa. In the middle of the 19th century, eight missionary societies engaged the assistance of a famous German philologist and Egyptologist, Carl Richard Lepsius, in constructing a universal orthography for missionaries to use in field translations of the Bible. The result, first published in 1855, was a somewhat unwieldy combination of roman characters and superscripts and subscripts.

In the Introduction to his second edition, Lepsius declared that "An intimate relation exists between linguistic science and Missionary labours" (Lepsius 1863: 1). This intimate relationship has continued to modern times through the work of organisations such as The Summer Institute of Linguistic (SIL) and the Laubach Society and has resulted, inter alia, in major contributions to the study of language by linguists who worked with these organisations such as Kenneth Pike. Of greater interest here, however, are principles

invoked for the design of new orthographies. Most philologists and linguists since the 15th century have held that an ideal orthography has a one-to-one relationship between symbol and sound. By "one-to-one" is generally meant a unique symbol for each distinctive sound and a unique, distinctive sound for each symbol.¹ Leonard Bloomfield, for example, working in the USA in the first half of the 20th century, held this view, claiming that only ignorance kept the English speaking world with such a terrible writing system (Bloomfield 1933). According to the exponents of this perspective, which includes most spelling reformers, the road to perdition is paved with irregular letter-sound correspondences.

Much more could be said about the evolution of this one-to-one principle and something could also be said in its defence. My purpose here, however, is not to trace its origins and more recent advocacy but to use it as a base to explore how modern orthographies work. The question I want to explore concerns the range of mechanisms that are employed in modern orthographies: what are these devices, how did they evolve and what impact might they have upon the reader and writer. The one-to-one principle is not intended as a straw man but simply as a convenient starting point for studying orthographic devices. My focus will be primarily upon alphabetic systems and, within this group, upon systems that use roman characters. Other writing systems such as Russian and Hebrew will be mentioned occasionally, but no attempt made to explore them extensively.

2. Deviations from the one-to-one principle

2.1 Sounds and letters

For the languages that use the roman alphabet, most deviations from the one-to-one principle derive from the mismatch of symbols and distinctive sound categories (phonemes) each language has, which in every case is more than the number of letters available in the roman alphabet. Built into this principle, however, is an assumption that all distinctive sound categories, or phonemes, should be represented by a unique symbol or symbol combination. There are at least three situations where this assumption could be questioned. First, the marking of phonemically distinct suprasegmentals such as tone may degrade readability of an orthography. This is a claim made by Bird (1997) from studies done on a Bantu language in Cameroon, where he found that phonemic tone

markings reduced reading fluency as measured by rate of reading (i.e., words per minute).

A second case occurs for infrequently occurring, low functional load phonemes. The frequency of occurrence of a phoneme or the density of the phonological neighbourhoods for words in which it occurs may be so low in a language that neither reading nor spelling is impaired by not having a unique representation for it. In English, this is the case for /ʒ/, which has no unique spelling. It occurs in about 120 words among the 20,000 most frequently occurring in English print and in most of these it is spelled ⟨s⟩ as in *closure*, *occasion*, *pleasure*, and *usual*. In a handful of recent French borrowings it is spelled ⟨g⟩ (e.g., *massage*, *regime*, and *sabotage*). Otherwise, it is ⟨j⟩ (*jabot*, *bijou*), ⟨t⟩ (*equation*), ⟨z⟩ (*azure*, *brazier*), or ⟨ss⟩ (*scission*), the last four spellings accounting for only six low frequency words. This case occurs in other languages, especially when a handful of borrowings brings a new phoneme that is retained in the language or causes an allophone to assume phonemic status. A similar case occurs for /ŋ/ in English, where it contrasts only in morpheme final position where a following velar stop has been lost: *ban* ~ *bang*, *sun* ~ *sung*. Where a velar stop remains, it is spelled ⟨n⟩ because the phonotactics of English do not allow /n/ in such positions; that is, /n/ shifts to /ŋ/ before velar stops in the same syllable and sometimes across syllable boundaries.

A third case is more complex and concerns the options selected in any phonemic analysis. Consider the English phonemes /č/ and /ʃ/. These could be treated as independent phonemes for English or as the combinations /tš/ and /dž/. In describing Middle French, it makes sense to treat them as combinations of phonemes because the first elements were lost (including the first element of /ts/), thus giving rise to the correspondences in English ⟨ch⟩ → /č/ for French words such as *chief* that were borrowed into English before this sound change, and ⟨ch⟩ → /ʃ/ for the same word, now spelled *chef*, that was reborrowed after the sound change. How such decisions on the inventory of phonemes affect spelling difficulty is not always predictable. In the English speaking countries control over spelling has never been centralised, therefore leaving to chancery scribes, orthoepists, lexicographers and the like the opportunity to influence spelling options. In France, the French Academy has played a central role in such decisions but has not been free from the influence of the Ministry of Education, which has appointed a number of special commissions to consider orthographic reforms; major dictionaries (e.g., *Petit Larousse*); public opinion; and other government commissions and legislation (Tranel 1987).

A curious case occurs with English /ə/ as in *bird* and *worm*. Linguists tend to treat this sound not as a separate phoneme but as a sequence of /ə/ plus /r/, under the assumption that /ər/ does not occur in English so it can be interpreted as the r-coloured vowel phoneme. (Of course, this ignores cases such as *arise* where schwa plus ⟨r⟩ occur across a syllable boundary.) It is doubtful that this analysis has affected the way /ə/ is spelled in English because the orthography was well settled long before modern linguistics began its phonemic machinations. However, this case places some burden on the one-to-one advocates to decide whether there should, in a reformed spelling system, be a single symbol for this phoneme or whether the schwa plus ⟨r⟩ solution is adequate.²

Many writing systems that are based on the roman alphabet have adopted a sparing use of diacritics for some sounds, along with digraphs or trigraphs for others. Turkish orthography, which was designed in the 1920s as part of Kemal Ataturk's social and economic reforms of Turkish society, uses an augmented roman alphabet of 29 symbols, including a number of superscripts (e.g., ⟨ö, â, ğ⟩) and one subscript (⟨ç⟩). In addition, three digraphs are included: ⟨ey⟩, ⟨iy⟩, ⟨uy⟩. English, German, French, Spanish, and Italian make extensive use of digraphs (and occasional trigraphs such as ⟨sch⟩, ⟨eau⟩, and ⟨tch⟩), with limited use of diacritics. Finnish, which is celebrated for its letter-sound simplicity, has adopted a 21-letter version of the roman alphabet, including two unlauded symbols, ⟨ä⟩ and ⟨ö⟩. In addition, Finnish marks long vowels and long consonants through gemination of the symbols used for the short versions of the sounds.

