



Neurocognitive Contexts for Morphological Complexity: Dissociating Inflection and Derivation

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Abstract

We review experimental findings about the processing of morphologically complex words, and provide a neuro-cognitive account of the mechanisms that underlie this processing. Within the framework of the brain network that supports language comprehension, we argue that complex words created by regular and rule-based combinations, such as regular inflections in English (e.g. *played*, *jumps*), engage a left-lateralized frontotemporal subsystem, specialized for grammatical computations. In contrast, processing of lexicalized and unpredictable complexity, present in derived words (e.g. *bravely*, *warmth*), engages a bilateral subsystem, which underpins whole-word, stem-based lexical access. We suggest a potential neurobiological framework for this proposed organization.

In psycholinguistic accounts of the human language system, morphemes are standardly defined as the smallest linguistic units that carry meaning (Henderson 1985). They contribute systematically to the meanings of words containing them, and are essential for language productivity: stems (e.g. *jump*, *dark*) and affixes (e.g. *-ed*, *-ness*) recur in different words, and coining a new word is most often achieved by putting existing morphemes into new combinations. As a result, a relatively small number of familiar elements are recombined in highly flexible ways to express a virtually infinite number of ideas, concepts and actions. In this study, we review experimental findings about the ways morphological structure affects word processing, and argue that only a neuro-biologically grounded approach can provide a comprehensive account of the ways morphologically complex words are represented and processed in language comprehension.

Several decades of psycholinguistic research show that the human cognitive system is sensitive to the morphological structure of words (Marslen-Wilson et al. 1994, 2008; Frost et al. 1997; Rastle et al. 2000, 2004; Longtin et al. 2003; Longtin and Meunier 2005). For instance, the strand of research that uses priming techniques consistently shows that a word (e.g. *build*) is recognized faster when it is preceded by a morphologically related inflected or derived word (e.g. *builds*, *builder*), compared to when it is preceded by an unrelated word (e.g. *writer*). On the assumption that such facilitation results from repeated access to the same underlying representational or processing component, this was taken to suggest that the comprehension of morphologically complex words involves decomposition of the suffixes (*-s*, *-er*) from the stems (*build*) at some processing stage. Similarly, a different strand of research has shown that the processing time for morphologically complex words is significantly influenced by the frequency of their constituent morphemes as well as by the frequency of the form as a whole (Taft 1979, 2004; Burani

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et al. 1984; Burani and Caramazza 1987; Cole et al. 1989; Baayen et al. 1997; Bertram et al. 2000), further suggesting that morphological structure affects processing at some level of language comprehension.

These psycholinguistic findings have been instrumental in the development of cognitive theories of the processing and representation of morphologically complex words. The results allowed researchers to test competing theories and build detailed models of the underlying cognitive processes and representations. However, psycholinguistic data on their own cannot provide a full picture. Reaction times, the most commonly used index of the underlying processes, are inherently tied to task-related strategic decisions that occur during and after the recognition of a word. In the fast and dynamic process of online language comprehension, lexical input must be processed for its sound, meaning and morphological structure before a participant makes a response expressed by the reaction time measure. Furthermore, computational models of language processing suggested by psycholinguists rarely take into account the neural architecture that supports lexical processing. Knowledge about the functional brain networks that underlie language comprehension can provide evidence for, and against, the neural reality of the representations and processes postulated by language models, and can constrain cognitive theories in a way that is not possible with behavioural methods alone (Henson 2005). To achieve better understanding of how the cognitive system processes morphologically complex words, we need to understand the underlying neural systems. This can be achieved by using neuroimaging techniques, such as functional magnetic resonance imaging (fMRI), electronencephalography and magnetoencephalography (MEG), as well as data from patients with brain damage.

Converging evidence from these sources shows that language comprehension engages a network of frontal and temporal brain regions (Tyler et al. 1995, 2002; Binder et al. 2000; Bookheimer 2002; Beeman 2005; Marslen-Wilson and Tyler 2007). Although more pronounced in the left hemisphere, the network spans over both left and right frontotemporal regions, including superior temporal, middle temporal and inferior frontal gyri (Figure 1). The existing evidence also suggests that this frontotemporal network consists of two functionally distinct subsystems, whose activation is modulated by quantitative and qualitative variations in the complexity of the incoming input. The first, bilateral frontotemporal subsystem, is engaged by the sound-to-meaning mapping and general perceptual processing demands of simple words (e.g. *dark*). The second, left-lateralized frontotemporal subsystem, is activated by the presence of complexity due to the combinations of grammatical morphemes (such as the English past tense inflection, as in *play + ed*) – a specifically linguistic form of complexity which gives the human language its unique structural organization and expressive powers (Marslen-Wilson and Tyler 2007; Bozic et al. 2010).

