



The orthographic representation of a word's morphological structure: beneficial and detrimental effect for spellers

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Abstract

In this paper we present a review of the literature on the role of a word's morphological structure in written language processing, with an emphasis on spelling. First, we describe that many orthographies have opted for a representation of a word's morphological structure. Second, we discuss experiments that have demonstrated the importance of a word's morphological structure in reading, both in isolated word recognition experiments (so-called blind morphological decomposition) and in reading for meaning. Third, we discuss experimental findings that the written representation of a word's morphological structure can have beneficial effects in spelling, already in young children with a good morphological awareness. However, several experiments have also shown that, in some circumstances, the speller's task of representing morphology in written words creates considerable challenges and causes spelling errors rather than providing assistance. Closer inspection of this dissociation between beneficial and harmful effects reveals that two factors play a crucial role in determining the error risk: (a) the distinction between stems and affixes (i.e., morphological accessibility based on semantic transparency) and (b) the frequency with which a morpheme type in a language (stem, affix) must be retrieved in writing texts (accessibility based on type and token frequency). The review offers a theoretical framework against which the other papers in this special issue can be situated.

Keywords Morphological principle · Stem level · Suffix level · Blind morphological decomposition · Morphological awareness · Spelling errors · Homophone dominance · Usage frequency

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1 The phonological and morphological principle in alphabetic orthographies

Alphabetic orthographies use letters or letter combinations, i.e., graphemes, to orthographically encode the sounds of a word. At the same time, it is striking to observe that in many orthographies this so-called phonological principle is overruled by a morphological principle. The latter implies that the same morpheme preserves its spelling across the words in which it occurs, even at the expense of not applying the phonological principle. For instance, despite the difference in the pronunciation of the English past tense suffix in the word forms <kicked> and <filled> – [t] and [d], respectively – the suffix has the same spelling, i.e., <ed>, as in all other regular past tense forms in English.

The same occurs in many other languages. For instance, in Dutch the verb forms <vind>, ‘find, 1st person singular present tense’ and <vindt>, ‘finds, 3rd person singular present tense’ are homophones: they are both pronounced as [vɪnt]. This is due to (a) the devoicing of voiced consonants in final position (here, the phoneme /d/) and (b) the subsequent process of degemination, i.e., the successive [t]-sounds yielded by the devoicing process for the orthographic ending <dt> are not pronounced with a longer duration than a single [t]-sound, i.e., they do not yield a geminate. Crucially, even though the verb forms are homophones, their morphological structure is represented in their spelling. Importantly, as well, the morphological principle is applied at both the levels of the stem and the inflectional suffix. The <d> in <vind> and <vindt> is the final letter of the stem, which has the same spelling, i.e., <vind>, in all words in which that stem occurs. Interestingly, the spelling of the stem itself not only observes the morphological principle by maintaining its spelling across the words and word forms in which it appears; its spelling is itself already the outcome of an application of the morphological principle. The final sound of <vind> is [t], but the fact that the sound [d] is heard in morphologically related forms like <vinden>, ‘to find’, betrays the presence of an underlying phoneme /d/ – at least, this is how the linguistic reasoning goes. This phoneme is mapped onto the letter <d>, and, hence, the resulting spelling of the stem, i.e., <vind>, is the output of the operation of the morphological principle. At the same time, the morphological principle applies at the level of the inflectional suffix. The suffix for the 3rd person singular present tense is spelled as <t> in <vindt> because the sound [t] is pronounced in an inflected verb form like <loopt>, pronounced as [lɔ:pt], which betrays the presence of an inflectional marker. The morphological principle requires its orthographic representation, i.e., the letter t, to appear in all inflected verb forms in the same grammatical function, even if this letter is not pronounced, as in <vindt> and <zendt>, ‘sends’, and the 3rd person singular present tense of all homophonic verb forms of the same type.

In languages like French, with a rich inflectional morphology, the precedence of the morphological principle over the phonological one sometimes leads to a variety of distinct spelling forms. Consider the differences in the orthographic representation of the final [e]-sound in the following French word forms, all pronounced [parle]: <parler>, ‘to talk’, <parlez>, ‘(you) talk, 2nd person plural present tense’, <parlé>, <parlée>, <parlés> and <parlées>, ‘(have) talked’, four past participle forms, encoding the distinctions masculine/feminine and singular/plural. In these examples, the

same [e] sound has different spellings, depending on the morpheme or morpheme combination that is orthographically represented: <er> in the infinitive, <ez> in the 2nd person plural present tense, <é>, <ée>, <és>, or <ées> in the past participle, depending on whether the letter sequence encodes masculine + singular (<é>), feminine + singular (<ée>, in which case the <e> encodes feminine), masculine + plural (<és>, in which case the <s> encodes plural), and feminine + plural (<ées>, in which case feminine and plural are encoded by the letters <e> and <s>, respectively).

Note that the French examples also demonstrate that the written language includes morphological markers that are 'silent', like the suffix <s> that marks the plural. This is also the case for the stem-final letter <d> in the Dutch form <vindt>, whose pronunciation is merged with that of the present tense suffix <t> into the single sound [t] (degemination). This phenomenon can also be found in Hebrew, where the possessive suffix attached to plural nouns (e.g., <sfat-av>, 'his lips' spelled שפתיים preserves the ' spelling (the letter Yod) that indicates stem plurality, despite having no phonological implementation (which should have been the vowel <i>). The situation is different in the above English examples <kicked> - <filled>, where the sounds [t] and [d], respectively, betray the presence of a suffix. The phenomenon does exist in English, as well, though. For instance, the difference between the plural form <boys>, the genitive singular <boy's>, and the genitive plural <boys'> gives rise to considerable and persistent spelling problems (Bryant et al., 1997).

To be sure, not all orthographies have been designed to respect a morphological principle. In some orthographies, there is an almost one-to-one mapping between sounds and graphemes, such that spellers can spell what they hear. That is, for instance, the case in written Italian, Spanish, Finnish, and Turkish. To distinguish between these two types of orthographies, a distinction is made between shallow orthographies, in which the phonological principle almost rules across the board, and deep orthographies, in which the mappings between sounds and letters are less consistent. Application of the morphological principle, overriding the phonological principle, is one major cause of such inconsistencies. Note, however, that the distinction between shallow and deep orthographies is a continuum, not a dichotomy.

Despite the existence of shallow orthographies, it is striking that many orthographies incorporate a morphological principle. This observation indicates that different groups of people who were responsible for devising the spelling principles for their language set out from the same working hypothesis: keeping the spelling of a morpheme constant is likely to help word recognition and/or spelling.¹ Of course, it remains an empirical question whether this intuition is correct. Experiments addressing this issue started around the end of the 1960s, and, since then, many studies have been reported on the role of morphology in both word recognition and spelling. Most studies focused on word recognition, with the leading question: "Does the orthographic representation of the word's morphological structure help readers in retrieving the target word from their mental lexicon?" Considerably fewer studies addressed the advantages (or disadvantages) of the morphological principle in spelling.

¹Note that we do not claim that all spelling principles were deliberately and consciously designed by people. It seems that many changes and characteristics that spelling systems acquire are the result of unconscious processes that are somewhat similar to those taking place in spoken language (see Ravid, 2012).

This discrepancy in researchers' attention for word recognition versus spelling should not come as a surprise. Intuitively, it seems that, across many experiential domains, keeping the input constant will help the recognition process, leading to faster and less error-prone perception, i.e., smooth memory retrieval. Hence, it seems a reasonable hypothesis that maintaining the spelling of a morpheme will assist the process of word recognition. In spelling, the situation is less obvious. Whereas keeping the output constant in a production process is also likely to facilitate this process, the linguistic units involved in morphology are quite abstract, and, for that reason, arguably less accessible for spellers than the sounds they can hear. Moreover, even in deep orthographies, a lot of graphemes result from the application of the phonological principle. Hence, the relative application frequencies of the phonological and the morphological principles, both type-wise and token-wise, too, may cause less familiarity with the morphological principle, with consequences for the speed with which it is applied. The usage frequency of a morphological principle will indeed turn out to be important (see below).

