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Morphological priming in bilingualism research*

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The review describes how morphological priming can be utilised to study the processing of morphologically complex words in bilinguals. The article starts with an overview of established experimental paradigms based on morphological priming, discusses a number of basic methodological pitfalls with regard to experimental design and materials, then reviews previous L2 morphological priming studies, and concludes with a brief discussion of recent developments in the field as well as possible future directions.

Keywords: L2 processing, morphology, decomposition, morphological priming

Introduction

A fundamental issue in research on the processing of morphologically complex words is to what extent the internal grammatical structure of such words plays a role during word recognition. For example, an inflected verb form such as *walked* possesses an internal grammatical structure in the sense that it consists of the verbal stem *walk* and the past-tense suffix *–ed*. The question of whether the processing of a word such as *walked* involves the decomposition of the word into its morphological constituents *walk* and *-ed*, or whether complex words are represented and processed in essentially the same way as simplex words, has been subject to considerable debate in both L1 and L2 processing research.

Word recognition in the human mind and brain is extremely fast and largely automatic. As a result, the study of morphological processing requires elaborate experimental paradigms which are able to tap into the mechanisms involved in this process. One such paradigm, which has been used extensively in the past 30 years, is MORPHOLOGICAL PRIMING.

The morphological priming paradigm

In a typical morphological priming experiment, participants perform lexical decisions on target words such as *walk*, with their lexical decision times being measured. The target words are preceded by either a morphologically complex prime word such as *walked*, which is based on the same stem as the target word, or by a control prime which is morphologically unrelated to the target, such as *brush*. If the processing of a complex word such as *walked* involves the decomposition of the word into its morphological constituents, this should lead to the activation of the stem *walk* during processing of the prime word. This should facilitate subsequent recognition of the target word *walk*, with faster lexical decision times relative to the unrelated control condition, because for a prime-target pair such as *walked-walk*, the stem *walk* is already activated when the target word *walk* is encountered, while this is not the case for a prime-target pair such as *brush-walk*.

In order to conceal the true purpose of the experiment, morphological priming experiments typically contain a substantial number of filler trials. This is particularly important because L2 learners often possess considerably more elaborate explicit knowledge about the morphological properties of the language than native speakers, which might lead to strategic effects. In addition, in order to make the lexical-decision task meaningful, it is common to add additional filler trials in which the target word is a nonword (typically so that 50% of all trials contain nonword targets).

With regard to the dependent measure, morphological priming experiments are by no means limited to lexical decision times, but can also rely on measures such as naming latencies (e.g., Coughlin & Tremblay, 2014), EEG (see Bosch & Leminen, to appear) or fMRI (e.g., De Grauwe, Lemhöfer, Willems & Schriefers, 2014). Primes and targets can be presented either visually or auditorily, making the paradigm suitable for research on both written and spoken word recognition (see Gor & Cook, 2010, and Gor & Jackson, 2013, for two examples of L2 studies investigating spoken word recognition). Also, while the majority of studies have focussed on late L2 learners, the paradigm has also been employed to investigate other

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groups of bilinguals, such as heritage speakers (Gor & Cook, 2010; Jacob & Kırkıcı, 2016).

