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The place of morphology in learning to read in English

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ABSTRACT

Morphology is a major organising principle of English and other alphabetic languages, but has been largely neglected in theories of reading acquisition. In this article, I develop the view that learning to appreciate morphological relationships may be a vital part of acquiring a direct mapping between printed words and their meanings, represented in the ventral brain pathway of the reading network. I show that morphology provides an important degree of regularity across this mapping in English, and suggest that this regularity is directly associated with irregularity in the mapping between spelling and sound. I further show that while children in primary school display explicit knowledge of morphological relationships, there is scant evidence they show the rapid morphological analysis of printed words that skilled readers exhibit. These findings suggest that the acquisition of long-term morphological knowledge may be associated with the ongoing development of reading expertise. Implications for reading instruction are discussed.

1. Introduction

It is hard to overestimate the importance of reading on an individual's access to knowledge, prosperity, health, and social engagement. Yet, unlike spoken language, which is acquired by all typically-developing children, reading is a learned skill that requires years of practice and formal instruction. Much is known about the foundations of learning to read in early childhood, at least in the case of alphabetic writing systems, and this knowledge has begun to permeate educational policy and practice (e.g., Rose, 2006). However, morphology has been relatively neglected in our theoretical conceptualisations of reading acquisition. This is partly because theoretical models of reading acquisition have tended to focus on monosyllabic, and in many cases, monomorphemic words (e.g., Harm & Seidenberg, 2004; Plaut, McClelland, Seidenberg, & Patterson, 1996). This state of affairs has also arisen because research in this area has tended to focus on young children in the first stages of learning to read.

In contrast, research on skilled adult reading suggests that the analysis of morphological information is a routine part of word recognition (e.g., Amenta & Crepaldi, 2012, for review) that arises very rapidly in processing (e.g., Rastle & Davis, 2008, for review). This research indicates that skilled adult readers must have acquired morphological knowledge at some stage of reading acquisition. The nature of this knowledge, and the way that it manifests in different reading

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tasks over different periods of development, will almost certainly depend on the manner in which morphological information is represented in the spoken language and writing system (e.g., Plaut & Gonnerman, 2000). In this article, I focus primarily on the representation of morphological information in English, and the consequences of this for the acquisition of morphological knowledge, although I also consider whether and how this characterisation may differ in other alphabetic languages. I demonstrate that morphological information brings an important degree of regularity to the mapping between English printed words and their meanings, and that this form of regularity is directly associated with irregularity in the mapping between spelling and sound. Following this, I put forward the hypothesis that the acquisition of morphological knowledge plays an important role in the development of reading expertise, underpinned by the ventral reading pathway in the brain. Finally, I discuss the implications of this characterisation for approaches to reading instruction.

2. Dual-pathway theories of reading

Writing in English and other alphabetic languages is achieved through a system of visual symbols that represent sounds. In such writing systems, there is a systematic relationship between spelling and sound, such that words that look similar also sound similar (e.g., *cat*, *mat*, *can*, *man*). Because the primary regularities to capture within any alphabetic writing system are between spelling and sound, it is appropriate and unsurprising that research on learning to read has been dominated by questions around the acquisition and impact of this knowledge.

There is now very strong evidence that learning to appreciate the relationship between spelling and sound is fundamental in the initial stages of reading acquisition (e.g., Lervåg, Hulme, & Melby-Lervåg, 2017). The reason that learning this relationship is so important is that it provides the developing reader with access to their spoken language knowledge about the meanings of words. This spoken language knowledge is typically acquired before reading instruction begins, and is often viewed as more robust than knowledge of written language, as it is an inborn capacity served by dedicated neural hardware (Pinker, 1997). One influential framework known as the *Simple View of Reading* therefore suggests that problems in mapping spelling to sound *or* in spoken language knowledge can give rise to reading difficulties (Gough & Tunmer, 1986). For this reason, there has been substantial emphasis on promoting methods of reading instruction that teach the spelling-sound relationship explicitly, alongside the provision of broader language and literacy experiences (e.g., Rayner, Foorman, Perfetti, Pesetsky, & Seidenberg, 2001).