2 The role of morphological structure in reading

In this paragraph we will describe two sets of findings. In Sect. 2.1 we will focus on results obtained in word recognition experiments, in which participants are presented with a single word on each trial and must respond to it as fast and as accurate as possible (for instance, make a lexical decision, i.e. decide whether the item is an existing word in the language or a non-word). In Sect. 2.2 we will discuss the results from experiments in which participants must read sentences for meaning while their reading times are measured. In both types of experiments, the question is whether readers use a word's morphological structure to access a lexical representation in their mental lexicon.

2.1 The use of morphology in word recognition experiments

The first experiments addressing this issue revealed that a word stem is accessed during the recognition of inflected word forms and derived words and serves as an access code to the representation of these words in the mental lexicon. Participants could identify a briefly flashed word faster if it was morphologically related to a word the participants had studied earlier, as in the pair <cars> - <car>, compared to a condition where the relationship was only orthographic, as in <card> - <car> (Murrell & Morton, 1974). Taft and Forster (1975) found that so-called bound stems, like <trieve> (from <retrieve>) are more difficult to reject as nonwords than matched orthographic controls that do not function as bound stems in a derived word, like <gulate> (from <regulate>). Baayen et al. (1997) found that reaction times to singular nouns are co-determined by the frequency of the plural form, suggesting that the plural is morphologically decomposed during recognition, with an ensuing access to the singular form and, hence, an increase in its frequency.

In some experiments, especially those where a morphological relationship existed between the target and a previously presented word, participants could become aware

that morphological relatedness was the target of the research and, possibly, adopt a morphological decomposition strategy. In that case, the findings would obviously be uninformative for the normal word recognition process. Forster and Davis (1984) strongly criticized so-called repetition priming experiments, both on empirical and theoretical grounds. In such experiments, participants are presented with pairs of morphologically related words, each pair consisting of a prime (first member) and a target (second member), separated by a number of intervening trials. To remedy against the possibility of strategic effects, Forster and Davis devised the masked priming technique. In masked priming experiments three stimuli follow each other in a rapid succession: a forward mask (a row of hashmarks or a word in lowercase letters, typically presented for 500 ms), a prime word (related along a particular dimension to the target, like morphology, or not, typically presented for a very brief duration of 50 or 60 ms), and a target (typically presented for 500 ms or until response). The advantage of this technique is that, due to the rapid succession and superposition of these three stimuli, participants do not even become aware of the prime. Hence, this prime cannot be stored in the participant's short-term memory for the experimental items and cannot be recalled when the target appears, nor can it be used for the deployment of morphological decomposition strategies. Consequently, facilitation in a masked priming paradigm is most likely the result of the prime having lowered the access threshold of the target's lexical representation. Interestingly, the outcome of several experiments with the masked priming technique in combination with morphologically related prime-target pairs strongly suggests that morphology does have a beneficial effect in word recognition.

A seminal paper was published by Longtin et al. (2003). They found equal facilitation on lexical decision times when visual targets were preceded by masked primes that were transparent derivations (<gaufrette> - <GAUFFRE>, 'wafer'-'waffle'), opaque derivations (<fauvette> - <FAUVE>, 'warbler'-'wildcat'; only etymologically related), or, crucially, pseudo-derivations (<baguette> - <BAGUE>, 'little stick'-'ring'). These pseudo-derived words were no derivations at all, but words that are concatenations of orthographic sequences matching an existing stem and a real suffix. For instance, <baguette> is a mono-morphemic word, which is not at all related to <bague>. The letter string <ette> only happens to have the same spelling as the French diminutive suffix, and the first letters of the word coincidentally match the spelling of the existing word <bague>. Longtin et al. interpreted these results as an indication that any letter string ending in a potential suffix automatically undergoes a blind process of morphological decomposition into this potential suffix and the remainder of the word, which is treated as a potential stem. Upon decomposition the candidate stem is used to attempt lexical access. The fact that pseudo-derivations like <baguette> cause facilitation on lexical decision times to their subsequent pseudo-stem <bague>, which is a real word, indicates that such access effectively succeeds, and, hence, that blind morphological decomposition occurs during word recognition. It appears that the presence of a letter string that matches the spelling of a true suffix is a sufficient cue for a decomposition process that segments the word into this potential suffix and a candidate stem. Importantly, as predicted by this account, masked prime-target pairs like <abricot> - <ABRI> ('abricot'-'shelter'), in which the prime begins with a letter string that happens to match the spelling of an existing word but

does not end in a letter string matching the spelling of an existing suffix (<ot>), did not cause facilitation on the embedded word but even yielded inhibition. Comparable experiments (see Longtin & Meunier, 2005; Rastle et al., 2005) confirmed the existence of a blind morphological decomposition process.

2.2 The use of morphology in reading experiments

The finding that words' morphological structure is used to recognize words is an important result. However, do readers also rely on morphology when reading sentences for meaning? A few studies targeting this question have been reported.

Brysbaert et al. (2000) made use of the existence of Dutch verb homophones with the same pronunciation in the present and past tense (e.g., <wieden>, 'are weeding' and <wiedden>, 'were weeding'). The pronunciation of these word forms, by definition, does not signal their grammatical function, but their morpho-graphic spelling does. The critical sentences in Brysbaert et al.'s research were of the following type:

Terwijl de moeders wieden in de tuin, zitten de vaders in hun luie stoel.

'While the mothers are weeding in the garden, the fathers are sitting in their chair.'

Terwijl de moeders wiedden in de tuin, zaten de vaders in hun luie stoel.

'While the mothers were weeding in the garden, the fathers were sitting in their chair.'

In the examples above, the homophones <wieden> and <wiedden> are both pronounced as [widən] but differ in (only) a single letter to mark the tense distinction. The authors contrasted these sentence pairs with two other sets of pairs: pairs in which the verb forms were both homophonic and homographic in the present and past tense (e.g., <spitten>, 'are digging' vs. 'were digging') and pairs in which the verb forms were neither homophonic nor homographic (<harken> - <harkten>, 'are raking' vs. 'were raking').

The researchers were interested in participants' reading times in a self-paced reading task, in which participants must press a button to see the next word(s) in the sentence. The reading times on the main verb of these sentence pairs, which is the second verb form, should reveal whether readers use the morpho-graphic spelling of a preceding verb homophone for sentence comprehension (the first verb form, in the subordinate clause). These reading times should be longest for the sentences with homophonous homographs (e.g., type <zitten>, 'are/were sitting'), as, in this case, the first verb form does not contain any morphological marker that situates the sentence in the present or the past, i.e., the present and past tense forms have the same spelling. Hence, a surprisal effect is expected on the following verb form in the main clause (<zitten>/<zaten>, 'are sitting'/'were sitting'), because this is the first word in the sentence that informs the reader whether the ambiguous first verb form was in the present or past tense. Such a surprisal effect should manifest itself in a reading delay. In contrast, in the sentences where the first verb form is heterophonic and heterographic (e.g., <harken>/<harkten>, 'are raking' vs. 'were raking'), the audible difference between the present and past tense, i.e., the presence or absence of a [t]-sound, should not cause a surprisal effect when reading the second verb form and,

hence, yield no reading delay. The crucial question is whether sentences in which the first verb form is a heterographic homophone (<wieden> vs. <wiedden>, 'are weeding' vs. 'were weeding'), i.e., with an orthographic marking of their morphological structure, will cause a surprisal effect and produce a reading delay on the second verb form. This will only be the case if readers make no use of the encoded morphological information. However, Brysbaert et al. observed that readers do rely on the morphological structure encoded in the spelling of these verb homophones: "In two experiments, we found that homophonic verbs were processed very much like heterophonic verbs, even when the context heavily constrained the reader to one interpretation of the homophonic verb forms." (p. 48) It appears that a written word's morphological structure not only causes a process of blind morphological decomposition in word recognition experiments but is also used as a source of information during reading for meaning.