A fundamental problem in morphological processing research is to tease apart the role of the morphological, semantic, and orthographic information contained in a word. For morphological priming, prime-target pairs such as *walked-walk* are not only morphologically related (in the sense that both words are based on the same stem), but are also similar with regard to other, non-morphological properties. For example, *walked* and *walk* are orthographically and phonologically similar, and are also related in meaning. As a result, a priming effect for a prime-target pair such as *walked-walk* is not necessarily morphological in nature, but could also be due to other, non-morphological similarities between prime and target, such as semantic relatedness or surface-form similarity. Thus, in order to be able to make the claim that priming effects are really caused by prime and target sharing the same stem, the experimental design has to include possibilities to rule out these alternative, non-morphological explanations for a priming effect. To achieve this, morphological priming experiments typically contain control conditions with prime-target pairs which are only semantically related (such as *battle-fight*) or only surface-form related (such as *scandal-scan*). Additionally, a substantial number of studies have also attempted to deal with the issue by adding an identity control condition, in which a target word such as *walk* occurs as both prime and target. The rationale behind this is that if a priming effect for a pair such as *walked-walk* is indeed caused by the fact that *walked* and *walk* are based on the same stem, this priming effect should be as strong as the priming effect for the identity pair *walk-walk.* The identity condition thus allows for a distinction between FULL PRIMING (i.e., a priming effect which is as strong as the one observed for the identity control condition*)* and PARTIAL PRIMING (i.e., a priming effect which is weaker than the one for the identity control condition), with full priming being considered particularly robust evidence that a priming effect is genuinely morphological in nature (Stanners, Neiser, Hernon & Hall, 1979, and much subsequent work). Yet another possibility to control for the influence of non-morphological factors is based on comparisons between different groups of morphologically related prime-target pairs. For example, a number of studies (e.g., Neubauer & Clahsen, 2009; Feldman et al., 2010) have compared morphological priming effects for regular (e.g., *walked-walk*) and irregular (e.g., *threw-throw*) forms. Regular forms such as *walked* differ from irregular forms such as *threw* with regard to whether or not the stem can be identified by stripping of an affix, while the semantic and orthographic similarities between prime and target can be kept similar for both groups of forms. Thus, a difference in priming effects can be potentially informative with regard to issues related to morphological decomposition. Finally, it is possible to employ specific experimental procedures which have been shown to be less affected by particular non-morphological factors. In a CROSS-MODAL PRIMING experiment, for instance, prime and target words are presented in different modalities, typically with the prime word being presented auditorily and the target word visually. This method is considered to reduce effects of surface-form similarity. However, participants are consciously aware of the prime word and thus have full access to its semantic and conceptual properties, which typically causes robust semantic priming effects. In a MASKED-PRIMING experiment, in contrast, prime words are presented on screen for only an extremely short amount of time (typically for an SOA between 30 and 70 ms, which can also be experimentally manipulated), and are also preceded by a visual mask (typically a number of hash marks). As a result, participants are usually not consciously aware of the prime words. This type of presentation has been shown to considerably reduce semantic priming effects, typically with either no or only very small facilitation for prime-target pairs such as *battle-fight* in the semantic control conditions (e.g., Rastle, Davis, Marslen-Wilson & Tyler, 2000; Marslen-Wilson, 2007). Finally, in a LONG-LAG or DELAYED PRIMING experiment, primes and targets are presented overtly and in the same modality, but are separated from each other, for example with a number of (typically morphologically simplex) filler words presented in between. This typically reduces semantic and form-based priming effects, but preserves priming effects for morphologically related words (e.g., Raveh & Rueckl, 2000; Rueckl & Aicher, 2008; De Grauwe et al., 2014).

The results from a particular morphological priming experiment can differ substantially depending on the exact experimental procedure employed in a study. For instance, an especially striking effect which is largely specific to masked priming comes from studies which have investigated priming effects for so-called pseudo-morphologically related prime-target pairs, such as *corner-corn*. While *corner* and *corn* are morphologically unrelated, *corner* superficially looks as if it consisted of the existing English stem *corn* and the existing English affix *–er*. In masked priming, but typically not in cross-modal priming (e.g., Longtin, Segui & Hallé, 2003; Meunier & Longtin, 2007) or long-lag priming (e.g., Rueckl & Aicher, 2008), prime-target pairs such as *corner-corn* yielded robust priming effects (e.g., Rastle, Davis & New, 2004, Marslen-Wilson, Bozic & Randall, 2008). Rastle and colleagues consider this so-called CORNER-CORN EFFECT as evidence for an early and semantically blind morpho-orthographic segmentation mechanism, which, at a pre-lexical level of processing, decomposes a word into stems and affixes. With regard to the difference between masked and cross-modal priming, Marslen-Wilson (2007)

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argues that the different priming paradigms address distinct levels of processing, with masked priming tapping into an early, automatic, and pre-lexical level and overt priming addressing a later, central-lexical level. While the idea of an early morpho-orthographic decomposition mechanism for complex words in L1 speakers is not entirely uncontroversial (e.g., Baayen, 2007; Stockall & Marantz, 2006), it is important to note that it is at least difficult to directly compare the results from masked and cross-modal priming experiments, even when the respective studies are otherwise (i.e., with regard to experimental materials and participants) very similar.