Translating the printed word to a sound-based code is also an important feature of skilled adult reading (see Rastle & Brysbaert, 2006, for review). However, in contrast to a theory in which the computation of sound-based codes is *obligatory* for accessing meaning (e.g., Frost, 1998), research on skilled reading in alphabetic writing systems has converged on a theoretical perspective in which the computation of sound-based representations provide *one route* to accessing meaning (e.g., Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; Harm & Seidenberg, 2004). In this latter type of theory, skilled readers may also access meaning via a direct spelling-to-meaning mapping. This dual-pathway conceptualisation is supported by a recent meta-analysis of neuroimaging data revealing dorsal (spelling-to-sound-to-meaning) and ventral (spelling-to-meaning) pathways for reading (Taylor, Rastle, & Davis, 2013). Fig. 1 provides an illustration of a dual-pathway theory of skilled reading and its neural underpinnings.

The model illustrated in Fig. 1 suggests that acquiring a phonologically-mediated pathway to reading comprehension is not *sufficient* to be a skilled reader. One also needs to learn to recognize individual words rapidly, a process sometimes called *orthographic learning* (e.g., Castles & Nation, 2006).[1] How might readers learn the direct mapping from spelling to meaning? There has been comparatively little research on this question, and cognitive theories are underspecified (see Nation, 2009, 2017, for discussion). However, there is good reason to believe that this development arises during a later stage of reading experience than the development of the phonologically-mediated pathway. In particular, longitudinal data have shown that the brain regions underpinning the spelling-to-meaning (ventral) pathway become increasingly more sensitive to letter strings between the ages of 7 and 13 (Ben-Shachar, Dougherty, Deutsch, & Wandell, 2011), in a manner associated with improved performance in speeded word reading, but not in nonword reading or phonological processing skill. These data fit with conceptualisations of regions of the ventral pathway as supporting reading expertise (McCandliss, Cohen, & Dehaene, 2003), and with theories suggesting that there is a shift from reliance on the dorsal pathway to the ventral pathway as readers develop greater expertise (Pugh et al., 2000).

In this article, I develop the hypothesis that coming to appreciate morphological relationships in spelling may be central to developing reading expertise along the direct spelling-to-meaning (ventral) pathway.

3. Morphological regularities in English writing

The importance of learning the relationship between spelling and sound in reading derives from the nature of alphabetic writing systems, in which letters or groups of letters consistently represent sounds. In contrast to the relationship between spelling and sound, the relationship between spelling and meaning is arbitrary, at least when words comprising a

[1] Though becoming a skilled reader might require the development of a direct mapping between spelling and meaning, it is critically important to remember that the acquisition of spelling–sound knowledge is likely to be a *necessary precursor* to learning the direct pathway between spelling and meaning. In this vein, Share (1995) argued that phonological decoding provides a self-teaching mechanism that allows a learner to acquire orthographic knowledge of individual words (see Ziegler, Perry, & Zorzi, 2014 for computational implementation). The existence of a direct spelling–meaning pathway in skilled readers should not be interpreted as suggesting that learning to read does not require spelling–sound knowledge.

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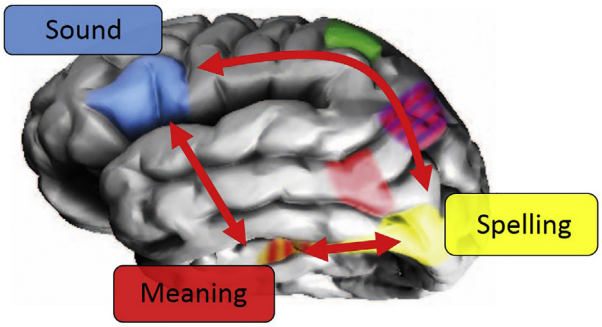

Fig. 1 – The dual-pathway theory of skilled reading and its neural underpinnings. Adapted from Taylor et al. (2013).

single morpheme are considered (e.g., Plaut & Gonnerman, 2000). For example, while words that look similar such as *punt* and *pant* also sound similar, they are not similar in meaning. In the absence of any underlying regularity, it is not hard to understand why learning to relate such words to meanings is very difficult; this is essentially a paired-associate learning task (Taylor, Davis, & Rastle, 2017). In such cases, learning the meaning of one printed word confers no benefits at all for learning the meaning of another visually similar word.