Bredel et al. (2013) raised a similar question: do readers of German make use of the morphological principle when reading sentences? In German, as in Dutch (see above), a verb stem has a constant spelling across the word forms in which it occurs. As in Dutch, this gives rise to homophones. However, in contrast to Brysbaert et al., who used verb homophones from the inflectional paradigm of the same verb, Bredel et al. used homophones derived from different verbs, and, hence, represented different stem meanings. For instance, the infinitives <hasten>, 'to hurry', and <has-sen>, 'to hate', give rise to the homophones <haste> and <hasste>, respectively, i.e., 'hurry' (stem <hast> + present tense suffix <e>) and 'hated' (stem <hass> + past tense suffix <te>). The focus of Bredel et al.'s research was to study the effect of the morpho-graphically correct versus incorrect (i.e., homophone with wrong meaning) spelling on poor and good readers. Their hypothesis was that good readers rely on the morphological principle in reading for meaning, whereas poor readers depend more on phonological decoding and are less able to notice that the spelling of a verb homophone does not represent the morphological structure of the target form.

They presented their participants with three tasks: (a) a task in which the participants merely had to make timed grammaticality judgments of single sentences, which they used as a baseline, (b) a task in which they had to make the same type of judgment but with sentences containing a verb form that either respected the principle of stem constancy or violated that principle, giving rise to a homophone with a different meaning (e.g., <hasste> when <haste> was the correct spelling or vice versa), and (c) a task in which participants had to choose which sentence of a pair contained the homophone with the correct morpho-graphic spelling (e.g., <haste> or <hasste>).

In the single sentence condition, where the participants either saw a spelling form respecting the stem constancy principle or a form with a deviant stem spelling (task b), good readers reacted more slowly when the sentence contained a deviant stem spelling of the verb form. In contrast, the poor readers reacted equally fast to both types. This suggests that good readers in German make use of a word's morphological structure for accessing their mental lexicon, whereas poor readers rely on the phonological decoding of the forms and experience no help from morphology. This outcome was corroborated by the results of the task with sentence pairs (task c). This task was not more difficult for the good readers than the single sentence task but was considerably more difficult for the poor readers. They ran into problems because the

task forced them to choose between two homophonic spellings based on the verb forms' morpho-orthographic spelling. These findings, too, indicate that phonologically correct but morphologically deviant stem representations can easily be detected by good readers but not by poor ones.

The reaction time differences between the two reader types were matched by differences in the certainty with which they assessed the sentences or sentence pairs. Good and poor readers did not differ when the judgments concerned sentences with non-deviant stem representations. In such cases, it does not matter whether one relies on the verb form's morphological structure or on its pronunciation. However, good readers were equally certain in judging deviant and non-deviant sentences, whereas poor readers were less certain when judging deviant sentences. This, too, indicates that the good readers used the morphological principle of stem constancy whereas the poor readers did not. Together, these results suggest that, in languages where words' morphological structure is orthographically represented, good readers rely on this morphological structure when reading for meaning.

Nonetheless, some results indicate that readers do overlook morphological information in a word's spelling in certain conditions. Verhaert et al. (2016) reported an off-line proof-reading experiment in Dutch, in which participants had to indicate all spelling errors, both misspellings of verb homophones (like <vind> for <vindt> or vice versa) and other words. They found that a spelling error on a verb homophone was more often overlooked when the error matched the higher-frequency form of the homophone pair than in the reverse case, i.e., when the error was the most familiar form. This outcome matched the effect of homophone dominance that they also observed in spelling experiments (see below). Participants whose grammatical awareness was better developed made fewer errors but showed the same pattern. So, this experiment seems to suggest that even good readers sometimes ignore the morphological structure that is represented in the spelling of a word form.

However, the apparent contradiction between the Brysbaert et al. experiments and the Bredel et al. study on the one hand, and the Verhaert et al. study on the other hand, is not a real conflict but seems to result from important differences between the experiments. Brysbaert et al. and Verhaert et al. both focused on the use of inflectional suffixes. However, in the former study the suffix of the first verb form was crucial for interpreting the second verb form as a present tense or as a past tense. When the first verb form was a homophone, its morpho-graphic spelling made the sentence temporarily ambiguous when readers relied on the word form's pronunciation but non-ambiguous when they used the orthographically encoded information. The structure of the sentences in the experiment strongly encouraged participants to use the homophones' morphological structure, to avoid interpretation problems in the second part of the sentence. In contrast, the sentences in Verhaert et al. were not temporarily ambiguous, even when relying on their pronunciation, because the suffix represented grammatical properties of earlier words in the sentence, and, hence, redundant information. Moreover, the homophone pairs in the Brysbaert et al. study represented a semantic contrast (present vs. past tense), whereas the homophones in the Verhaert et al. study represented a syntactic contrast (1st vs. 3rd person singular present tense), such that the wrong homophone involved a cost at the semantic level in the former study but not in the latter one. The differences in the result patterns

between the Verhaert et al. study and the Brysbaert et al. study thus reflect the theoretical morphological distinction between inherent and contextual inflection (Booij, 1996).

There is also a major difference between the Verhaert et al. experiment and the Bredel et al. study. The latter focused on the stem of inflected words, not on the suffix. Moreover, deviant items, i.e. spelling errors, were homophonous with a non-intended word, i.e., a word with a different meaning, if the participants only relied on the word's pronunciation. In contrast, the Verhaert et al. experiment focused on inflectional suffixes whose wrong spelling gave rise to a homophonous form within the same inflectional paradigm, which still made it possible to retrieve the correct word meaning. This suggests that an inflected word form's morphological structure may be easily overlooked in reading for meaning when the homophonous error is (a) the higher-frequency homophone of a homophone pair of the same word and (b) causes no problems at the semantic level. Note that, despite the observation that many inflectional suffixes of the verb homophones were indeed overlooked in the proof-reading task, this was not always the case and was particularly so when the non-target homophone was more frequent than the intended word form.

The overall conclusion of the role of morphological structure in reading experiments is in line with the findings in isolated word recognition experiments. Good readers use morpho-orthographic spellings for achieving access to their mental lexicon when reading ordinary sentences for meaning. The Brysbaert et al. (2000) and Bredel et al. (2013) experiments show that they certainly do so when inferring the intended meaning from the morpho-orthographic structure is crucial for understanding the sentence. On the other hand, the Verhaert et al. study shows that morphological cues may be more safely ignored when the erroneous spelling is a high-frequency homophone that represents the same core meaning as the intended spelling and only differs from it in the encoding of abstract grammatical aspects of the sentence (e.g., grammatical person). The finding that readers rely on a written word's morphological structure when reading for meaning in circumstances where a correct interpretation of the sentence is at stake makes a lot of sense, as the core function of morphology is to act as an interface between form and meaning.

With this overview of the role of morphology for the reader in mind, we can now turn to the role morphology may play for the writer, in spelling.

3 The role of morphological structure in spelling

The findings on the role of morphological structure in spelling can be summarized under two headings: (1) morphological structure can be helpful but (2) there are also conditions in which morphological structure can be harmful.