Bilateral temporal activation, particularly in the regions of primary auditory cortex (PAC) and superior temporal sulcus (STS), has commonly been associated with lower-level

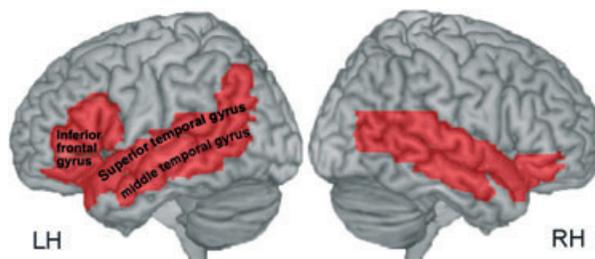


Fig 1. Bilateral fronto-temporal language network.

auditory processing (Binder et al. 1997, 2000; Scott et al. 2000; Davis and Johnsruide 2003; Uppenkamp et al. 2006). However, a number of studies with healthy and brain-damaged participants suggest that the engagement of temporal regions, especially those inferior and lateral to the PAC and STS, is not limited to low-level acoustic and phonetic analyses. Compared with acoustic baselines such as musical rain, noise-vocoded speech or spectrally rotated speech, spoken words have been shown to activate bilateral superior and middle temporal gyri, regions long implicated in processing lexical meaning (Tyler et al. 1995, 2002, 2005a; Mummery et al. 1999; Binder et al. 2000; Scott et al. 2000; Bookheimer 2002; Davis and Johnsruide 2003; Longworth et al. 2005; Bozic et al. 2007a; Hickok and Poeppel 2007; Hickok et al. 2008). Neuropsychological data in particular (evidence from acute stroke, Wada and chronic lesion studies) strongly imply that both hemispheres have access to the representations of lexical meaning, and that damage to one hemisphere produces only relatively mild effects on the comprehension of simple words.

Longworth et al. (2005) showed that brain-damaged patients with extensive damage to left frontal and superior temporal regions can produce semantic priming effects and reaction times comparable to those of healthy controls, when presented with pairs of simple spoken words (e.g. *hope-wish*). Hickok et al. (2008) tested participants who underwent the Wada procedure as a part of their epilepsy treatment. Their L or R hemisphere was temporarily anesthetized, and participants were asked to match a spoken word (e.g. *bear*) to one of the four pictures: an identical picture (*bear*), a semantic foil (*moose*), a phonetic foil (*pear*) or an unrelated picture. Although their performance was somewhat worse with L hemisphere anaesthesia, participants still performed well above chance levels. More importantly, most errors were induced by the semantic foils, demonstrating that both L and R hemisphere have access to lexical identity and meaning. These results are particularly telling as they show that lexical access in R hemisphere happens even after acute disruption, and not as a result of compensation due to neural plasticity and semantic reorganization (Finger et al. 2003; Desmurget et al. 2007). Based on these data, we hypothesize that both hemispheres are engaged to a similar degree when the linguistic input consists of simple frequent words.

The second subsystem of the language comprehension network is undoubtedly the specialized left-lateralized frontotemporal network, which been salient in accounts of the brain basis of language at least from the time of Paul Broca. This subsystem seems to support combinatorial processes invoked by morpho-phonologically and syntactically complex lexical items (Marslen-Wilson and Tyler 2007). This hypothesis is backed up by neuroimaging findings on healthy volunteers, which consistently show the involvement of LH inferior frontal, temporal and inferior parietal regions in processing lexical information that relies on combining simple linguistic elements into more complex structures (e.g. grammatical, syntactic and morphological information; Binder et al. 2000; Friederici et al. 2003; Shtyrov et al. 2005; Tyler et al. 2005a; Bozic et al. 2010). In addition, neuropsychological data show that damage to the left (but not right) frontotemporal regions causes permanent disruption to these combinatorial aspects of language processing. Patients with LH damage, especially in the left inferior frontal lobe, have problems with production and comprehension of syntactically and morphologically complex sequences (Goodglass et al. 1993; Longworth et al. 2005).