This characterisation of the relationship between spelling and meaning changes substantially when words with more than one morpheme are considered. It has long been argued that morphemes provide "islands of regularity" in the mapping between printed words and their meanings (Rastle, Davis, Marslen-Wilson, & Tyler, 2000). These islands of regularity arise because stems occur repeatedly in words with similar meanings (e.g., trusty, trust, distrust, untrustworthy), and affixes alter the meanings of stems in a highly-predictable manner (e.g., cleaner, builder, teacher; Plaut & Gonnerman, 2000; Rastle & Davis, 2008). Thus, in contrast to the case with *punt* and *pant* where learning the meaning of each word is a separate problem, these forms of regularity allow knowledge of one exemplar to assist learning of another (e.g., knowing the words *cleaner*, *builder*, and *teacher* may assist interpretation of *tweeter* as 'someone who tweets'). These forms of regularity have been under-appreciated in psychological work on reading because of the previously-noted focus on monomorphemic words. Yet, in English and other languages, the vast majority of words consist of more than one morpheme (Baayen, Piepenbrock, & van Rijn, 1993). Thus, any consideration of how we acquire the direct mapping between spelling and meaning must consider these regularities.

Morphological regularities also exist in spoken language (e.g., the stem 'trust' exists in spoken representations of *trusty*, *distrust*, and *untrustworthy*), and it is often noted that English spoken language morphology is impoverished relative to other languages (e.g., Frost & Grainger, 2000), such as Finnish (e.g., Moscoso del Prado Martín, Bertram, Häikiö, Schreuder, & Baayen, 2004) and German (Hasenäcker, Beyersmann, & Schroeder, 2016). This characterisation might lead one to argue that morphological knowledge may play a lesser role in English language processing than in other languages with richer morphology. However, what is relevant when discussing the place of morphology in reading acquisition is the extent to which morphological information is present in the *spelling*. Critically, morphological regularities are often far more salient in English spelling than in English spoken language. This principle is nicely illustrated with reference to the English past tense (Carney, 1994). In spoken language, the English past tense is usually denoted by phonemes/əd/, /d/or /t/, depending on surrounding context (e.g., 'busted', 'snored', 'kicked', respectively). However, these final phonemes are *always* spelled 'ed' in past tense forms. Thus, the relationship between form and meaning in this case is more prominent in the written language than in the spoken language. It is important to note that the past tense is not a special case in this respect: English is filled with examples in which inflectional and derivational morphological relationships are communicated more consistently in writing than in spoken language (see e.g., Berg & Aronoff, 2017).

One particularly interesting aspect of English morphology is that the writing system sacrifices regularity between spelling and sound in order to communicate this important information about meaning. If spelling–sound transparency were prioritised, then one would spell the words discussed above as 'busted', 'snord', and 'kict'. Yet, the writing system admits spelling–sound inconsistency (e.g., the spelling '-ed' maps to multiple sounds) in order to create a reliable orthographic cue to meaning: word final spelling '-ed' denotes the past. In fact, further linguistic analysis suggests that English may have evolved in such a way to *reserve* particular spellings for particular meanings. For example, there are virtually no cases in which words with a single morpheme contain word final spelling '-ed' (Berg, Buchmann, Dybiec, & Fuhrhop, 2014). This is achieved because words that might reasonably be spelled using '-ed' (i.e., ending in the sound sequences/Id/,/ɛd/, and/əd/) are given alternative spellings if they are monomorphemic (e.g., horrid, instead, salad; Berg et al., 2014). The proliferation of spellings here weakens the spelling–sound mapping, but strengthens the consistency of the mapping between spelling and meaning. Similar cases are also present in English derivational morphology. For example, Berg and Aronoff (2017) reported that while the sound sequence/əs/ has many potential spellings (e.g., service, nervous, princess, haggis), the spelling '-ous' is reserved to communicate adjective status. Here again, the presence of multiple spellings for a particular sound sequence allows one spelling to become associated with a particular meaning. If English writing were a simple one-to-one transliteration of spoken language – a perfect system for learning to decode the printed word back into spoken language – this information would be lost.

The characterisation of morphology that I have provided suggests that the organisation of English spelling may assist readers to capture important information about meaning. Though English spoken language may not be characterised by a particularly rich morphological system in comparison with other alphabetic languages, morphological information in the spelling is *highly visible*. Nevertheless, a full theory of the acquisition of morphemic knowledge will require considerable additional research to determine precisely how morphological information is represented in English spelling, and how this information may differ from that in other languages.