3.1 Beneficial effects of morphological structure on spelling

The seminal work by Treiman has shown that children at a young age already catch on to a word's morphological structure and rely on this awareness of its constituent morphemes in their spelling attempts. In American English, the phoneme /t/ is pronounced as a flap [r] or [d] in intervocalic position, for instance, in words like <duty>

and <dirty>. Treiman et al. (1994) found that children between 5 and 8 years old can recover the correct spelling of this [d]-sound by relying on the word's morphological structure. They made fewer errors on derived words like *dirty*, in which a stem is followed by a suffix (<dirt> + suffix <y>) than on matched mono-morphemic words like <duty>, which do not consist of a stem + suffix <y>. The findings by Treiman and Cassar (1997) converged on the same conclusion: young children use their insight into the morphological structure of a word when attempting to spell a word. The authors matched inflected word forms and mono-morphemic controls on the pronunciation of their final consonant cluster, for instance, the cluster [nd] in the pair <tuned> - <brand> or the cluster [st] in the pair <faced> - <feast>. In the spelling of the inflected word forms, the phonological principle is overridden by the morphological principle: in <tuned> and <faced>, the final sound in [nd] and [st] is spelled as <ed>. In contrast, in the spelling of the control words (<brand> and <feast>) the phonological principle is applied, such that the final sound in [nd] and [st] is spelled as <d> and <t>, respectively. Treiman and Cassar's item contrast is interesting because young children often experience problems with the spelling of consonant clusters like the ones in the examples above, often omitting the first consonant. Their experimental results showed that such omission errors occurred more often in the control items than in the inflected word forms, suggesting that their awareness of a word's morphological structure helped them spell these words. This outcome further supports the claim that young children's spelling attempts are guided by a word's morphological structure. See also Deacon and Bryant for identical findings in experiments with an even stricter experimental design, in which item pairs were used with identical orthographic patterns in the control items and inflected word forms (Deacon & Bryant, 2006a, e.g., <rocked> - <rocket>) or derived words (Deacon & Bryant, 2006b, e.g., <turning> - <turnip>). These findings countered the potential critique that better results in earlier experiments resulted from the higher frequency of the letter string in the stem of inflected (or derived) words.

Sénéchal arrived at the same conclusion in French. A typical property of French is the presence of 'silent letters' in word-final position (e.g., <tabac>, [taba], 'tabacco'). Sénéchal (2000) and Sénéchal et al. (2006) compared words whose 'silent letter' could be recovered from the pronunciation of a morphologically related word and controls that did not allow such a recovery process. For instance, the <p> in <galop> ([galɔ], 'galop') can be recovered from the derived verb galloper ([galɔp], 'to gallop'), whereas the <c> in <tabac> can only be spelled correctly if its spelling has been memorized. Children between 9 and 10 years old (Grade 4), spelled the 'silent letter' more often correctly in the morphological condition, thus demonstrating their ability to use morphological relations between words for spelling purposes at an early age. They also reported to explicitly rely on morphological relations among words when spelling.

Also in French, Pacton et al. (2007) demonstrated children's reliance on the morphological structure of words by confirming the prediction that this strategy should lead to overgeneralization errors on words like <numéro> ('number'). The derived word <numéroter> suggests the presence of a 'silent letter' <t> in the singular form but, in cases like these, the correct spelling lacks this letter. Good spellers indeed made more such overgeneralization errors, indicating that reliance on morphological

relations belongs to the spelling arsenal of good spellers, which occasionally leads to spelling errors. Other testing paradigms, like learning experiments with French pseudowords, led to the same conclusion (e.g., Pacton et al., 2018).

The explicit focus on spelling errors supported the conclusion that spellers try to take the morphological structure of words into account. Schiff et al. (2020) showed that the degree to which morphological structure is identifiable in the Hebrew word affects its correct spelling. Bar-On and Kuperman (2018) studied the erroneous intrusion of a vowel letter in Hebrew words and found that the majority of these errors did not disrupt the word's morphological structure. Gahl and Plag (2019) studied errors in the spelling of suffixes like <able>/<ible> (e.g., <acceptable>, <accessible>) and <ence>/<ance> (e.g., <avoidance>, <occurrence>) and found that the error risk was determined by factors related to morphological structure: the strength of the morphological boundary and the segmentability of the derivation. Like Sandra (2010), these authors make the claim that the study of spelling errors should follow the same rationale as the one adopted in studies of speech errors: errors constitute a rich source of data for discovering the representations, processes, and temporal dynamics of language production (e.g., Fromkin, 1971; Garrett, 1975).

3.2 Detrimental effects of morphological structure on spelling

However, morphological structure is not always helpful. Obviously, for it to be so, it must be easily accessible. That is why, for instance, Sénéchal found that children with a strong morphological awareness made more use of a word's morphological make-up than others. This should not come as a surprise. However, it is reasonable that easy accessibility is related to the morphological domain to which the spelling target belongs – and this is the point where the distinction between inflectional and derivational morphology comes in. Indeed, it is striking that the experiments described above (and others like them) all made use of derivations. On the other hand, it is equally striking that the studies reporting spelling problems for multi-morphemic words (see below) used inflected word forms. Due to the generally strong semantic relationship between a derivation and its stem, the latter is easily accessible, certainly for children with a good morphological awareness. In inflected word forms, the stem should also be easily accessible, as such forms are merely form variants of a single word and share the meaning of that word.

In line with this observation, we shall see that the spelling problems on these forms indeed do not occur on the stem but on the inflectional affix. It is to be expected that accessibility to the information encoded by these affixes is more difficult to retrieve, as they encode abstract grammatical properties like tense, person, gender, case, etc. Such retrieval problems are even more likely to occur when the affix is not pronounced and must be mapped onto a 'silent letter'. In such cases, spellers must (a) be able to apply the morphological principle, i.e., have sufficient morphological awareness (and morpho-syntactic awareness, see below), and moreover (b) be able to apply that principle in time, i.e., before any other, error-prone retrieval procedures can determine the spelling output. Several experiments, in a variety of languages, demonstrated that inflectional affixes indeed form a source of notorious spelling errors (as a matter of fact, suffixes in all studies we are aware of).

Sandra and colleagues reported several studies in which they demonstrated that Dutch verb homophones are such a persistent error source. Dutch verb forms give rise to two types of verb homophones, due to the interaction between morpho-orthographic patterns and the rules for pronouncing them. Type 1: as mentioned earlier, when the stem ends in the phoneme /d/, the 1st and 3rd person singular of the present tense are homophones (stem + no inflectional suffix in the former case, stem + suffix spelling t in the latter case), as in <vind> - <vindt>. Type 2: when a so-called weak prefix is used, the 3rd person singular present tense and the past participle are homophones (stem + suffix spelling t, stem + suffix spelling d), as in <gebeurt> - <gebeurd>, [yɔbørt], ‘happens’-‘(has) happened’). Because the verb forms are homophones, the phonological principle can be of no help and the correct spelling is only possible by appealing to a morphological analysis. More correctly, as the information encoded by these inflectional suffixes is related to the syntax of the sentence (e.g., the grammatical subject or the auxiliary), a morpho-syntactic analysis is in order. Sandra and colleagues found more verb homophone intrusions (for both homophone types), i.e., violations of the morphological principle at the suffix level (e.g., <vind> where <vindt> is correct), when the non-target homophone was more frequent than the target homophone, a phenomenon they called ‘homophone dominance’. This especially occurred when the participants’ working-memory was overloaded, which happened when participants did not have enough time to retrieve the morpho-syntactic information. Such is, for instance, the case in a speeded dictation task or when the word determining the suffix spelling is separated from the target by a number of words in the sentence (for type 1: the grammatical subject; for type 2: the auxiliary; Sandra, 2010, Sandra et al., 1999, Sandra & Van Abbenyen, 2009; see also Assink, 1985; Frisson & Sandra, 2002; see Sandra et al., 2004, and Sandra 2019, 2022 for a discussion of the data from a theoretical perspective). Note that the retrieval of morpho-syntactic information is, in itself, likely to be time-consuming, due to the abstract nature of the information that must be identified in the sentence.