In sum, the existing evidence suggests that the language comprehension network consists of two functionally distinct subsystems: a bi-hemispheric subsystem, which supports sound-to-meaning mapping for linguistically simple words, and a left hemisphere frontotemporal subsystem, which is selectively engaged by processing demands due to the presence of linguistic complexity. We believe that this neuro-functional framework is of the

critical importance in understanding the way morphologically complex words are processed and represented by the cognitive system.

It is, however, essential to make a distinction between the different types of morphologically complex words and the ways they are constructed, focusing here on English in particular. There are three different ways of forming morphologically complex words in English: inflection (*walk–walked*, *horse–horses*), derivation (*happy–happiness*, *happy–unhappy*) and compounding (*boathouse*). Inflections grammatically change verbs (changing their tense, e.g. by adding *-ed*, *walk–walked*) or nouns (changing their number, e.g. by adding *-s*, *dog–dogs*). Derivations are new words, derived from another word, changing its meaning and often grammatical category (e.g. *brave–bravely*, *govern–government*). Compounding is the process of combining two or more stem morphemes into a single new word (such as *boathouse*, *bedroom* and *penknife*). In this study, we focus on complex words created by the processes of inflection and derivation only.¹ These differ fundamentally in several important aspects (Marslen-Wilson 2007).

In traditional linguistic accounts, complex words with inflectional affixes are taken to be a surface variant of the underlying stem, rather than a new word distinct from that stem. In other words, inflectional processes do not create new lexical entries in the mental lexicon. Furthermore, inflectional processes are strongly determined by the requirements of the grammatical context in which they occur. Inflectional processes produce morphologically and syntactically complex combinations where the constituents are salient, regular and predictable (*play + ed*, *jump + ed*, *dog + s*, etc.). As inflectional morphemes (in English and similar languages) are purely grammatical in nature, and do not alter the semantic content of the stem they attach to, they are likely to be combined online rather than stored and processed as full forms. Comprehension of inflected forms would therefore require parsing of the suffix from the stem, before the stem can be mapped onto its representation in the mental lexicon. Behavioural studies provide clear evidence that inflected words are processed with respect to their constituent morphemes (e.g. Stanners et al. 1979; Fowler et al. 1985), and it has been often suggested that inflections are stored and processed compositionally (e.g. Marslen-Wilson and Tyler 2007).

Processes of derivational morphology, on the other hand, are seen as creating new words in the mental lexicon. Derivational affixes (e.g. *-er*, *-ly*, *-ness*) change the meaning and grammatical category of stems they attach to. In contrast to inflection, derivational processes are context-independent and less predictable, even idiosyncratic. The meaning of a derived form may be broadly compositional with respect to the meaning of the constituents (i.e. semantically transparent: *brave–bravely*, *govern–governor*) or it may bear no resemblance to the meaning of its apparent constituents (semantically opaque: *arch–archer*, *depart–department*, *wit–witness*) (Marslen-Wilson et al. 1994). In either case, these new combinations are expressing new meanings, and are forming tight connections between stems and suffixes. Psycholinguistic research shows that the morphological structure of derived words is detected at the early stages of visual word recognition (Rastle et al. 2000; Longtin and Meunier 2005; Marslen-Wilson et al. 2008), but this does not necessarily imply that their central semantic representations are organized decompositionally. Instead, the semantic compositionality of derived words (i.e. the degree of their transparency/opacity) and properties of the suffix such as the frequency and productivity are suggested to be the key variables determining how strong the stem-affix connection is, and how far derived words are represented in terms of their morphemic content (e.g. Bertram et al. 2000). Clahsen et al. (2003) associate derivations with stored whole representations, but with preserved marking of their morphological structure, especially for semantically transparent forms with productive affixes (see also Marslen-Wilson 2007).

Based on the described properties of inflectionally and derivationally complex words in English, clear predictions can be formulated about the ways they should be represented and processed in the frontotemporal language comprehension network. The presence of predictable, rule-based and saliently combinatorial structure in regularly inflected complex words (e.g. *played*) should trigger decompositional processes, engaging the left-lateralized frontotemporal subsystem, which supports these core combinatorial grammatical functions. Non-predictable and lexicalized combinations present in derived words (e.g. *bravely*, *warmth*) should engage this left-lateralized subsystem to a lesser extent. Instead, derivationally complex words may rely more strongly on the bilateral processing subsystem, which underpins whole-word, stem-based sound-to-meaning mapping, although the morphological structure of derived words could still be detected and processed by the comprehension system, as shown in psycholinguistic experiments (e.g. Rastle et al. 2000; Longtin et al. 2003; Marslen-Wilson et al. 2008). In other words, processing inflectional complexity should be strongly left-lateralized, whereas processing derivational complexity should engage both hemispheres to a similar degree.