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4. Morphological processing in skilled reading

In recent years, there has been a growing recognition that skilled reading reflects and is constrained by properties of writing systems (Frost, 2012). Thus, if a writing system communicates morphological information, then skilled adult readers should be sensitive to morphological structure when recognizing and comprehending printed words. Evidence from across multiple alphabetic languages suggests strongly that this is the case (see Amenta & Crepaldi, 2012, for a review of key findings). For example, the time taken to recognize a morphologically-complex word (e.g., darkness) is dependent on the frequency of the stem (e.g., dark) within that word (e.g., Niswander, Pollatsek, & Rayner, 2000; Taft & Ardasinski, 2006). Similarly, the size of a word's morphological family (i.e., the words that can be derived from the stem) influences the recognition of both simple (e.g., Baayen, Feldman, & Schreuder, 2006) and complex words (e.g., Bertram, Baayen, & Schreuder, 2000; Kuperman, Bertram, & Baayen, 2010). Finally, the recognition of a stem target is speeded by the prior masked presentation of a morphologically-related prime (e.g., darkness-DARK). Importantly, this priming cannot be attributed to a simple summation of orthographic and semantic similarity between prime and target (Rastle et al., 2000). These findings have been taken to indicate that morphologically-complex words are analysed in terms of their constituent morphemes during word recognition.

Intriguingly, it appears that the initial analysis of morphological structure in skilled adult reading is based on morphemes defined *orthographically* (Rastle, Davis, & New, 2004). That is, in the case of masked priming, many studies have now shown that morphological facilitation is obtained not only when primes have a genuine morphological relation (e.g., darkness-DARK) but also when they have a pseudo-morphological relation (e.g., corner-CORN). Critically, these priming effects are greater than those obtained on the basis of pure letter overlap (e.g., brothel-BROTH; -el is not a suffix in any English word), thus confirming their morphological nature (e.g., Longtin, Segui, & Hallé, 2003; Rastle et al., 2004; see Davis & Rastle, 2010, and Rastle & Davis, 2008, for reviews of these findings). Rastle et al. (2004) suggested that these effects reflect a rapid process of morphological segmentation operating on any printed word that comprises an *apparent* morphological structure, a phenomenon they termed '*morpho-orthographic segmentation*'. These data are consistent with suggestions that morphological knowledge is activated at an orthographic level prior the activation of whole-word representations (Taft & Forster, 1975). Work using eye-tracking demonstrates that this morpho-orthographic analysis also arises in sentence reading, even when sentence contexts demonstrate that morphological parsing is inappropriate (e.g., as in the case of items like 'corner'; Amenta, Marelli, & Crepaldi, 2015). Event-related potential (ERP) data suggest that the activation of semantic contents arises relatively quickly following this morpho-orthographic analysis (Lavric, Elchlepp, & Rastle, 2012); hence, this form of analysis is not detected in paradigms that typically reflect semantic processes such as cross-modal priming (Longtin et al., 2003) or visual priming with fully-visible primes (Rastle et al., 2000). One important question is why the skilled reading system should be designed in this manner, when research has shown that segmentation of pseudo-morphological words such as '*corner*' yields a processing cost (Lavric et al., 2012). Recent linguistic analysis has begun to answer this question: at least in English, it appears that these types of pseudo-morphological words should be very rare (Berg & Aronoff, 2017). Thus, the occasional mistaken analysis of a word like '*corner*' is balanced against the speed afforded by a relatively superficial analysis of morphological structure. It is also noteworthy that some evidence suggests that morpho-orthographic segmentation may be modulated by language and reading proficiency (Andrews & Lo, 2013; Beyersmann, Grainger, Casalis, & Ziegler, 2015).[2]