Whereas these researchers observed problems for the spelling of the inflectional suffix, strikingly few errors were made on the final letter of the stem (e.g. <vindt> was sometimes misspelled as <vind> but almost never as <vint>). Such errors were also virtually non-existent in a corpus of anonymized chat messages studied by Surkyn et al. (2020): they found only 14 such errors on a total of 5804 Type 1 homophone tokens in the corpus (0.24%). Clearly, the orthographic representation of the stem of these homophonic inflected forms is more accessible. As mentioned earlier, this is presumably in part due to the stem’s strong semantic relationship with the infinitive. A second plausible reason is the frequency with which the morphological principle must be applied at the stem level in Dutch (e.g., <vind> because of <vinden>). This frequency is overwhelmingly high, as it applies across all nouns, adjectives, and verbs ending in d (whose non-inflected form is pronounced with a final [t]-sound): in nouns, as in <paard> - <paarden>, [pa:rt] - [pa:rdən], ‘horse - horses’; in adjectives, as in <goed> - <goede>, [gut] - [gudə], ‘good - inflected form’, and in verbs, as in <vind> - <vinden>). The high application frequency (both type-wise and token-wise) of this morphological principle should make it quite familiar for spellers and, hence, easy to apply. In sharp contrast, the spelling of a homophonous suffix must be performed so infrequently – on average in about only 5 to 10 percent of all verb

forms, both in type and token counts (Sandra & Van Abbenyen, 2009) – that Dutch spellers cannot become sufficiently familiar with the application of the morphological principle at the suffix level. The consequence is that spellers will need more time to apply the morphological principle at the suffix level than at the stem level. In situations where (a) writing speed is important, (b) the focus is on text meaning or other aspects of the multi-layered writing process, or (c) spellers do not take the time to apply this relatively slow process, they expose themselves to the influence of another spelling determinant. More particularly, they risk falling prey to a process of retrieving a whole-word form, and since frequency is a strong determinant of word retrieval, this will most often be the higher-frequency member of the homophone pair. As the homophone with the highest frequency is, by definition, the most probable target spelling, this procedure does not necessarily cause an error. However, as word forms whose spelling observe a morphological principle are governed by a deterministic spelling procedure, a probabilistic procedure is unreliable and bound to cause spelling errors. Whenever the lower-frequency member of the homophone pair is the target, this probabilistic spelling procedure will cause an error. Thus, the effect of homophone dominance emerges: more errors on lower-frequency verb homophones than on higher-frequency ones, irrespective of the target's grammatical function (Type 1: 1st or 3rd person singular present tense; Type 2: 3rd person singular present tense or past participle).

Importantly, the same pattern of findings was found in a large corpus of anonymized chat conversations on Facebook Messenger and WhatsApp, and again for the two homophone types (Surkyn et al., 2020). Whereas social variables like gender, age, and educational track predicted the chatters' error rates, these variables did not interact with homophone dominance. This indicates that we should distinguish between variables that act as error triggers and variables that are responsible for error patterns. Social group as a trigger variable determines the rate of spelling errors, while relative frequency of the two verb homophones as a pattern variable gives rise to the effect of homophone dominance (which was equally strong in all groups defined by the social variables, given the absence of an interaction). Corroborating results were reported by Schmitz et al. (2018), who used Twitter data. Together, these results extend the results obtained in controlled experiments to spontaneous writing situations outside the lab, making them more ecologically valid.

Surkyn et al. (2021) used the same corpus data to study the spelling of partially homophonous past participles ending in the letter <d>, like <gedroomd>, [ɣədrou:mt], '(has) dreamt', which is partially homophonous with <droomt>, [dro:mt], 'dreams', and <droomde>, [dro:mdə], 'dreamt'. They found evidence in favor of analogical support from the inflectional paradigm for the spelling of the past participle suffix. This analogical support was operationalized as (the logarithm of) the ratio of the summed frequencies of the inflected forms containing the letter <d> (e.g., <droomde>) over the summed frequencies of the inflected forms containing the letter <t> (e.g. <droomt>). The higher this ratio, i.e., the more support from the inflectional paradigm for the <d>-spelling, the fewer errors were made on the final, correct <d> spelling of the past participle. The influence of this intra-paradigmatic factor shows that the spelling of at least these past participles, which have no true homophones, is affected by frequency relationships between spelling forms in the

inflectional paradigm. However, it is important to emphasize that this support was not necessarily positive: when the ratio was in favor of the <t>-spelling, more errors were made on the past participle. Hence, even though this effect is not based on whole-word retrieval, as in the case of the two types of verb homophones discussed earlier, but on an analogy between morphologically related forms, it is also a probabilistic, and hence, error-prone, spelling determinant. The bottom-line is the same: a word's morphological structure is not necessarily beneficial for spellers but can also create considerable challenges and be harmful, due to the abstract nature of the information that must be retrieved.

French experiments, reported by Largy et al. (1996) are very much in line with the Dutch data. Largy et al.'s participants had to write down sentences that had just been dictated and at the same time to recall a list of five words or to report the number of clicks they had heard during dictation. The use of a concurrent task (dual-task paradigm) was used to create cognitive overload in working-memory. In their critical sentences, like <Les chimistes prennent des liquides. Ils les filtrent> ('The chemists take liquids. They filter them.'). Largy et al. found homophone intrusions like <filtres>, which corresponded to the plural form of the noun rather than the plural form of the verb (<filtrent>, 'filter'). As in the Dutch experiments, more intrusions were made when the noun homophone was more frequent than the target verb homophone, i.e., an effect of homophone dominance was observed. Note that, in this case, homophone dominance even involved inflected forms belonging to two different lexical categories (verbs and nouns). Sandra and Fayol (2003) made a systematic cross-linguistic comparison of the findings in Dutch and French.

3.3 The importance of the usage frequency of a morphological principle

At this point, these findings might suggest that inflectional suffixes always give rise to many spelling problems (a) because these suffixes are harder to retrieve than stems for semantic reasons and (b) because spellers are insufficiently familiar with the application of the morphological principle at the suffix level. However, research by Gillis and Ravid (2006) demonstrates that this is indeed the case for Dutch but not for all written languages. Their research suggests that the culprit is not so much a word's morphological structure (or the suffix level) per se but, as has already been alluded to above, the frequency with which the morphological principle that is required for the spelling of the target morpheme is applied, and hence, the familiarity of spellers with this morphological principle. Gillis and Ravid made a comparison between spelling verb homophones in Dutch, a language with a relatively sparse inflectional morphology, and the spelling of comparable word forms in Hebrew, a typologically totally different language, which obliges the speller to attend to morphology all the time (see Ravid, 2012, for a comprehensive description of the way morphology operates in Hebrew spelling). Gillis and Ravid (2006) found that Hebrew children in Grades 1-6 had few problems with words whose spelling depended on their morphological structure, whereas Dutch children encountered considerable problems with verb forms requiring the application of the morphological principle at the suffix level (problems that persist into adulthood, even occasionally in the texts of good adult writers, as described above). In a later paper, Ravid and Gillis (2000) state that "language typology

determines the sensitivity of children learning to spell to morphological cues (p. 8)". This claim is fully in line with our above analysis that the abundant application of the morphological principle at the stem level in Dutch causes no spelling problems, but that the infrequent application of the morphological principle at the level of the verb suffix is a major cause of the many spelling problems for Dutch verb homophones. Note, incidentally, that the combined set of research findings underscores the importance of cross-linguistic research and the danger of making overgeneralizations based on a single language.