For inflections, this is precisely the pattern that emerges from the literature. Data from a number of neuroimaging studies show the crucial role of the left frontotemporal regions for processing inflectional morphology (Laine et al. 1999; Shtyrov and Pulvermüller 2002; Shtyrov et al. 2005; Tyler et al. 2005a,b; Lehtonen et al. 2006; Bozic et al. 2007a). A PET study in Finnish by Laine et al. (1999) showed significantly stronger activation for processing inflected as opposed to simple words in BA 44/45 (Broca's area). Another study in Finnish that compared processing of inflected and monomorphemic words using fMRI (Lehtonen et al. 2006) showed increased activation for inflected words in several left frontotemporal regions. In English, Tyler et al. (2005a) used fMRI to compare activation for spoken regular and irregular past tense pairs (*jumped–jump* vs. *taught–teach*). The results showed increased neural activation in frontotemporal regions (BA 44 in left inferior frontal gyrus and BA 21/22 in temporal lobes) for regular morphologically compositional words (e.g. *jumped*), compared to irregular non-compositional word forms (e.g. *taught*). This could not be explained as a result of greater phonological complexity of the regulars, as the same regions were activated when the regulars were contrasted with phonologically matched control pairs. The authors concluded that this reflects involvement of the left inferior frontal regions in the structural, morpho-phonological segmentation of complex regular stimuli, whereas the superior and middle temporal gyri support access to lexical representations from the stems of regular forms. Using MEG, Shtyrov et al. (2005) compared brain responses to the same brief acoustic stimulus in different contexts: perceived as a noise burst with no resemblance of speech, perceived as a consonant at the end of a meaningless pseudoword or perceived as an inflectional suffix denoting grammatical information at the end of a real word. A left-lateralized mismatch negativity signal was observed in frontal regions only in the real word context, when the acoustic stimulus was interpreted as an inflectional suffix.

Bozic et al. (2010) compared the processing of simple spoken words with words ending in the inflectional rhyme pattern (IRP). This is the phonological pattern in English which indicates that the ending of a word may be an inflectional affix, and is defined as a coronal consonant (i.e. *d*, *t*, *s*, *z*) that agrees in voice with the preceding segment (Post et al. 2008). This pattern is shared by all regular {-d} and {-s} inflections in English, and can be present both in real inflected forms (*played*, *packs*), and in pseudo-inflected forms where a simple word has an apparent inflectional ending (*trade*, *flax*). Compared against simple words (e.g. *cream*), words ending in the IRP (e.g. *played*, *trade*, *trend*) activated left inferior frontal area BA 45, reinforcing the conclusion that left frontal regions perform

decompositional computations on grammatical morphemes, required for processing inflectionally complex words.

In the neuropsychological domain, Tyler et al. (2002) used auditory priming to assess the comprehension of the regular and irregular past tense words in non-fluent patients with lesions that included left frontotemporal brain areas (specifically, the inferior frontal and the superior temporal gyri). These patients failed to show priming for the compositional regular past tense words (e.g. *jump–jumped*), but showed the normal pattern of response facilitation for the non-compositional irregular past tense words (e.g. *teach–taught*) and semantically related words (e.g. *swan–goose*). Similarly, Ullman et al. (2005) tested the performance of 20 left hemisphere stroke patients on processing regular and irregular past tense forms in a range of tasks. The results showed that patients' performance was worse at computing regular than irregular past tenses in reading, writing, production and repetition. In another patient study, Tyler et al. (2005b) correlated signal intensity across the entire brains of brain-damaged patients with behavioural priming scores for morphologically related regularly inflected past tense forms (e.g. *jumped–jump*), irregularly inflected past tense forms (e.g. *slept–sleep*), and pairs related only in phonological form (e.g. *pillow–pill*) or in meaning (e.g. *card–paper*). These correlational analyses revealed that priming for regularly inflected forms was strongly associated with a network of left frontotemporal sites, in particular the inferior frontal gyrus, such that damage to these regions has a significant impact on processing regularly inflected words but does not seem to affect the processing of irregularly inflected words. Taken together, all these studies point to a key role played by the left hemisphere frontotemporal subsystem in processing predictable, rule-based and saliently compositional inflectional complexity.