I have argued that morphological relationships provide an important degree of regularity between the spellings of words and their meanings. Thus, coming to appreciate these relationships may be a critical part of acquiring the direct mapping between spelling and meaning that is necessary for skilled reading. We do not have good causal evidence for this hypothesis at present. However, neuroscientific data demonstrate that morphemic processing in skilled adult readers engages ventral brain regions, which are thought to be involved in mapping from spelling to meaning. Functional magnetic resonance imaging (fMRI) studies have reported neural masked morphological priming effects for printed words in left occipitotemporal cortex (e.g., Devlin, Jamison, Matthews, & Gonnerman, 2004; Gold & Rastle, 2007). Electrophysiological investigations further suggest that morphological segmentation arises within the first 200 msec of word identification (Lavric et al., 2012). Tying these results together, magnetoencephalography (MEG) studies have reported that morphological properties of printed words are associated with modulation of the M170 component, originating from left ventral occipitotemporal cortex (e.g., Lewis, Solomyak, & Marantz, 2011; Solomyak & Marantz, 2010). Priming studies using MEG have revealed morphological effects in a similar region (Cavalli et al., 2016; Lehtonen, Monahan, & Poeppel, 2011). In sum, the available data indicate that morphological analysis of printed words may be associated with processing in the ventral reading pathway.

5. Acquisition of morphological knowledge

We have seen that skilled readers analyse the morphemic structure of printed words (e.g., Rastle et al., 2004), that this analysis arises rapidly in visual word recognition (e.g., Lavric et al., 2012), and that it is associated with processing along the ventral reading pathway (e.g., Lewis et al., 2011). Recent data also indicate that this pathway continues to develop into adolescence (Ben-Shachar et al., 2011), following earlier reliance on the dorsal pathway (Pugh et al., 2000). We might therefore predict that the rapid morphemic analysis characteristic of skilled readers is acquired relatively late in reading acquisition.

[2] These arguments around proficiency have been put forward to explain occasional failures to replicate the morpho-orthographic pattern (e.g., Morris, Porter, Grainger, & Holcomb, 2011).

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There is substantial evidence that when children come to the problem of learning to read, they already possess explicit morphological knowledge (e.g., Carlisle, 1995; Kirby et al., 2012). Acquisition of this form of knowledge is typically assessed through oral tasks that measure conscious manipulation of morphemes; for example "Teach: He was a very good …" (*teacher*; Carlisle, 2000), or "push: pushed as jump: …" (*jumped*; Kirby et al., 2012). Performance on such tasks is positively associated with both single-word reading aloud and passage comprehension in young readers (e.g., Carlisle, 2003; Deacon & Kirby, 2004; Kirby et al., 2012). Such findings have motivated calls to target morphological knowledge in literacy instruction (Bowers, Kirby, & Deacon, 2010; Nunes & Bryant, 2006).

However, while there is clear evidence for explicit morphological knowledge in young readers, a more challenging question concerns the circumstances under which developing readers use this knowledge in online reading tasks. There is evidence that children in the first few years of reading instruction begin to show morphological effects in single-word reading aloud and recognition tasks. For example, Burani, Marcolini, and Stella (2002) reported that Italian children between the ages of 8 and 10 read aloud morphologically-structured nonwords more quickly and accurately than nonwords without morphological structure. In a similar reading aloud experiment, children between the ages of 9 and 11 read aloud morphologically-complex English words with a high-frequency stem more quickly and accurately than those with a lower-frequency stem (Deacon, Whalen, & Kirby, 2011). In lexical decision, Casalis, Quémart, and Duncan (2015) reported that English and French children between the ages of 7 and 10 found morphologically-structured nonwords (e.g., *gifter*) harder to reject than nonwords (e.g., *curlip*) without a morphological structure. The same pattern of results was reported by Burani et al. (2002) with respect to Italian children of a similar age, with both of these studies replicating observations from skilled readers (Crepaldi, Rastle, & Davis, 2010). More recent research using this paradigm with three age groups of developing English readers (ages 7–9, 12–13, and 16–17) demonstrated that while the two younger age groups showed an effect of morphological structure on accuracy, only the older adolescents (16–17 years old) and adults showed this effect on reaction time (Dawson, Rastle, & Ricketts, 2017).

These data have led to proposals that morphological knowledge is represented in some manner in lexical memory within the first few years of reading acquisition. For example, "Morphemes provide lexical reading units of a larger grain size than graphemes …" (Burani, Marcolini, De Zuca, & Zoccolotti, 2008, p. 252); "… children at all reading ages take advantage of morphemic lexical units …" (Burani et al., 2002, p. 581); "… morphemes may develop as orthographic and phonological salient reading units …" (Burani et al., 2008, p. 254); "… common letter patterns might become consolidated in lexical memory …" (Deacon et al., 2011, p. 476). However, these proposals are rather underspecified, and an important challenge for the future will be to determine precisely how morphemic knowledge characterises different components of the reading system through the process of reading acquisition.