2.2 Order preserving

One of the most obvious characteristics of any orthography is order preservation between spelling units and sound units. If unit A precedes unit B in pronunciation, then the spelling for unit A should precede that for unit B in writing. As necessary as this appears for any practical orthography, it is actually violated in several places in English. Consider words such as *where* and *which* in those dialects that preserve the guttural at the beginning. The pronunciation for these starts /hw-/ yet the spelling is reversed to ⟨wh-⟩. Similarly, final /əl/ as in *bottle* and *little* also has a reversed spelling, ⟨le⟩. In both of these cases earlier order-preserving spellings were reversed by 13th century English scribes, probably to break up sequences of minims that were difficult to read (Strang 1970).

2.3 Redundant symbols

It is ironic that orthographies in many countries have to adopt various mechanisms for recording a surfeit of phonemes yet still have redundant symbols. French, for example, has at least four different symbols for the phoneme /k/: ⟨c⟩ as in *carte*, ⟨k⟩ as in *kaki*, ⟨q⟩ as in *quand*, and ⟨x⟩ as in *taxi*. Even though ⟨k⟩ occurs in only a handful of borrowings, ⟨x⟩ occurs (for /k/) only in the combination /ks/ in the same morpheme, and ⟨q⟩ has a limited use, the speller of French must still contend with considerable uncertainty. Redundant symbols result from borrowings, merging of sounds, sound change, and intentional scribal creation. In English, for example, spellings such as ⟨kh⟩ for /k/, ⟨rrh⟩ for /r/ and ⟨sch⟩ for /s/ occur only in borrowings made over the last 500 years. Similarly, in Dutch where spelling reforms have maintained a distinction between native and non-native words, the graphemes ⟨c, q, th, y, and x⟩ occur only in non-native words (i.e., borrowings) (Neijt 2002).

Sound merging with retention of the different spellings accounts for the ⟨ee⟩ and ⟨ea⟩ spellings in English for /i/ as in *sweet* and *beat*. At one time these represented separate phonemes; however, they merged in the 15th century and both spellings were retained (Scragg 1974). A different situation accounts for the pseudo-geminates ⟨dg⟩, ⟨ck⟩, and ⟨tch⟩, which appear totally redundant at first glance. However, they were adopted to mark short vowels where otherwise ⟨gg⟩, ⟨kk⟩, or ⟨chch⟩ would be required (Venezky 1999).

A further case of redundant symbols, particularly in English, occurs with geminate consonants as in *manner*, *topped*, *fulfill* (American spelling), and *travelling*. At work here is a marker system in English whereby doubled consonants mark short vowels. *Manner* is a respelling of the French *manière* 'manner, way' to make the English spelling more 'regular'. *Topped* represents one of the most regular rules in English orthography but one that is not totally free of exceptions. Any word that ends in a single consonant (except ⟨x⟩) after a short, stressed vowel that is spelled with a single letter, doubles the consonant before an ending that begins with a vowel. Exceptions are made on both sides of the Atlantic, however. In the UK, *worshipped* and *travelling* are preferred over the US spellings *worshipped* and *traveling*, even though they violate the rule. However, the US prefers *enrollment*, where the doubled consonant is unnecessary, to the British *enrolment*. Both countries appear to make exceptions for a small group of mostly computer terms that double a final consonant after a non stressed vowel: *outputted*, *inputted*, *formatted*, *formatting* (Burchfield 1996: 797).

2.4 Silent letters

A second form of luxury in an alphabetic system is silent letters, yet a large number of writing systems have them. In Turkish, for example, a ⟨g⟩ after a vowel is unpronounced, inserted to show vowel lengthening. Similarly, Russian has hard and soft signs that have no sounds of their own but mark the sound of a preceding unit (Condoyannis 1969). English has a bevy of silent markers such as the ⟨e⟩ at the end of *race*, the ⟨u⟩ in *guide*, and the ⟨e⟩ at the end of *nurse*. English, like French, also has a large number of silent letters that do not function as markers: the ⟨t⟩ in *chalet*, the ⟨w⟩ in *write*, the ⟨k⟩ in *knee*, and the ⟨gh⟩ in *though*. Latin American Spanish has dropped certain final consonant sounds such as /s/ and often /d/ while retaining their spellings (Greenfield 1942).

In English *damn*, *autumn*, and *hymn*, a final sound has been lost without spelling change, but in these cases the final ⟨n⟩ helps to retain morpheme identity since the pronunciation of ⟨n⟩ occurs in some inflected and derivational forms of these words: *damnation*, *autumnal*, *hymnal*. Tranel (1987), in discussing French orthography, distinguishes silent letters that have an auxiliary value ('valeur auxiliaire') because they affect the pronunciation of other letters, from silent letters that have a null value. Thus the ⟨h⟩ in *chiromancie* 'palm-reading' prevents the ⟨c⟩ from appearing before the ⟨i⟩ and therefore being pronounced as /s/. In *chlore* 'chlorine', ⟨h⟩ is assigned a null value. Although the distinction is based on defensible principles, the treatment of ⟨ch⟩ as a sequence of independent units is questionable. A much simpler solution is to accept ⟨ch⟩ in classical borrowings as a spelling for /k/ when in fact that correspondence occurs.

Across all of these cases, four distinct sources of silent letters can be distinguished. One is through fiat, that is, spelling reform as promulgated by some authority. This holds for the Russian hard and soft signs as well as the Turkish ⟨g⟩. It also holds for a number of English silent letters, although no national authority was involved. Instead, a prestigious body such as the Chancery scribes were responsible for the changes. A second is through sound change without corresponding spelling change. The silent final consonants in Latin American Spanish are examples of this origin, as are the silent initial consonants in *write* and *knee* in English. A third is through borrowing, where the silent letter exists in the word already. In English, both *chalet* and *honour* were borrowed from French after the ⟨t⟩ in *chalet* and the ⟨h⟩ in *honour* (Fr. *honour*) had become silent.

Finally, silent letters have resulted from scribal pedantry. During the Renaissance, for example, English scribes respelled many English words to make them more similar to their real or imagined Classical origins. It was during this

period that the ⟨b⟩ was inserted in *debt*, *doubt*, *subtle*, and *subject*. In *subject* the ⟨b⟩ latter became pronounced (cf. Fr. *sujet*).