In contrast to numerous studies on inflectional morphology, only a small number of neuroimaging and neuropsychological studies have focused on the processing of morphologically complex derived words, in either the spoken or written domain. The results that emerged are less consistent than those for the inflections. In the neuropsychological domain, some studies have reported impairments for processing inflectional morphology but relatively intact processing of derivational morphology in patients with damage to the left hemisphere (Miceli and Caramazza 1988; Marslen-Wilson and Tyler 1998). There are also reports of patients who show problems with derivational morphology (Badecker and Caramazza 1991; Marangolo et al. 2003; Hamilton and Coslett 2008; Marangolo and Piras 2008, 2010), but not all of them have benefited from a precise description of patients' lesion sites. Marangolo et al. (2003, Marangolo and Piras 2008) describe patients with a selective deficit in producing nouns derived from verbs, with MRI-documented damage to frontoparietal regions in the right hemisphere. However, the same impairment was not observed for deriving adjectives from nouns. The authors suggest that this selective deficit results from impaired inhibition mechanisms, subserved by the R basal ganglia, which are necessary when there is a strong competition between the possible alternatives (e.g. deriving nouns from verbs), but not when the competition is weak (e.g. deriving nouns from adjectives). However, the same processes have also been related to the comparable regions in the left hemisphere (e.g. Longworth et al. 2005), suggesting that the inhibition of competing alternatives is likely to engage bilateral, rather than exclusively RH subcortical structures.

Using fMRI in healthy participants, Davis et al. (2004) compared the processing of morphologically simple and complex words in a one-back synonym-monitoring task. Direct comparisons between the two types of words did not reveal any significant activation. Vannest et al. (2005) also explored the processing of derivations using fMRI, but focused only on regions of interest (ROIs) in Broca's area and basal ganglia in the left

hemisphere. The activation for different types of complex words was contrasted against a baseline of monomorphemic words, and effects of morphological complexity were found in both ROIs. Comparing derived German nouns with high or low complexity (i.e. derived in one or two steps from the stem noun), Meinzer et al. (2009) showed activation for more complex words in left and right temporo-occipital areas, as well as left frontal brain regions, suggesting that processing complex derivational morphology engages a large bilateral neural network. Similarly, in Italian, Marangolo et al. (2006) reported bilateral frontoparietal activation for the production of derived verbs, which contrasted to predominantly left-lateralized activation seen in the same task for inflections.

Although not fully clear-cut, the finding that seems to be shared across many of these studies is that processing derivational complexity does not selectively engage the same left-lateralized decompositional subsystem that is involved in the processing of grammatical compositionality in inflected words. Instead, processing derivational morphology seems to engage a larger, bilateral network of regions, which have been associated with processing lexical meaning (Binder et al. 2000; Bookheimer 2002; Bozic et al. 2007a; Hickok and Poeppel 2007; Tyler and Marslen-Wilson 2008). This hypothesis about lexical-semantic-based processing of derivational complexity was specifically tested in an fMRI experiment by Bozic et al. (2009). Here, the effects of lexical-semantic complexity of derived words (i.e. a presence of an embedded stem which may or may not be related in meaning to the derived word, e.g. *bravely* vs. *witness*) were contrasted with the effects due to the presence of derivational suffixes. The results showed bilateral activation due to lexical-semantic complexity, consistent with the emerging pattern of experimental evidence. In contrast, the presence of derivational affixes did not selectively activate the left-lateralized subsystem, suggesting that derivational affixes in English do not trigger morpho-syntactically critical decompositional processes in the same way as inflectional affixes.

Results such as these have important implications for theories of the representation and processing of derivational complexity. If derivational complexity does not selectively engage the left-lateralized decompositional subsystem, and is instead processed by a bilateral system that underpins whole-word, stem-based sound-to-meaning mapping, this suggests that derived words, at least in English, are not stored and processed with respect to their morphological structure. This interpretation is consistent with the linguistic definitions of derivations as full-form lexical entries, which are not assembled or disassembled online in the same manner as inflections. However, this does not exclude the possibility that the morphological structure of derived words can still be detected by the comprehension system, and indeed preserved in their lexical representations (Clahsen et al. 2003; Marslen-Wilson 2007). Some evidence for this can be seen in studies by Devlin et al. (2004), Gold and Rastle (2007) or Bozic et al. (2007b), which have shown that, when directly and explicitly primed, effects of derivational complexity can be observed in the specifically left hemisphere language regions. It is likely that these results capture the neural signature of the morphological processes observed in behavioural priming studies (Rastle et al. 2000; Longtin and Meunier 2005; Marslen-Wilson et al. 2008), which can be triggered either very early in the processing stream (Devlin et al. 2004; Gold and Rastle 2007) or propagate to later processing stages (Bozic et al. 2007b).