One potentially important piece of data is that developing readers in primary school do not appear to show the morpho-orthographic segmentation characteristic of skilled adult readers. Masked priming experiments across English (Beyersmann, Castles, & Coltheart, 2012) and French (Beyersmann, Grainger, Casalis, & Ziegler, 2015) have shown robust morphological priming effects on word recognition for these children, but only when morphological primes have a semantically-transparent relationship with targets (e.g., darkness-DARK). Beyersmann et al. (2012) found no evidence that children aged between 8 and 10 show morpho-orthographic analysis: priming effects for pseudo-morphological pairs (e.g., corner-CORN) could not be distinguished from those based on non-morphological form overlap (e.g., brothel-BROTH). In a related comparison, Beyersmann et al. (2015) could not differentiate masked priming effects for suffixed nonword pairs (e.g., tristerie-TRISTE) and non-suffixed nonword pairs (e.g., tristald-TRISTE) in readers aged approximately 7–11 (see also Hasenäcker et al., 2016, for a similar study in German). Skilled adult readers *do* show a significant difference in the magnitude of masked priming across these conditions (e.g., Meunier & Longtin, 2007), a finding consistent with the notion that skilled adult readers possess orthographic representations that are structured morphologically, and that are activated prior to representations of whole words.[3] These findings suggest that while children have some degree of morphological knowledge in some component of the reading system, the stable morphological representations that underpin rapid orthographic analysis in skilled readers (e.g., Rastle & Davis, 2008; Rastle et al., 2004) may not be sufficiently robust until later into secondary education when readers have accumulated more text experience.

One important question is whether this developmental trajectory holds across different languages, or whether morphological knowledge may be acquired more rapidly in languages with richer morphology. I have already argued that the visibility of morphology in a language's *spelling* is likely to be the critical variable in respect of acquiring morphemic representations in reading acquisition, and that further work is required to assess whether and how languages differ on this dimension. Once this work has been conducted, the question of whether morphological knowledge develops differently across languages could be investigated in cross-linguistic studies using comparable materials and procedures. To my knowledge, such studies have not yet been undertaken, and there is insufficient evidence at this time to suggest that the acquisition of morphological knowledge differs across readers

[3] Quémart, Casalis, and Colé (2011) claimed to find evidence for morpho-orthographic analysis in French developing readers between the ages of 8 and 13 (grades 3, 5, and 7). Indeed, they did report significant masked priming by-subjects for pseudo-morphological items (e.g., baguette-BAGUE; there was no by-items analysis). However, while simple effects comparisons showed no priming in the non-morphological form condition (e.g. , abricot-ABRI), whether there was a significant difference in priming effects across pseudo-morphological and non-morphological conditions was not reported. This comparison is critical for establishing the presence of morpho-orthographic analysis (e.g., Longtin et al., 2003; Rastle et al., 2004).

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of different alphabetic languages. In fact, the developmental trajectory observed in English (Beyersmann et al., 2012) also appears to be observed in Hebrew, a Semitic language with particularly rich morphological structure (Schiff, Raveh, & Fighel, 2012). Schiff et al. (2012) studied the impact of semantic transparency on Hebrew masked morphological priming in groups of 4th and 7th grade children (aged approximately 9 and 12 years, respectively). Both groups showed strong priming when primes had a morphological and semantic relationship with targets; however, when primes had only a morphological relationship with targets, priming was absent for the younger children and weak for the older children. Strong morphological priming effects are observed in skilled adult readers of Hebrew irrespective of semantic relatedness (Frost, Forster, & Deutsch, 1997).