So, can a word's morphological structure have detrimental effects for spellers? Certainly, and these effects have clearly been observed in several languages (see also Juul & Elbro, 2004, and Chliounaki & Bryant, 2003, for similar findings in Danish and Greek, respectively). However, it is not the morphological structure per se that causes the problems but the familiarity of the spellers with the morphological principle that determines the spelling. This familiarity is determined by the frequency with which the morphological principle needs to be applied, and this, in turn, affects the speed with which the target morpheme can be accessed for determining its spelling. This conclusion should not come as a surprise: like in all sectors of life, language users – in this case, spellers – are good in what they often do and not so good in what they are seldom confronted with.

Obviously, not all spellers fall prey to the same extent to the pitfall of whole-word retrieval. We repeatedly referred to the accessibility of the word's morphological structure and the target morpheme that must be spelled. It is reasonable to assume that some spellers have a better accessibility to this information than others, i.e., have a stronger morphological awareness (see, for instance, the work by Sénéchal). Surkyn et al. (2020, 2021) showed that social variables like gender, age, and educational track affect error rates, but, at this point, it is unclear which cognitive factors determine whether a speller is good in orthographically representing the morphological structure of words. Grammatical skills, adequate rule-knowledge, working-memory capacity, and spelling attitude are, among others, plausible candidates. Obviously, a minimal requirement is that spellers know the underlying morphological principle. Chamalaun et al. (2021) demonstrated that participants' ability to identify the grammatical function of a verb is a reliable predictor of their spelling success on Dutch verb homophones, which encode syntactic relationships in the sentence.

3.4 What have we learnt?

In Sects. 3.1 and 3.2 we have gained more insight into the impact of a word's morphological structure in reading and spelling.

In the word recognition process of experienced readers, morphological analysis, more particularly, blind morphological decomposition, appears to be a powerful process. Even derived word primes that are masked from consciousness have been shown to be automatically decomposed during reading, as their stem facilitates subsequent lexical decision times to their stem target. Importantly, this is not an orthographic effect, as it does not appear when the overlapping letters do not form a morpheme in the prime (e.g., *abricot-abri*). Research on the use of a word's morphological structure has shown that good readers also use this structure when reading for meaning,

because the spelling of the stem and/or an affix provide important semantic information, thus supporting the understanding of the sentence. Spelling errors on inflected forms seem to matter less when the affix encodes syntactic information that has already been provided by preceding words (making affix information redundant) and when the error is also the more accessible higher-frequency homophone of the intended word form, such that no semantic cost is involved.

In spelling, young children soon discover that they can rely on morphological relationships to solve spelling problems. Those who benefit most are the ones with the strongest morphological awareness. Recall that Bredel et al. reported the same effect in an experiment where participants had to read for meaning (see above). As all these experiments seem to be performed with derived words, it is reasonable that reliance on morphological relationships is co-determined by the accessibility of the morpheme that must be spelled. The strong semantic relationship between a derived word and its stem should make the stem easily accessible, at least for children who quickly develop a morphological awareness. In such cases, a word's morphological structure yields beneficial effects.

The situation is quite different when inflectional suffixes that are not pronounced must be recovered. Several experiments, in different languages, show that this is especially the case for inflected word forms with 'silent letters', which are often homophonous with another inflected word form in the inflectional paradigm. Such word forms can only be spelled by relying on a morpho-syntactic analysis, as their inflectional affixes cannot be learnt by rote but are determined by the syntactic context. In contrast to the spelling of a word's stem, the spelling of these suffixes cannot easily be determined in many orthographies (a) because they encode more abstract information than the stem and, hence, can be retrieved less easily and (b) because spellers must apply the morphological principle for the suffix spelling much less frequently than the morphological principle for the stem spelling. This specially creates problems when working-memory is overloaded (writing speed, distance between word determining the affix and the target) or when working-memory is not used (due to absent-mindedness, lack of rule-knowledge). Silent inflectional suffixes that must be spelled in such working-memory conditions create the ideal triggers for a probabilistic spelling process: a process that retrieves the higher-frequency verb homophone or, in the case of Dutch partially homophonous past participles, a process that is affected by the dominant spelling of the inflectional suffix in the inflectional paradigm. Such probabilistic processes are, by definition, error-prone, as the higher-frequency homophone or the suffix that receives most support does not always match the target spelling. Hence, under some circumstances, even the best spellers can fall into the trap created by the interplay between working-memory limitations and the 'pressure' of error-prone, probabilistic retrieval processes, and make an occasional error. This also explains why these errors are so persistent.

From an analytic perspective, such errors seem 'stupid', as the mechanistic application of a morphological principle cannot lead to spelling errors and is descriptively quite simple. Hence, it is not surprising what Bryant et al. (1997) write about errors on the application of the English apostrophe: "[t]he apostrophe has become a kind of cultural shibboleth: educated people, it is typically assumed, use it well and uneducated people do not. In some circumstances, such as applying for a job or even

writing an examination essay, the misuse of apostrophes can be a serious disadvantage. (p. 107)'' The public opinion concerning errors on Dutch verb homophones is the same. However, the psycholinguistic spelling research into these errors reveals that they are, in a sense, the natural outcome of factors that are inherent to our cognitive system and, hence, why they are so persistent.

At the same time, our literature review shows that sufficient familiarity with mapping (parts) of a word's morphological structure largely depends on the frequency with which this mapping must be performed. The virtual absence of errors on the morphologically determined spelling of the stem in Dutch verb homophones and the fluency with which Hebrew children deal with morphology in spelling attest to this. Finally, our review also shows that spellers' error rates not only depend on language-related factors, but also on participant-related factors like morphological awareness, rule knowledge, and social factors like gender, age, and educational track.

4 This special issue

Against this theoretical background, we can now situate the papers in this special issue. The issue brings together four papers focusing on the impact of a word's morphological structure on its spelling. Some papers report, in line with one part of the literature (see Sect. 3.1), that morphological awareness positively affects spelling performance. Others, in line with another part of the literature (see Sect. 3.2), focus on the difficulties that (some) morphological patterns may cause.

The papers vary along a range of dimensions, making them a source of valuable insights on the topic. Most papers focus on visual writing systems (Berg, Hartmann & Claeser; Shalhoub-Awwad & Cohen-Mimran; Weth, Dording, Klasen, Fayol, Funke & Ugen) but one paper studies morphology in a tactile writing system, i.e., Braille (Englebretson, Cay Holbrook, Treiman & Fischer-Baum). There are corpus studies (Berg et al., Englebretson et al.) and experimental studies (Shalhoub-Awwad & Cohen-Mimran, Weth et al.). Some researchers focus on very young children (Shalhoub Shalhoub-Awwad & Cohen-Mimran), others on children in the first grades of elementary school (Englebretson et al., Weth et al.), and still others on pupils at the end of secondary school (Berg et al.). Together, the papers cover a variety of languages: English (Englebretson et al.), German (Berg et al., Weth et al.), French (Weth et al.), Arabic (Shalhoub-Awwad & Cohen-Mimran), and Hebrew (Shalhoub-Awwad & Cohen-Mimran). Whereas English, German, and French belong to the family of Indo-European languages, Arabic and Hebrew are typologically different, belonging to the family of Semitic languages. Additionally, these languages make use of different writing systems than Indo-European languages (e.g., they are written from right to left, and primarily represent consonants). Moreover, they also differ from each other, i.e., use different scripts and have distinct orthographic rules.