2.5 The constancy principle

Both French and English orthographies adhere often to a principle whereby the spellings for many root morphemes remain constant even though their pronunciations may change under derivation and inflection. Thus, English *sign* and *signal* both retain the spelling ⟨g⟩ even though it is silent in *sign* and could have been dropped. For English this is an erratic principle, deriving more from historic accident than from any overt spelling decisions by scribes, lexicographers, or the like. In *teeth* ~ *teethe*, for example, both sounds involved can be spelled only by ⟨th⟩, so that no matter which way the morphophonemic change occurred — whether by voicing in *teethe* or devoicing in *teeth*, the ⟨th⟩ spellings were mandatory. On the other hand, the failure of this principle to hold for *deep* ~ *depth*, *feed* ~ *fed*, *declaim* ~ *declamation*, *sheep*-*shepherd* demonstrates its lack of universality. Since most inflectional endings and many derivational ones do not undergo as extensive phonological change as root morphemes, this principle appears to apply primarily to the latter. For English, the main exceptions are the various ⟨s⟩ inflections (plural, possessive, contraction) and the past tense ⟨d⟩.

In the recent (1998) orthographic reform in German (Rechtschreibreform), this principle (*das Stammprinzip*) played a major role. For example, many consonants were doubled so that their stems would be identical to those in inflected or derivational forms where they already doubled. *Mop*, as an example, was respelled as *Mopp* to be compatible with the verb *moppen*. Similarly, the ⟨m⟩ in *numerieren* ('to number') was doubled to preserve the stem identity with *Nummer* ('number'). A variety of other changes were also made to realise a constancy principle; for example, a number of ⟨e⟩ spellings were changed to ⟨ä⟩ as in *belemmert* ('cheated'), which was respelled as *belämmert* to show the stem identity with *Lamm* ('lamb'). (*Belämmert* is colloquial, with the sense of 'pulling the wool over someone's eyes').³

In examining this principle in English orthography, at least three classes of spellings need to be defined. In all of these, a morpheme has different pronunciations in different words; the question that we pursue is how consistently the alternative pronunciations are represented in the orthography and what other options were available for these spellings. In the first class, represented by the *teeth* ~ *teethe* situation, there are no other spellings for the sounds involved and

therefore the constancy principle holds. Other common alternations in this class are the short and long vowel contrasts such as *state* ~ *static*, *senile* ~ *senility*, and *extreme* ~ *extremity*. If we take as base forms the long vowel words *state*, *senile*, and *extreme*, then the corresponding short vowel spellings are the most common ones available. The vowel /ɪ/ in *extremity* could be spelled ⟨ea⟩ but this would be unusual.

The constancy principle also holds in English for a few inflectional endings such as ⟨s⟩/⟨es⟩ as in *boys*, *bats*, and *bridges*. The spelling ⟨z⟩ is potentially available for *boys* and *bridges* but ⟨z⟩ is little used in final position in English, occurring mostly in borrowings such as *fez* and *quartz*, where it represents /z/ and /s/, respectively.

For the second case, no single spelling is available for the two different phonemic units represented. This is the case, for example, with *decide* ~ *decision* and *belief* ~ *believe*. No single graphemic unit can represent both /d/ and /z/, nor can any single unit represent both /f/ and /v/. (I assume that no generalization could reasonably be drawn from the ⟨f⟩ → /v/ correspondence in *of*.) Many such alternations exist for English, especially if etymologies are considered. Thus, *poor*, *poverty*, and *pauper* all derive ultimately from Latin *pauper* 'poor'. Exactly what the alternation is here is not easy to discern, however. For *poverty* and *pauper* it is probably /v/ ~ /p/. However, *poor* requires, at a minimum, a zero phoneme alternating with /p/.

The third case is for all alternations where spelling options are available and therefore the morpheme's identity could be retained or not. Within this class we note the two obvious subclasses: one for those cases where morpheme identity is preserved and one for the cases in which it is not. All of the silent letter alternates such as *damn* ~ *damnation*, where a letter is silent in one form and pronounced in another, fit into the first subclass because deletion of the silent letter is a viable option. Similarly, final ⟨c⟩, particularly in ⟨ic⟩ endings, where certain suffixes lead to a /k/ ~ /s/ alternation, as in *electric* ~ *electricity*, belongs in this class. Since ⟨c⟩ can represent both /k/ and /s/, the ⟨c⟩ spelling has been retained where this alternation occurs. Also fitting in here are alternates such as *sign* ~ *design*, *sound* ~ *resound*, and *house* (noun) ~ *house* (verb). But compare *brass* ~ *brazed*, *grass* ~ *grazed*, and *glass* ~ *glazed*, where different spellings have been adopted. These are members of the second subclass where morpheme identity has not been retained.

A case that spans the two subclasses is the past tense marker ⟨d⟩/⟨ed⟩ as in *learned*, *burned* and *spoiled*. Where it is spelled with ⟨d⟩ or ⟨ed⟩, it is placed in the identity subclass. Such forms might be pronounced with either a final /d/ or

/t/, as in *bagged* and *jumped*. However, it can also be spelled in some verbs with a <t>: *learnt*, *burnt*, *spoilt*; where this occurs, these words are classed with other non identity preserving words. (But note the complication caused by the different pronunciations of the past tense marker in *burned* and *burnt*.) American spelling tends to prefer the <d>/<ed> spellings but most US dictionaries list the <t> spelling as an alternate for a few past tense and past participle forms (e.g., *burnt*, *spoilt*). Spelling may vary, nevertheless, across forms of the same word. According to Burchfield (1996: 120), for example, *burnt* is preferred in British spelling for the past participle and adjectival forms but *burned* for the past tense. The <d>/<ed> example is only roughly parallel to the plural <s>/<es> case, especially since some forms have only a <t> past tense marker; e.g., *kept*, *slept*.

Given these cases, what conclusions can be drawn about the constancy principle in English? First, it is of interest for spelling reform to note that a reform that fully embraces this principle would call for respellings that would bring pairs such as *deep* ~ *depth*, *brass* ~ *brazed*, and *declaim* ~ *declamation* into compliance. This is what the German spelling reform is attempting to accomplish for German. So far as English orthography stands, the principle is applied in the majority of the class three cases. These are the ones in which options are available. (In class one it occurs automatically and in class two it could not occur without radical restructuring of the orthography.) A fuller analysis is required, however, to determine the actual degree of compliance.

2.6 The etymological principle

Dutch orthographic reform, whether by the Dutch Language Union or by any of the earlier bodies that laboured in this field, has claimed an etymological principle as one of its guiding precepts. "The choice of one out of different letters for similar sounds is based on the derivation or older form which was in use when sounds that are similar now, could still be distinguished clearly" (Te Winkel 1863: 14; cited in Neijt 2001: 212). This principle, although applied originally to native words, is now considered in the spelling of both native and non-native words. Similarly, the 1998 German spelling reform distinguished native and non native words, allowing in some cases alternative spellings for non native ones; e.g., *Joghurt*/*Jogurt*. English appears also to have been based, at least in part, on an etymological principle; however, the resulting orthography is not a result of the careful application of this and other principles but a pastiche of different tendencies at different time periods, with chaos a constant companion.