If young children possess some degree of morphological knowledge early in reading instruction, sufficient to impact on some measures of reading performance within the first few years of reading instruction, then why do they not show evidence of stable morphological representations that can be accessed rapidly in word recognition? There is not yet a satisfactory answer to this question. However, recent laboratory simulations of the acquisition of morphological knowledge have revealed a similar dissociation. Tamminen, Davis, and Rastle (2015) trained adults on vocabularies comprising novel words that were morphologically structured (e.g., sleepnule, teachnule, buildnule). These novel words were defined in such a way that the new affix (-nule, in this case) impacted on the meanings of the 'stems' in a consistent manner (e.g., -nule reflects agency). Participants' knowledge of the novel morpheme (e.g., -nule) was then assessed using a variety of tasks. Across several experiments, participants showed rapid acquisition of explicit knowledge of the form, function and meanings of the novel morphemes. However, this explicit knowledge was not sufficient to permit participants to benefit from that knowledge in online language processing tasks unless certain conditions were met. One criterion that was important for acquiring this deeper form of morphological knowledge was that the novel morphemes needed to arise in multiple different word contexts during learning. The requirement for high *contextual diversity* in the acquisition of implicit morphological knowledge is consistent with our understanding of statistical learning in infants and adults (Gómez, 2002), and with theoretical advances in respect of orthographic learning (Nation, 2017). However, further research is necessary to understand more deeply how explicit knowledge is encoded in long-term representations that can impact on rapid word reading.

6. Morphology in reading instruction

Morphology provides a bridge between form and meaning in alphabetic languages, and I have argued that this is particularly true in English spelling, where morphology is highly visible. We have seen that the analysis of morphological information contributes to rapid word recognition in skilled adult readers, and that different forms of morphological information seem to be available to children across different stages of reading development. One important question therefore concerns whether and how reading instruction programmes should be designed to communicate morphological information.

It is now well established that explicit instruction of the relationship between letters and sounds in the first years of reading instruction has a significant positive impact on reading success (i.e., systematic phonics; National Reading Panel, 2000). Likewise, many have argued that specific instruction on morphological relationships may also improve reading performance (e.g., Goodwin & Ahn, 2010, 2013), and this notion has been implemented in reading interventions such as Structured Word Inquiry (Bowers & Bowers, 2017) and RAVE-O (Wolf et al., 2009). However, much less detailed work has been conducted to specify what form this instruction should take, or at what point in reading development it should be delivered. For example, the meta-analyses conducted by Goodwin and Ahn (2010, 2013) included a range of morphological interventions, a range of different control groups, and the age range and reading abilities of participants varied substantially (e.g., they included participants between preschool and 12th grade). Deciding whether morphological instruction is beneficial clearly requires answers to these specific questions.

Recently, Bowers and Bowers (2017) have put forward a strong case that the relationships between phonology, orthography, morphology and etymology should form the basis of reading instruction *from its earliest stages*. Using Structured Word Inquiry, children might be asked to investigate the etymology of the words '*design*' and '*sign*' to discover that they share the Latin root '*signare*', whereas etymological study of '*display*' and '*play*' reveals that they are unrelated. Particularly given the view that I have articulated that morphology plays a prime role in English spelling, it is difficult to argue with the notion that enhancing children's understanding of this aspect of the writing system is positive. Indeed, this is generally confirmed in the meta-analyses cited earlier (Goodwin & Ahn, 2010, 2013). However, the reason that this proposal is controversial derives from the claim that this type of instruction should be implemented in the *first stages* of learning to read as an alternative to systematic phonics instruction. Because there is limited instructional time, any focus at this stage on morphology and etymology will necessarily detract from time spent on learning spelling-sound relationships (Taylor et al., 2017). Support for Bowers and Bowers' (2017) claim would need to come from randomised controlled trial evidence testing their approach against standard systematic phonics for young children just beginning to learn to read. To my knowledge, no such evidence exists.

In order to support their case, Bowers and Bowers (2017) described three intervention studies (Bowers & Kirby, 2010; Devonshire & Fluck, 2010; Devonshire, Morris, & Fluck, 2013). However, these fall well short of an appropriate standard of evidence. Bowers and Kirby (2010) did not measure reading performance in younger children; instead, they measured the impact of Structured Word Inquiry on vocabulary acquisition in older children (aged approximately 10 years). Similarly, there were no reading performance measures in Devonshire and Fluck (2010). Instead, they investigated spelling performance in children aged between 7 and 9, contrasting morphological instruction with an alternative method that

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combines a visual strategy ("look, cover, write check") with emphasis on phonic knowledge. Finally, Devonshire et al. (2013) compared the impact of Structured Word Inquiry with "standard classroom instruction" (Bowers & Bowers, 2017, p. 136) on reading and spelling performance in younger children aged 5–7. Devonshire et al. (2013) reported that the standard classroom instruction condition consisted of "traditional phonics" (p. 85). However, they also noted that the reading scheme being used was "not a phonic reading scheme; it takes more of a 'whole word' approach and children are encouraged to guess words from context or picture clues" (p. 88). Thus, while this study produced some positive evidence for morphological instruction in young children learning to read, there are questions about the nature of the standard instruction condition that would need to be addressed through further research.