Englebretson et al. report data on the use of Braille contractions. These are units in which two letter representations in Braille are collapsed into a single one. The authors wonder what happens when a contraction straddles a morpheme boundary vs. when it does not. In the former case, the contraction ignores the morphological structure, cutting across it, whereas in the latter case it does not. The authors observe that their

participants, who are still not fully proficient in using this system (children: Grades 1-4), sometimes fall back on their intuitions. When doing so, they more often do not use the contraction when it is at odds with the word's morphological structure, i.e., when it straddles a morpheme boundary, than when it occurs within a morpheme. This confirms earlier findings (e.g., by Treiman and co-workers) that young children try to make use of their knowledge of a word's morphological structure. Hence, the tendency to render a word's morphological structure is very strong, from a young age onwards, not only in an orthography based on the visual modality but also in one based on the tactile modality.

Shalhoub-Awwad & Cohen-Mimranoub-Awwad investigate the impact of morphological awareness on spelling success in Arabic and Hebrew. Whereas both orthographies make use of roots and patterns, Arabic is considerably more consistent at the level of phoneme-to-grapheme mappings, i.e., spellers can often rely on the phonological principle. Hebrew spelling requires a much stronger reliance on morphology, such that spellers must also often appeal to the morphological principle. The authors show that, in Hebrew, morphological awareness indeed explains more additional variance in the data after other predictors have been entered than in Arabic. This shows that children quickly learn to apply the morphological principle when their orthography obliges them to attend to the word's morphological structure for spelling. This finding fits the finding by Gillis and Ravid (2006) that familiarity with morphology has a direct impact on spelling success. It is also in line with the finding by Sandra and colleagues that Dutch spellers seldom make errors on the stem part of verb homophones, as they often have to apply the morphological principle at the level of the stem but make more errors (even experienced spellers from time to time) on the inflectional suffix, as they seldom have to apply the morphological principle at the level of the suffix. An added value of the Shalhoub-Awwad & Cohen-Mimranoub-Awwad study is that they collected measures of morphological awareness in kindergarten, such that their results cannot be contaminated by formal schooling.

Berg et al. investigate a large corpus of handwritten exit exams at the end of secondary school. Setting out from the knowledge that most spelling errors occur at word endings, they wonder which endings are most affected. They find that letter omissions occur more often in inflectional endings than at the end of word stems or derivational suffixes. This paper, too, is in line with the finding that inflectional suffixes are a source of errors, which is arguably due to their abstract nature (less accessible) and the application frequency of the morphological principle at that level.

Weth et al. report a training study in Grade 4. They set out from the observations that children make many errors on the inflectional endings for plural in French, which are 'silent letters', and on noun capitalizations. They argue that both are related to the speller's syntactic awareness, more particularly, of the noun phrase. In French, the article, the adjective, and the noun of a noun phrase are all marked with the suffix spelling *s* in the plural. In German, a noun that is the head of a noun phrase is capitalized. In a training study with a fixed number of videos, they attempt to raise the children's syntactic awareness, with the aim of reducing the number of errors. This training turns out to be beneficial in French but not in German. The authors discuss several possible explanations for this discrepancy. Their finding that the silent plural

marker in French causes problems fits the literature. Their training study also shows that it is possible to ameliorate the problem by training the children on the problem and raising their awareness of the importance of the morphological principle and teaching them to apply it. The training increases the application frequency of the principle (see above) but it would be important to find out in future research whether this learning effect generalizes to spontaneous writing assignments or remains restricted to situations in which the participants are aware that they are tested on trained material. The discrepant results for French and German also highlights the fact that a theoretically well-motivated (i.e., syntactic) classification of a spelling problem (German noun capitalization of head NP) may clash with a different approach in schoolbooks, such that intervention might not yield the expected effect.

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References

- Assink, E. (1985). Assessing spelling strategies for the orthography of Dutch verbs. *British Journal of Psychology*, 76, 353–363. <https://doi.org/10.1111/j.2044-8295.1985.tb01958.x>.
- Baayen, H., Dijkstra, T., & Schreuder, R. (1997). Singulars and plurals in Dutch: Evidence for a parallel dual-route model. *Journal of Memory and Language*, 37, 94–117. <https://doi.org/10.1006/jmla.1997.2509>.
- Bar-On, A., & Kuperman, V. (2018). Spelling errors respect morphology: A corpus study of Hebrew orthography. *Reading & Writing*, 32, 1107–1128. <https://doi.org/10.1007/s11145-018-9902-1>.
- Booij, G. (1996). Inherent versus contextual inflection and the split morphology hypothesis. In G. Booij & J. van Marle (Eds.), *Yearbook of morphology*, Dordrecht: Springer. https://doi.org/10.1007/978-94-017-3716-6_1.
- Bredel, U., Noack, C., & Plag, I. (2013). Morphologie lesen: Stammkonstanzschreibung und Leseverstehen bei starken und schwachen Lesern. (Reading Morphology: Root Consistency Spelling and Reading Comprehension in Strong and Weak Readers.) In M. Neef & C. Scherer (Eds.), *Die Schnittstelle von Morphologie und geschriebener Sprache (The interface of morphology and written language)* (pp. 211–249). Berlin: Mouton de Gruyter. <https://doi.org/10.1515/9783110336665.211>.
- Bryant, P., Devine, M., Ledward, A., & Nunes, T. (1997). Spelling with apostrophes and understanding possession. *British Journal of Educational Psychology*, 67, 91–110. <https://doi.org/10.1111/j.2044-8279.1997.tb01229.x>.