The English words *mechanic* and *machine* both retain a ⟨ch⟩ spelling that reflects their Greek and Latin origins. (Both words were borrowed from Greek via Latin and Middle French.) However, *mechanic* has retained a ⟨ch⟩ → /k/ correspondence while *machine* has been influenced by sound change in French and has ⟨ch⟩ → /s/. Some initial consonants that became silent in English also lost their spellings while others retained theirs. Thus, the initial ⟨h⟩s in *raven* and *laugh* (Old English *hrafn*, *hliehhan*) were lost in both pronunciation and spelling while the silent ⟨w⟩ and ⟨k⟩ were retained in *write* and *knee*. Foreign spellings such as ⟨aa⟩, ⟨eau⟩, ⟨iew⟩, ⟨rrh⟩, and ⟨kh⟩ are retained (*aardvark*, *beau*, *view*, *catarrh*, *khan*) while vowel ligatures (ae, oe) that were used in Middle English were dropped. For English, no regular application of an etymological principle is apparent. When spelling was fluid, many foreign spellings were naturalised; after spelling was fixed, foreign spellings were mostly retained. The same can be said of the spellings of words that derive from the earliest period of the English language (the Old English period).

2.7 Scribal constraints

The last set of deviations from the one-to-one principle are called scribal constraints (Venezky 1999) because for English most of them derive from graphotactic patterns adopted by late Medieval scribes to make manuscripts easier to read. These constraints include the insertion of a silent ⟨e⟩ after what would otherwise be a word final ⟨u⟩ or ⟨v⟩; the alternation of ⟨u⟩/⟨w⟩ and ⟨i⟩/⟨y⟩ as second elements of digraph vowel spellings such that ⟨w⟩ and ⟨y⟩ generally occur at the ends of words and before vowels and ⟨i⟩ and ⟨u⟩ elsewhere; the elimination of geminate consonants in word final position in monosyllables except for ⟨ff⟩, ⟨ll⟩, and ⟨ss⟩; and a handful of other patterns, including restrictions on which letters can be geminated and which vowel spellings can occur before the pseudo-geminates ⟨ck⟩, ⟨dg⟩, and ⟨tch⟩. Almost all of these constraints place a larger burden on spelling than on reading and almost all have exceptions, particularly among the high frequency words (e.g., *bus*, *gas*, *if*, *of*, *owl*, *you*, *thou*). Nevertheless, scribal constraints comprise a critical part of scribal regularity — the spelling patterns that distinguish English orthography from random and semi-random arrangements of letters. (The other part of scribal regularity derives from phonotactics — the constraints that regulate the allowable sequences of sounds for a language. Because /dl/ does not occur as a syllable-initial sequence in English, and never did, the spelling ⟨dl-⟩ does not occur at the beginnings of English words.)

3. Human information processing

3.1 Probing the mind of the reader

Having considered the different ways in which practical orthographies deviate from a one-to-one principle, I now want to consider the question of the perfect orthography from a human information processing standpoint. The question now shifts from what currently exists to what impact different options have on human reading processes. It is worthwhile to note, before diving into this discussion, that more is considered today in the design of orthographies than simply the reading and spelling challenge to individuals. For example, the European Union has suggested that orthographic reforms among member countries take into account translations between languages and computer standardisation issues. Translation facilitation was also one factor in the decision of the Association of Spanish Language Academies in 1994 to drop ⟨ch⟩ and ⟨ll⟩ from the alphabetic sequence for Spanish. No spellings were changed but dictionary listings were, bring them more in line with those of other languages based on the roman alphabet.

In considering what impact different orthographic options have on the reader, one needs to consider separately the learner and the more advanced reader. Similarly, one should note the impacts separately on reading and on spelling. Orthographies that tend toward the phonemic (i.e., one-to-one) style help the learner, both in reading and spelling, while those that adhere to a constancy principle help the more advanced reader with reading but not with spelling. The graphemic discrimination of homophones, for example, makes spelling more difficult, but assists the faster reader in retrieving semantic information. Spelling reformers for English have long decried the difficulties of learning to read English with its deviations from a one-sound, one-symbol ideal, yet in the last two international comparisons of reading performance, USA children scored the second highest in the world at fourth-grade level (Elley 1992; IEA 2003). If children's reading ability is the main criterion for the choice of an orthography, these data suggest that most other nations should change to a more complex and irregular spelling system. However, in fairness to those who work with reading instruction, the extremely high variance in reading performance in the USA indicates that not all is well with the current teaching of literacy and perhaps more than the orthography should be considered in discussing national reading performance.

One of the most important considerations in examining the consequences of different orthographic options is how readers and spellers actually process

grapheme-phoneme and phoneme-grapheme correspondences and how they recognise and spell words. If there are universal processing principles, then the choices made might not have much impact on learning to read or spell or in the mature processing within these two skill domains. If, on the other hand, processing is largely determined by the orthographic principles employed, more caution should be advised. The literature on reading and spelling processes is vast and still rife with controversy. Nevertheless, there are some reasonable conclusions that could be drawn. I will not attempt a full review here of the subject; instead I want to suggest some directions for formulating the issue and for designing research programs. I especially want to emphasise visual processing issues in reading because they appear to be ignored somewhat in the current enthusiasm for phonemic awareness and other phonological components of reading.

It is important to note that for normally sighted individuals, all reading begins with visual input that must be matched with patterns stored in long-term memory. No matter how printed words are searched in the mental lexicon, a visual match must occur. Without it, pseudohomophones would be accepted as real words and many real homophones would not be properly recognised. The readers' first task is to locate an appropriate starting point on a printed page and to recognise the visual patterns, moving the eyes in a forward going direction for the orthography being read. Cross-national studies of eye movements in reading have shown that the eye movement pattern first reported by Javal in 1879 for French holds across orthographies (Javal 1879; Judd & Buswell 1922). All orthographies are read with fixations, followed by saccadic jumps, where the fixation times are controlled by the complexity of the text being read. For English, fixations for a mature reader average 200-250 milliseconds and the saccadic jumps tend to cover about 8 letter spaces (Rayner 1999).

Research on what happens in reading once a fixation is made extends back at least as far as Cattell's work in Wundt's laboratory in Leipzig in the early 1880s (Cattell 1885, 1886). Cattell studied letter and word recognition, legibility of different type styles, and the differences in reading unconnected versus connected letters and words, among other issues. Most of this work on reading was motivated not by a direct interest in reading but by a concern for the speed of mental events and, especially for Cattell, individual differences (Cattell 1888; Venezky 1984). Reading was a convenient task for measuring such events, especially in the naming of letters or words. The history of the study of visual processes in reading from that time forward followed the central trends in experimental psychology, particularly in the USA where the rise of educational

psychology and the dominance of behaviourism shifted experimental attention by the beginning of World War I to mental tests and to stimulus and response paradigms. In the late 1950s, attention began to shift back to cognitive issues and word recognition was again investigated. The work of Shannon (1948, 1951) on information measures led to an interest in the degree to which orthographic order, as measured by different approximations to English, could facilitate the recall of pseudowords (Miller, Bruner, & Postman 1954).