One further reason to doubt whether a focus on morphology and etymology at the expense of systematic phonics is appropriate for the initial stages of reading acquisition comes from analysis of the text experiences of young children. Analysis of the Children's Printed Word Database (Masterson, Stuart, Dixon, & Lovejoy, 2010) indicates that in the first year of reading instruction, 58% of words that children are exposed to in standard reading schemes comprise more than one morpheme, but that this figure drops to 20% when token frequency is taken into account.[4] Thus, morphological regularities are not relevant to the overwhelming proportion of tokens experienced in the first year of reading instruction. Of those words that comprise more than one morpheme, 86% contain the suffixes '-ed' or '-s' that attach to stems (Masterson et al., 2010). Thus, Masterson et al. (2010) argued that instruction on this limited set of suffixes may be appropriate during this period. This recommendation is broadly consistent with the approach to reading instruction in England, where the National Curriculum specifies that alongside systematic phonics, simple suffixes such as '-s', '-er', '-ing', '-ed' should be taught as part of the reading and spelling curriculum by the conclusion of 1st grade (when children are 5 or 6). The English National Curriculum then advances during the later years of primary school to higher-level morphological regularities that include a wide range of prefixes and suffixes, their functions or meanings, and any relevant spelling rules pertaining to their use (Department for Education, 2014). Further corpus analyses would be needed to assess how well this approach to morphological instruction supports the texts that children of different ages are reading and using to practice their reading skills; and ultimately, the evaluation of any reading method should be subject to empirical evidence.

In summary, the importance of morphology in English spelling suggests that explicit morphological instruction should be beneficial at some point in the process of learning to read. However, the preceding discussion suggests that there is insufficient empirical evidence to determine what form that instruction should take, and when it would be most effective. There is no compelling evidence at present that it should replace systematic phonics instruction in the first stages of learning to read, although it may be beneficial at later points in reading acquisition. This conclusion is consistent with multiple lines of evidence I have put forward in this article. In particular, though children already demonstrate explicit knowledge of morphemes very early in reading development, this knowledge does not translate to the ability to use that information in rapid printed word processing. It is unlikely that further training in the initial stages of reading instruction on morphological relationships would alter this picture. Instead, I have argued that the ability to use morphological knowledge fluently appears to arise much later in reading acquisition and may be associated with tuning of the ventral reading pathway representing spelling–meaning knowledge. It may be the case that morphological instruction during these later stages of reading acquisition is beneficial, although appropriate intervention studies would need to be conducted before a specific recommendation could be put forward.

7. Conclusions

Morphology is a major organising principle of English and other alphabetic languages, but has been neglected in theories of reading acquisition, partly because of a focus on morphologically-simple words in the most successful theoretical models, and partly because of a tendency to focus on younger children. In this article, I have asserted that learning to appreciate morphological relationships may be a vital part of acquiring the direct pathway between spelling and meaning, necessary for skilled adult reading. I have suggested that while English spoken language does not have particularly rich morphology, morphological relationships are highly visible in English spelling. There is ample evidence that these relationships are represented as long-term knowledge in adult skilled readers, although work is really only just beginning to uncover how morphological knowledge in young children becomes represented in such a way that can be accessed rapidly in word recognition. I have argued that the acquisition of this form of knowledge is associated with the ongoing development of reading expertise and becomes represented in the ventral reading pathway. Much further research is needed to understand how reading experience is translated into long-term stored knowledge, and the way in which particular forms of instruction might impact on this process.

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[4] These figures were retrieved directly from the Children's Printed Word Database (http://www.essex.ac.uk/psychology/cpwd/) on January 25, 2018. I thank Jo Taylor for her assistance in retrieving these data.

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