Pulling together the results reviewed above allows us to formulate a neuro-biologically informed theory of the way inflections and derivations are processed in language comprehension. Within the framework of the functionally distinct bilateral and the left-lateralized frontotemporal subsystems, it is uncontroversial that grammatically complex inflectional morphology selectively engages the left-lateralized subsystem. Complex combinations of stems and grammatical morphemes (e.g. *played*) need to be decomposed as part of the

lexical access process, and this is a function subserved by the decompositional subsystem in the left hemisphere. In contrast, the complex forms that have been created by combining stems and derivational suffixes (e.g. *government*) are not compositional in the same way, and are not decomposed into their constituent morphemes. Instead, they are more likely to be processed as full forms, and this process engages the bi-hemispheric subsystem that supports stem-based mapping of the lexical form to its underlying representation.

Such an organization of the language comprehension system, and the suggested manner in which the processing of inflections and derivations maps onto it, can be related to two recent findings. The first one is that the potentially analogous system for processing vocal signals in primates, which is arguably an important part of the evolutionary background to the human comprehension system, has a distinctly bilateral distribution (Gil-da-costa et al. 2006). Gil-da-Costa and colleagues showed that species-specific calls in macaques, which are crucial for communication, activate bilateral frontotemporal regions. The second finding is that there seems to be a specifically human increase in the left-hemisphere connections between frontal and temporal brain regions (Rilling et al. 2008). Rilling et al. used diffusion tensor imaging (DTI) technique to compare white matter connections between frontal and temporal regions in humans, macaques and chimpanzees, and showed a selective increase in left hemisphere connections in humans. As suggested by the previously reviewed neuroimaging and neuropsychological evidence, the left hemisphere subsystem is specialized for grammatical computations, required for processing inflectional complexity. This left-lateralization is a human-specific property of the comprehension system as grammar is absent in primate communication. This finding is further supported by DTI studies in human participants that show stronger left than right hemisphere connections for these frontotemporal systems (Buchel et al. 2004; Catani et al. 2005; Parker et al. 2005).

In sum, we present here a preliminary neuro-cognitive account of how morphologically complex words are processed during language comprehension. We argue that the underlying neural systems provide an essential framework for understanding the mechanisms of these processes. In the context of a bilateral frontotemporal language network, we suggest that salient and predictable inflectional complexity activates a left-lateralized decompositional subsystem, whereas lexicalized and unpredictable derivational complexity engages the bilateral subsystem. We also suggest a potential neurobiological framework for the proposed organization. However, it must be noted that the experimental data available and reviewed here come mainly from English, and that the account of processing morphological complexity developed here is very much dominated by the properties of this language. In comparison to other languages, English has a relatively impoverished morphological system, and a high proportion of surface forms are morphologically simple. At the same time, there are very dominant regular morphological processes marking tense (*-ed*) and number (*-s*). These properties can potentially put strong emphasis on the discrimination of simple and complex forms, and on the decompositional processes for regular inflections. Neural processing of English is important and interesting on its own, but clearly insufficient as a basis for the study of language as a whole. It will therefore be critical to establish whether the distinction between inflectional and derivational processes proposed here holds for other languages. Language families with very different morphological structure, such as Slavic or Semitic, may provide a different challenge to the system, and only a comprehensive cross-linguistic investigation can provide a fully explanatory account of the ways morphological structure is processed in the mind and the brain.

Notes

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¹ We do not consider compounds here, since they do not involve the combination of stems with grammatical morphemes in the same way as inflectionally and derivationally complex words. They are also typically idiosyncratic in their meaning (compare *fireman*, *snowman*, *milkman*) implying that they must always be stored as whole forms. This is not to say that compounds are not of considerable interest in their own right, both linguistically and psycholinguistically. However, they are of less direct relevance to the current set of questions.

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