With the formation of Project Literacy at Cornell University in the early 1960s came an interest in a wide range of reading problems, including the influence of grapheme-phoneme regularity on word recognition (Gibson & Levin 1975; Gibson, Pick, Osser, & Hammond 1962). These were the first experimental studies on grapheme-phoneme regularity but they were rapidly followed by many more in different laboratories, particularly in North America and Europe. For the purposes of this chapter, I want to summarise briefly the findings in two related areas that have been explored since the 1960s: orthographic regularity and the word superiority effect (WSE). Both give some insight into the role that orthographic regularity plays in word recognition and some understanding of how well the human information processing system can adjust to complex and often irregular orthography.

3.2 Orthographic regularity

Orthographic regularity has been a concern of psychological studies on word recognition and reading since the late 1950s, although the majority of work of interest here is more recent. As mentioned above, the earliest work was done by E. J. Gibson and her students and colleagues at Cornell University. This work was oriented toward discovering the shortest letter string that had an invariant pronunciation; however, experiments with congenitally deaf students showed the same effects found for hearing students (Gibson, Shurcliff, & Yonis 1970). Some of the work since then has been developmental, looking at either the acquisition of grapheme-phoneme patterns (Venezky 1976), or comparative, exploring differences across readers of different abilities or languages in processing regular and irregular spellings (e.g., Massaro & Taylor 1980; Wimmer, Landerl, & Frith 1999). Research on dyslexia has shown different types of reading disabilities based upon how irregular orthographic patterns are handled (Patterson & Morton 1985; Plaut & Shallice 1993). Work on a variety of languages and on cross-national similarities and differences has also been done (e.g., Monteiro 1995, reported in Rego 1999; Ziegler, Jacobs, & Stone 1996).

In most of the more recent work, orthographic regularity has been defined by one measure or another of the regularity of grapheme-phoneme patterns. For example, probabilities for English grapheme-phoneme correspondences have been computed by Berndt, Reggia, & Mitchum 1987; in addition, a variety of models have been proposed for processing of orthographic patterns (e.g., Brown 1987; Glushko 1979; Parkin 1984; Waters & Seidenberg 1985). However, equally strong evidence exists for influence from graphic patterns including the scribal regularity discussed above (e.g., Mason 1975; Parkin 1984; Venezky & Massaro 1987). Parkin (1984), among others, has found that the psychological concept of regularity for grapheme-phoneme correspondences does not depend upon strict, invariant mappings; instead, it is highly flexible, treating major and minor patterns similarly under certain experimental conditions. In addition, studies of rule and pattern learning from other domains such as language development have a number of parallels with orthographic acquisition. For example, over-generalisation or over-extension has been found in the learning of a number of language features, including morphology and semantics (see Harley 1995: 360-364 for a brief review). This same phenomenon has been found in the child's learning of grapheme-phoneme patterns (Venezky 1976). The same pragmatic factors affecting language acquisition proposed by Taylor and Taylor (1990) could be applied to the learning of orthography: Simple and short before complex and long, concrete before abstract, frequent and familiar before less frequent and unfamiliar, etc. With a shift in emphasis and an occasional change in vocabulary, the study of orthographic regularity could be fit to the mainstream of language and cognitive development.

3.3 The word superiority effect

One of the most powerful demonstrations of the application of orthographic knowledge is the word superiority effect (WSE), first studied by Gerard Reicher at the University of Michigan (Reicher 1969). Daniel Wheeler replicated Reicher's original studies with some refinements in methodology (Wheeler 1970), so the paradigm commonly used to study this effect is called the Reicher-Wheeler paradigm.⁴ Reicher (1969) presented, at brief exposures, single-letter, single-word, and random letter string displays to adults, followed by a mask to eliminate any after-image. The mask display was followed immediately by two letter choices at a cued position (using dashes to represent letters) where for words, both choices would make words. For example, for the display word WORK the response choices for the last letter would be D and K. A random letter string

display, created through a permutation of the letters for a displayed real word (e.g., OWRD), would also be followed by the same two-choices for the last letter position.

Reicher (1969) found that accuracy was significantly higher for letters in a real word than in a random letter string or for letters alone. The effect was relatively small — about a 12% advantage for words — but has held up with replication (e.g., Gilmore & Egeth 1976; Thompson & Massaro 1973; Wheeler 1970). Subsequent studies showed that the effect could be eliminated by having a constant target set (Bjork & Estes 1973; Thompson & Massaro 1973) or by blocking on the stimulus type (words, letters, random letter strings). These manipulations demonstrate that the reader can act strategically, adjusting basic processing to optimise task performance. An important extension of the Reicher-Wheeler paradigm for studying reading was made by Baron and Thurston (1973), which showed a word superiority effect for legal pseudowords but not for illegal pseudowords. This information eliminates whole word templates as an explanation for the WSE because presumably, the Baron & Thurston (1973) participants had never seen the pseudowords before. Therefore, some aspects of the regularity of the orthography, in particular, *scribal regularity* (Venezky & Massaro 1987) must be invoked.

The Baron and Thurston (1973) finding about pseudowords confirms that scribal regularity information is available to the mature reader. It does not confirm that such information is actually used in normal, silent reading but it does show that as a consequence of encountering millions of words in reading, the reader acquires and can apply when needed information about which letters can occur where in English words. When combined with the studies that show effects from bigram frequency, trigram frequency, and letter spatial frequency, the importance of orthographic structure becomes apparent.

3.4 Neurological evidence for orthographic structure

Further evidence that orthographic structure is used in processing printed words derives from recent work on brain functioning. Posner and Raichle (1997), as an example, have shown with functional magnetic resonance imaging (fMRI) that while words, legal pseudowords, consonant strings, and strings of letter-like symbols are initially detected in the same area of the brain, only words and legal pseudowords activate the same processing area after this initial detection stage.⁵ Differences in event related potentials (ERPs) have also been found for words and consonant strings (Compton, Grossenbacher, Posner, &

Tucker 1991). In a replication of this study, the authors concluded that orthographic regularity rather than word familiarity was responsible for the main effect (McCandliss, Posner, & Givón 1997: 108): "Orthographic effects support the notion that readers eventually internalize the regularities inherent [in] the structure of written words."