- Bryshaert, M., Grondelaers, S., & Ratinckx, E. (2000). Sentence reading: Do we make use of orthographic cues in homophones? *Acta Psychologica*, *105*, 31–56. [https://doi.org/10.1016/S0001-6918\(00\)00047-0](https://doi.org/10.1016/S0001-6918(00)00047-0).
- Chamalaun, R. J. P. M., Bosman, A. M. T., & Ernestus, M. T. C. (2021). The role of grammar in spelling homophonous regular verbs. *Written Language & Literacy*, *24*(1), 38–80. <https://doi.org/10.1075/wll.00047.cha>.
- Chliounaki, K., & Bryant, P. (2003). Choosing the right spelling in Greek: Morphology helps. *Revue Française de Linguistique Appliquée*, *1*, 35–45. <https://doi.org/10.3917/rfla.081.0035>.
- Deacon, H., & Bryant, P. (2006). Getting to the root: Young writers' sensitivity to the role of root morphemes in the spelling of inflected and derived words. *Journal of Child Language*, *33*, 401–417. <https://doi.org/10.1017/S0305000906007409>.
- Deacon, H., & Bryant, P. (2006). This turnip's not for turning: Children's morphological awareness and their use of root morphemes in spelling. *British Journal of Developmental Psychology*, *24*, 567–575. <https://doi.org/10.1348/026151005X50834>.
- Forster, K., & Davis, C. (1984). Repetition and frequency attenuation in lexical access. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, *10*, 680–698. <https://doi.org/10.1037/0278-7393.10.4.680>.
- Frisson, S., & Sandra, D. (2002). Homophonic forms of regularly inflected verbs have their own orthographic representations: A developmental perspective on spelling errors. *Brain and Language*, *81*, 545–554. <https://doi.org/10.1006/brln.2001.2546>.
- Fromkin, V. (1971). The non-anomalous nature of anomalous utterances. *Language*, *47*, 27–52. <https://doi.org/10.2307/412187>.
- Gahl, S., & Plag, I. (2019). Spelling errors in English derivational suffixes reflect morphological boundary strength: A case study. *The Mental Lexicon*, *14*, 1–36. <https://doi.org/10.1075/ml.19002.gah>.
- Garrett, M. F. (1975). The analysis of sentence production. *The Psychology of Learning and Motivation*, *9*, 133–177. [https://doi.org/10.1016/s0079-7421\(08\)60270-4](https://doi.org/10.1016/s0079-7421(08)60270-4).
- Gillis, S., & Ravid, D. (2006). Typological effects on spelling development: A crosslinguistic study of Hebrew and Dutch. *Journal of Child Language*, *33*, 621–659. <https://doi.org/10.1017/S0305000906007434>.
- Juul, H., & Elbro, C. (2004). The links between grammar and spelling: A cognitive hurdle in deep orthographies? *Reading & Writing*, *17*, 915–942. <https://doi.org/10.1007/s11145-004-2109-7>.
- Largy, P., Fayol, M., & Lemaire, P. (1996). The homophone effect in written French: The case of verb-noun inflection errors. *Language and Cognitive Processes*, *11*, 217–255. <https://doi.org/10.1080/016909696387178>.
- Longtin, C., & Meunier, F. (2005). Morphological decomposition in early visual word processing. *Journal of Memory and Language*, *53*, 26–41. <https://doi.org/10.1016/j.jml.2005.02.008>.
- Longtin, C., Juan Segui, J., & Hallé, P. (2003). Morphological priming without morphological relationship. *Cognitive Processes*, *18*, 313–334. <https://doi.org/10.1080/01690960244000036>.
- Murrell, G., & Morton, J. (1974). Word recognition and morphemic structure. *Journal of Experimental Psychology*, *102*, 963–968. <https://doi.org/10.1037/h0036551>.
- Pacton, S., Casalis, S., & Deacon, S. H. (2007). The joint influence of orthographic and morphological regularities on children's spelling: Evidence from French. Paper presented at the Congress of the Society for Scientific Studies of Reading, Prague, Czech Republic.
- Pacton, S., Jaco, A., Nys, M., Foulin, J. N., Treiman, R., & Peereman, R. (2018). Children benefit from morphological relatedness independently of orthographic relatedness when they learn to spell new words. *Journal of Experimental Child Psychology*, *171*, 71–83. <https://doi.org/10.1016/j.jecp.2018.02.003>.
- Rastle, K., Davis, M., & New, B. (2005). The broth in my brother's brothel: Morpho-orthographic segmentation in visual word recognition. *Psychonomic Bulletin & Review*, *11*, 1090–1098. <https://doi.org/10.3758/BF03196742>.
- Ravid, D. (2012). Spelling morphology: The psycholinguistics of Hebrew spelling. In *Literacy studies*, New York: Springer. <https://doi.org/10.1007/978-1-4419-0588-8>.
- Ravid, D., & Gillis, S. (2000). Effects of phonology and morphology in children's orthographic systems: A crosslinguistic study of Hebrew and Dutch. In E. Clark (Ed.), *Proceedings of the 30th Stanford Child Language Research Forum* (Vol. 30, pp. 203–210). Stanford: CSLI Publications.
- Sandra, D. (2010). Homophone dominance at the whole-word and sub-word levels: Spelling errors suggest full-form storage of regularly inflected verb forms. *Language and Speech*, *53*, 405–444. <https://doi.org/10.1177/0023830910371459>.

- Sandra, D. (2019). Morphological units: A theoretical and psycholinguistic perspective. In R. Lieber (Ed.), *The Oxford encyclopedia of morphology*, London: Oxford University Press. <https://doi.org/10.1093/acrefore/9780199384655.013.541>. (Published online: 2021.)
- Sandra, D. (2022). Too little morphology can kill you: The interplay between low-frequency morpho-orthographic rules and high-frequency verb homophones in spelling errors. In R. Levie, A. Bar-On, O. Ashkenazi, E. Datner, & G. Brandes (Eds.), *Developing language and literacy: Studies in honor of Dorit Diskin Ravid* (pp. 191–229). https://doi.org/10.1007/978-3-030-99891-2_8.
- Sandra, D., & Fayol, M. (2003). Spelling errors with a view on the mental lexicon: Frequency and proximity effects in misspelling homophonous regular verb forms in Dutch and French. In H. Baayen & R. Schreuder (Eds.), *Morphological structure in language processing* (pp. 485–514). Berlin: Mouton De Gruyter. <https://doi.org/10.1515/9783110910186.485>.
- Sandra, D., & Van Abbenyen, L. (2009). Frequency and analogical effects in the spelling of full-form and sublexical homophonous patterns by 12 year-old children. *The Mental Lexicon*, 4, 239–275. <https://doi.org/10.1075/ml.4.2.04san>.
- Sandra, D., Frisson, S., & Daems, F. (1999). Why simple verb forms can be so difficult to spell: The influence of homophone frequency and distance in Dutch. *Brain and Language*, 68, 277–283. <https://doi.org/10.1006/brln.1999.2108>.
- Sandra, D., Frisson, S., & Daems, F. (2004). Still errors after all those years ... : Limited attentional resources and homophone frequency account for spelling errors on silent verb suffixes in Dutch. *Written Language & Literacy*, 7, 61–77. <https://doi.org/10.1075/wll.7.1.07san>.
- Schiff, R., Rosenstock, S., & Ravid, D. (2020). Morpho-orthographic complexity in affix spelling in Hebrew: A novel psycholinguistic outlook across the school years. *Frontiers in Psychology*, 11, Article 868. <https://doi.org/10.3389/fpsyg.2020.00868>.
- Schmitz, T., Chamalaun, R., & Ernestus, M. (2018). The Dutch verb-spelling paradox in social media. *Linguistics in the Netherlands*, 35, 111–124. <https://doi.org/10.1075/avt.00008.sch>.
- Sénéchal, M. (2000). Morphological effects in children's spelling of French words. *Canadian Journal of Experimental Psychology*, 54, 76–86. <https://doi.org/10.1037/h0087331>.
- Sénéchal, M., Basque, M., & Leclaire, T. (2006). Morphological knowledge as revealed in children's spelling accuracy and reports of spelling strategies. *Journal of Experimental Child Psychology*, 95, 231–254. <https://doi.org/10.1016/j.jecp.2006.05.003>.
- Surkyn, H., Vandekerckhove, R., & Sandra, D. (2020). From experiment to real-life data: Social factors determine the rate of spelling errors on rule-governed verb homophones but not the size of the homophone dominance effect. *The Mental Lexicon*, 15, 422–463. <https://doi.org/10.1075/ml.20006.sur>.
- Surkyn, H., Vandekerckhove, R., & Sandra, D. (2021). The impact of analogical effects and social factors on the spelling of partially homophonous verb forms in informal social media writing. *Written Language & Literacy*, 24, 1–37. <https://doi.org/10.1075/wll.00046.sur>.
- Taft, M., & Forster, K. (1975). Lexical storage and retrieval of prefixed words. *Journal of Verbal Learning and Verbal Behavior*, 14, 638–647. [https://doi.org/10.1016/S0022-5371\(75\)80051-X](https://doi.org/10.1016/S0022-5371(75)80051-X).
- Treiman, R., & Cassar, M. (1997). The beginnings of orthographic knowledge: Children's knowledge of double letters in words. *Journal of Educational Psychology*, 89, 631–644. <https://doi.org/10.1006/jecp.1996.0045>.
- Treiman, R., Cassar, M., & Zukowski, A. (1994). What types of linguistic information do children use in spelling? The case of flaps. *Child Development*, 65(5), 1318–1337. <https://doi.org/10.1111/j.1467-8624.1994.tb00819.x>.
- Verhaert, N., Danckaert, E., & Sandra, D. (2016). The dual role of homophone dominance. Why homophone intrusions on regular verb forms so often go unnoticed. *The Mental Lexicon*, 11, 1–25. <https://doi.org/10.1075/ml.11.1.01ver>.