McCandliss et al. (1997) conclude that a single brain area is sensitive to orthographic regularity and that this sensitivity is independent of the lexical status of the stimulus. This is an important conclusion for understanding basic processing in reading because it indicates that orthographic regularity is not simply a function of lexical or sub-lexical frequency but instead represents abstract patterning extracted from lexical input, that is, a predictive model developed from both what does and what does not occur in printed words. The endings <-ipy>, <-ilf>, and <-osk> do not occur in common English words. Therefore legal pseudowords formed from them: *bipy*, *fipy*, *tilf*, *delf*, *cosk*, *mosk*, etc. have no rhyme neighborhoods yet according to the McCandliss et al. (1997) result should be processed by the same brain mechanisms as real words or pseudowords with large rhyme neighborhoods.

There is much more that could be said about brain mechanisms and orthographic regularity but the time has come to talk about research directions that could explore this area and tie it more closely to the main lines of psychological research. The next section is concerned with viewing the acquisition of orthographic structure as a perceptual learning task.

3.5 A framework for studying orthographic issues

For English, the development of reading ability can be understood as a form of perceptual learning. Gibson and Pick (2000), for example, point out that one of the universals of such learning is perceiving order. The human organism is strongly oriented to finding order in the data that it processes through its senses. One kind of order concerns the letters of the alphabet and their frequencies of occurrence. According to Hasher and Zachs (1984), competent readers have a high awareness of the relative frequencies of occurrence of the letters of the alphabet; in addition, as described above, studies of word recognition have shown that competent readers access higher order frequency information in word recognition such as bigram and trigram frequencies, spatial frequency, and scribal regularity (Mason 1975; Massaro & Taylor 1980). One argument that could be pursued experimentally is that in all orthographies,

such information is extracted by the competent readers and used for certain word recognition tasks.

A framework that appears most applicable to the study of visual processing in reading development, particularly for the earlier stages, is summarised by Goldstone (1998) in a review of current research on perceptual development. Goldstone (1998) posits four processes in all perceptual development: attention weighting, stimulus imprinting, differentiation, and unitisation. Attention weighting occurs as we learn what is important to attend to in a task. For reading, texts, sentences, and words are what we learn to attend to as we become mature readers. Perhaps the Stroop effect (Stroop 1935) is the best known demonstration of attention weighting. Even with training to avoid it, we cannot resist reading words and extracting their meanings when we encounter them (the words, that is) in the environment.

Stimulus imprinting implies that we develop special detectors for those objects that occur most frequently in the environment. Posner and Raichle (1997) have found that special areas of the brain are active in the processing of meaningful letter strings and of legal pseudowords but not for the same tasks when applied to the processing of consonant strings or sequences of symbols built from letter parts. This implies that those objects that are constructed according to the scribal principles of English have special processing areas not used for other types of visual input. It is reasonable to assume, furthermore, that these neurological structures develop through experience with print in which ever writing system is encountered.

Differentiation applies to reading at several levels in the perceptual development process. In learning to recognise the letters of the alphabet, children learn to form identity classes based on a set of visual features. What these features are for the English alphabet has been the subject of considerable experimental work (e.g., Bouma, 1971; Gibson & Levin 1975; Massaro et al. 1980). As with phonemic discrimination, children learn to attend to the distinctive features that discriminate letters and learn to ignore features such as serifs that are non-distinctive. As children learn to read they learn that symbol orientation, which is non-distinctive for identifying objects in the environment, is distinctive for letters (and numbers). For example, a cup remains a cup whether the handle is oriented to the left or to the right but lower case ⟨b⟩ when rotated 180 degrees becomes lower case ⟨d⟩. As word recognition becomes more automatic, frequently occurring words are discriminated more quickly. Whether this speeded word recognition occurs through recognition of letters and their order or through some use of the word configuration remains to be determined.

Studies done with alternating case spellings (e.g., tWiNs, TwInS) tend to show little transfer from one alternation sequence to another for the same word, indicating that the overall visual appearance of the word does have some role in visual word recognition (Crowder & Wagner 1992).

Unitisation, as applied by Goldstone (1998), applies to the unit size used in recognising a complex symbol. Children begin reading by fixating on each letter in a word; a mature reader recognises about 1.1 words per fixation. Somehow in the process of learning to read, the child learns to attend to or recognise larger and larger units with the same effort previously applied to smaller units. For Chinese characters, this principle leads to the prediction that while the recognition time for the beginning reader for a character would be a function of the number of strokes present, this relationship would not hold for the more mature reader with frequently occurring characters. The assumption here is that characters that occur frequently are recognised through clusters or complexes of their features and not through an exhaustive accounting of every stroke. This same principle may account for why letter-sound regularity tends to account for some of the variance in recognising low frequency English words but not high frequency ones. The higher frequency words are recognised as units while the low frequency ones require attention to sub-components.

4. Postscript

Countries can debate *ad infinitum* the relative merits of spelling non-native words differently from native words, of honouring or not honouring a constancy principle, and other fine points of orthographic design. However, from the standpoint of human information processing, the impact of these options, past the first few years of schooling, is apparently not very large. The human organism is order seeking, finding patterns in all sensory input. Whether these patterns are defined by scribal regularity or by such proxies as single letter positional frequency, bigram or trigram frequency, or letter-sound regularity, the reader extracts and utilises them in reading tasks. An orthography as complex as English, with all of its irregularities, is still not a major challenge to our processing systems. The average child, with average instruction, acquires a mastery of the system, moving from letter-by-letter reading to word-by-word reading to fluency in three to four years. Reading speed and fluency and comprehension continue to develop for many more years but the basic processing skills for most orthographies appear to be acquired relatively quickly.

That the initial learning process takes longer in English than in Finnish or Turkish may be a function of instruction. It could also result from the need to acquire a larger reading vocabulary in English so that generalisations about letter-sound correspondences can be made. Although many reading programs try to teach rules for letter-sound mappings, it is not understood how well children at ages 6–8 can apply such rules fluently until they encounter multiple environments in which the patterns for the rules occur. Whether the difficulty in learning decoding in English derives from the exceptions that occur to many patterns or from the large number of functional units that occur in the orthography, particularly for vowel spellings, is not established. For reading common English words, one has to learn the correspondences for the simple (single-letter) vowel spellings as well as those for a large number of digraph spellings: ⟨ai, ay, au, aw, ei, ey, ee, ea⟩ etc.

There are many other questions left to resolve in the study of orthography and reading. Morphological mechanisms such as the ⟨s⟩/⟨es⟩ plural in English occur in a number of writing systems. Do they facilitate reading? Does the mature reader actually tap into a morphological level of the language in reading words such as *baseballs* and *Mary's*? How are letter-sound correspondences activated? Is the phonological correspondent for an invariant consonant extracted on the fly from words with that same consonant or does it come from a rule or generalisation? And what functions do letter-sound correspondences serve in learning to read? We can assume that in mature reading, most words are recognised visually. If reading is oral, articulation programmes are extracted once the words are matched in a mental lexicon. How is the transition made from sounding out a word to recognising it as a unit visually? As I have argued elsewhere, pronouncing words from their functional graphemic units may facilitate the acquisition of rapid visual discrimination for words. That is, because a word such as *threat* must be broken into functional units ⟨th⟩, ⟨r⟩, ⟨ea⟩, ⟨t⟩ to be pronounced, the visual system is forced to focus on these units in the print and becomes adept at their visual recognition. If words were taught as holistic entities, this word might be recognised initially by its first and last letters and length, especially if these combined features did not overlap with any other known word.

There remains a need to examine these orthographic issues across orthographies. Do the same brain localisations for ordered print as found by Posner and Raichle (1997) for English occur in other languages? Will such localisation occur for orthographies that approach a one-to-one design, such as Finnish and Turkish? Do readers of these 'regular' orthographies utilise scribal information

and frequency based information in recognising words? The mechanisms for extracting frequency information from the environment appear to be quite powerful and relatively immune to training or ageing. The most logical hypothesis is that with all symbol systems, readers will extract without instruction information about the frequency of occurrence and ordering of the symbols and will form detectors to differentiate them. In addition, the more frequently occurring combinations will be recognised quickly by the mature reader. In addition, generalisations will be made about what could occur.

Reading research has made significant progress in demonstrating that reading is special. The time has now come to focus on how reading and spelling draw upon general information processing mechanisms and develop through the same perceptual learning phenomena observed in other domains.

Editors' remark

The version presented here is from December 2003. In a mail from December 11th 2003, Richard Venezky announced his aim to reconsider some small aspects of the text which he regarded as fundamentally finished. Sadly, his health condition did not allow him to take up the work on this subject again.

Notes

* I am grateful to Martin Neef for comments on an earlier draft of this paper and to Bill Iidsardi for assistance with a number of linguistic issues. Needless to say, however, neither is responsible for any part of the content of this chapter.

1. I'll leave for later in this paper the definition of "distinctive sound". For the present it can be understood as referring to the segmental phonemes of a language.
2. Space does not allow me to do justice to the current debate in linguistics over the nature of the phoneme and over such issues as the role of perceptual information in phonological analyses. On these issues, see Cluff & Luce 1990; Luce & Pisoni 1998; and McCarthy 2002.
3. Some of these spellings were suggested in earlier reforms; in addition, the presence of the morpheme *lamm* in *belämmert* is not universally accepted.
4. See Carr and Pollatsek 1985 for a review.
5. Functional magnetic resonance imaging (fMRI) is a relatively new tool for studying neurological structure and functioning. It takes advantage of the increased blood flow that occurs in a neurological area when it is activated; however, fMRI images require integration

of data obtained over a relatively long time period: 1.5–2 seconds. For an introduction to fMRI, see on the World Wide Web (<http://www.fmri.org/fmri.htm>).

References

- Baron, J., & Thurston, I. 1973. An analysis of the word superiority effect. *Cognitive Psychology*, 4:207–228.
- Berndt, R., Reggia, J., & Mitchum, C. 1987. Empirically derived probabilities for grapheme-to-phoneme correspondences in English. *Behavior Research Methods, Instruments, & Computers*, 19(1):1–9.
- Bird, S. 1997. When marking tone reduces fluency (Research paper HCRC/RP-91). Edinburgh: University of Edinburgh.
- Bjork, E. L., & Estes, W. K. 1973. Letter identification in relation to linguistic context and masking conditions. *Memory & Cognition* 1:217–223.
- Bloomfield, L. 1933. *Language*. New York: Holt, Rinehart and Winston.
- Bouma, H. 1971. Visual recognition of isolated lower-case letters. *Vision Research* 11:459–474.
- Brown, B. D. A. 1987. Resolving inconsistency: A computational model of word naming. *Journal of Memory & Language* 26:1–23.
- Burchfield, R. W. (ed.). 1996. *The new Fowler's Modern English Usage* (3rd ed.). Oxford: Clarendon Press.
- Buswell, G. T. 1920. An experimental study of the eye-voice span in reading (Supplementary Educational Monographs No. 17). Chicago: University of Chicago Press.
- Carr, T. H., & Pollatsek, A. 1985. Recognizing printed words: A look at current models. In *Reading research: Advances in theory and practice*, Vol. 5, D. Besner, T. G. Waller, and G. E. MacKinnon (eds.), 1–82. Orlando FL: Academic Press.
- Cattell, J. M. 1885. Über die Zeit der Erkennung und Benennung von Schriftzeichen, Bildern und Farben. *Philosophische Studien* 2:635–650.
- Cattell, J. M. 1886. The time it takes to see and name objects. *Mind* 11:63–65.
- Cattell, J. M. 1888. The psychological laboratory at Leipsig. *Mind* 13:37–51.
- Cluff, M., & Luce, P. 1990. Similarity neighborhoods of spoken two-syllable words: Retroactive effects on multiple activation. *Journal of Experimental Psychology: Human Perception and Performance* 16:551–563.
- Compton, P., Grossenbacher, P., Posner, M. I., & Tucker, D. M. 1991. A cognitive anatomical approach to attention in lexical access. *Journal of Cognitive Neuroscience* 3:304–312.
- Condoyannis, G. E. 1959. *Scientific Russian*. New York: Wiley.
- Crowder, R. G., & Wagner, R. K. 1992. *The psychology of reading: An introduction*. (2nd ed.). New York: Oxford University Press.
- Eco, U. 1995. *The search for the perfect language*. Oxford: Blackwell Publishers.
- Elley, W. 1992. How in the world do students read? The Hague: International Association for the Evaluation of Educational Achievement.
- Gibson, E. J., & Levin, H. 1975. *The psychology of reading*. Cambridge MA: MIT Press.

- Gibson, E. J., Pick, A., Osser, H., & Hammond, M. 1962. The role of grapheme-phoneme correspondence in the perception of words. *American Journal of Psychology* 75:554-570.
- Gibson, E. J., & Pick, A. D. 2000. *An ecological approach to perceptual learning and development*. Oxford: Oxford University Press.
- Gibson, E. J., Shurcliff, A., & Yonas, H. 1970. A utilization of spelling patterns used by deaf and hearing subjects. In *Basic studies on reading*, H. Levin and J.P. Williams (eds.). New York: Basic Books.
- Gilmore, G. C., & Egeth, H. E. 1976. When are nonwords easy to see? *Memory & Cognition* 4:519-524.
- Glushko, R. 1979. The organization and activation of orthographic knowledge in reading aloud. *Journal of Experimental Psychology: Human Perception and Performance* 5:674-691.
- Goldstone, R. L. 1998. Perceptual learning. *Annual Review of Psychology* 49:585-612.
- Greenfield, E. V. 1942. *Spanish grammar*. New York: Barnes & Noble.
- Harley, T. A. 1995. *The psychology of language: From data to theory*. Hove: Psychology Press.
- Hasher, L., & Zacks, R. T. 1984. Automatic processing of fundamental information. *American Psychologist* 39(12):1372-1388.
- Javal, E. 1879. Essai sur la physiologie de la lecture. *Annales d'Oculistique* 82:242-253.
- Judd, C. H., & Buswell, G. T. 1922. *Silent reading: A study of the various types* (Supplementary Educational Monographs No. 23). Chicago: University of Chicago Press.
- Lepsius, C. R. 1863. *Standard alphabet for reducing unwritten and foreign graphic systems to a uniform orthography in European letters*. (2nd ed.). London: Williams & Norgate.
- Luce, P., & Pisoni, D. 1998. Recognizing spoken words: The neighborhood activation model. *Ear and Hearing* 19:1-38.
- Marx, L. 1964. *The machine in the garden: Technology and the pastoral ideal in America*. New York: Oxford University Press.
- Mason, M. 1975. Reading ability and letter search time: Effects of orthographic structure defined by single-letter positional frequency. *Journal of Experimental Psychology: General*, 194:146-166.
- Massaro, D. W., & Taylor, G. A. 1980. Reading ability and utilization of orthographic structure in reading. *Journal of Educational Psychology*, 72(6):730-742.
- Massaro, D. W., Taylor, G. A., Venezky, R. L., Jastrzembski, J. E., & Lucas, P. A. 1980. *Letter and word perception: Orthographic structure and word processing in reading*. Amsterdam: North-Holland.
- McCandliss, B. D., Posner, M. I., & Givón, T. 1997. Brain plasticity in learning visual words. *Cognitive Psychology* 33:88-110.
- McCarthy, J. J. 2002. *Thematic guide to optimality theory*. Cambridge: University of Cambridge Press.
- Miller, G. A., Bruner, J. S., & Postman, L. 1954. Familiarity of letter sequences and tachistoscopic identification. *Journal of General Psychology* 50:129-139.
- Neijt, A. 2001. Reforms of Dutch orthography. In *Hieroglyphen, Alphabete, Schriftreformen*, D. Borchers, F. Kammerzell, & S. Weninger (eds.), 209-222. Göttingen: Seminar für Ägyptologie und Koptologie.

- Neijt, A. 2002. The interfaces of writing and grammar. In *The relation of writing to spoken language*, M. Neef, A. Neijt, and R. Sproat (eds.), 11–34. Tübingen: Niemeyer.
- Ogle, L. T., et al. 2003. Findings from the progress in International Reading Literacy Study (PIRLS) of 2001 (NCES report #2003073). Washington, D. C.: US Department of Education, National Center for Education Statistics.
- Parkin, A. J. 1984. Redefining the regularity effect. *Memory & Cognition* 12(3):287–292.
- Patterson, K. E., & Morton, J. 1985. From orthography to phonology: An attempt at an old interpretation. In *Surface dyslexia: Neuropsychological and cognitive studies of phonological reading*, K. E. Patterson, J. C. Marshall and M. Coltheart (eds.), 15–34. London: Lawrence Erlbaum.
- Plaut, D. C., & Shallice, T. 1993. Deep dyslexia: A case study of connectionist neuropsychology. *Cognitive Neuropsychology* 10:377–500.
- Posner, M. I., & Raichle, M. E. 1997. *Images of mind*. New York: Scientific American Library.
- Rayner, K. 1999. What have we learned about eye movements during reading? In *Converging methods for understanding reading and dyslexia*, R. M. Klein and P. A. McMullen (eds.), 23–56. Cambridge MA: MIT Press.
- Rego, L. L. B. 1999. Phonological awareness, syntactic awareness and learning to read and spell in Brazilian Portuguese. In *Learning to read and write: A cross-linguistic perspective*, M. Harris and G. Hatano (eds.). Cambridge: Cambridge University Press.
- Reicher, G. M. 1969. Perceptual recognition as a function of the meaningfulness of the stimulus material. *Journal of Experimental Psychology* 81:275–280.
- Scragg, D. G. 1974. *A history of English spelling*. Manchester: Manchester University Press.
- Shannon, C. E. 1948. A mathematical theory of communication. *Bell System Technical Journal* 27:379–423; 622–656.
- Shannon, C. E. 1951. Prediction and entropy of printed English. *Bell System Technical Journal* 30:50–64.
- Strang, B. M. H. 1970. *A history of English*. London: Meuthen & Co.
- Stroop, V. R. 1935. Studies of interference in serial verbal reactions. *Journal of Experimental Psychology* 18:643–662.
- Taylor, I., & Taylor, M. M. 1990. *Psycholinguistics: Learning and using language*. Englewood Cliffs: Prentice-Hall International.
- Thompson, M. C., & Massaro, D. W. 1973. The role of visual information and redundancy in reading. *Journal of Experimental Psychology* 98:49–54.
- Tranel, B. 1987. *The sounds of French: An introduction*. Cambridge: Cambridge University Press.
- Venezky, R., & Massaro, D. 1987. Orthographic structure and spelling-sound regularity in reading English words. In *Language perception and production: Relationships between listening, speaking, reading and writing*, A. Allport, D. Mackay, W. Prinz and E. Scheerer (eds.), 159–179. London: Academic Press.
- Venezky, R. L. 1976. Theoretical and experimental bases for teaching reading. In *Current trends in linguistics (Vol. 12: Linguistics and adjacent arts and sciences)*, T. A. Sebeok (ed.). The Hague: Mouton.
- Venezky, R. L. 1984. The history of reading research. In *Handbook of reading research*, P. D. Pearson (ed.), Vol. 1:3–38. New York: Longman.

- Venezky, R. L. 1999. *The American way of spelling*. New York: Guilford Press.
- Waters, G. S., & Seidenberg, M. S. 1985. Spelling-sound effects in reading: Time-course and decision criteria. *Memory & Cognition* 13:557-572.
- Wheeler, D. D. 1970. Processes in word recognition. *Cognitive Psychology* 1:59-85.
- Wimmer, H., Landerl, K., & Frith, U. 1999. Learning to read German: Normal and impaired acquisition. In *Learning to read and write: A cross-linguistic perspective*, M. Harris and G. Hatano (eds.), 34-50. Cambridge: Cambridge University Press.
- Ziegler, J. C., Jacobs, A. M., & Stone, G. O. 1996. Statistical analysis of the bidirectional inconsistency of spelling and sound in French. *Behavior Research Methods, Instruments, & Computers* 28(4):504-515.