Morphological priming in bilinguals

In studies investigating morphological processing in second-language (L2) learners, the same priming experiment is typically conducted with a group of L2 speakers and a control group of native (L1) speakers of the language. Priming effects are then determined separately for each of the two groups, and subsequently compared with each other. This procedure avoids any direct comparisons of lexical decision times between the L1 and L2 groups, which is useful given that L2 speakers often show generally slower lexical decision times overall. However, note that slower overall reaction times in L2 speakers can in principle also have an influence on the size of a priming effect. For example, it is possible that priming effects in an L1 group are relatively small because the group already shows very fast lexical decision times overall, so the possibility to speed up even more when primed by a morphologically related prime might be limited compared with an overall slower L1 group. A way to control for this is to conduct a z-transformation of the lexical decision times separately for each group prior to comparing L1 and L2 priming effects, which sets any group differences in overall lexical decision times to zero.

With regard to the experimental materials used in such a study, the fact that the items have to be suitable for L2 speakers typically has profound consequences for item selection. If materials have originally been designed for a study on L1 processing, and are then used to replicate the study with L2 speakers, it is often the case that a large number of data points have to be excluded due to incorrect lexical decisions or extremely slow lexical decision times. The fact that the materials have to be appropriate not only for L1, but also for L2 speakers also restricts the possibility to compare the results from the L1 control group with other studies on morphological processing in L1, which do not face such additional restrictions during item selection. As a result, comparisons between the results from the L1 control group in an L2 processing study and those from an experiment designed to investigate L1 processing is not without problems.

Previous morphological priming studies comparing L1 versus L2 speakers have yielded detailed insight into similarities and differences between L1 and L2 morphological processing. For example, a number of masked priming studies (e.g., Silva & Clahsen, 2008; Neubauer & Clahsen, 2009; Clahsen & Neubauer, 2010) have found substantial L1-L2 differences in morphological priming effects, with robust priming in L1, but either no or considerably reduced priming in L2 speakers. Note that the L2 groups in these studies nevertheless showed significant identity priming, suggesting that they were in principle sensitive to the masked prime words. Jacob, Fleischhauer, and Clahsen (2013) found a similar L1-L2 difference in a cross-modal priming study investigating the processing of regular German past participles, with full priming for L1 speakers, but only partial priming in the L2 group. This difference turned out to be specific to regular participles, and did not emerge for otherwise similar irregular forms. The pattern of results observed in these studies gave rise to the idea that the processing of complex words in L2 speakers relies less on morphological decomposition and instead more on storage and retrieval of full word-form representations in the mental lexicon. Interestingly, other L2 masked-priming studies (Feldman, Kostić, Basnight-Brown, Filipović Đurđević & Pastizzo, 2010; Diependaele, Duñabeitia, Morris & Keuleers, 2011; Coughlin & Tremblay, 2014; 2014; Foote, 2015), as well as L2 studies in which the primes were presented overtly (Basnight-Brown, Chen, Hua, Kostić & Feldman, 2007; De Grauwe et al., 2014), have instead found similar morphological priming effects in L1 and L2 speakers, and have interpreted this as evidence against fundamental L1-L2 differences in morphological processing. In order to account for this differential pattern of results, it has been suggested that L1-L2 differences might be restricted to particular morphological phenomena. For instance, Silva and Clahsen's (2008) masked-priming study determined morphological priming effects for both derived forms (with prime-target pairs such as *darkness-dark*) and inflected forms (with pairs such as *walked-walk*) in L1 speakers and two groups of (native Chinese and German) L2 speakers of English. For derived forms, only a gradual difference emerged, with a full priming effect for the L1 group and partial priming for the two L2 groups. For inflected forms, in contrast, while the L1 group displayed a full priming effect, both L2 groups showed no priming effects at all. Kırkıcı and Clahsen (2013) found a similar pattern of results in a masked-priming study on the processing of Turkish derived and inflected forms in L1 and L2 speakers. Again, the L2 group showed similar morphological priming effects as the L1 group for derivation, but no priming for inflection. Jacob, Heyer, and Veríssimo (2017) directly compared masked-priming effects for German derived vs. inflected forms

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in a study in which the same target word was primed by either a derived nominalization or a past participle. Again, while L1 speakers showed similar priming effects for both phenomena, the L2 group showed a difference, with significant priming effects only for derivation, but not for inflection. At least some of the studies reporting similar morphological priming effects for L1 and L2 speakers (Diependaele et al., 2011; De Grauwe et al., 2014) have investigated the processing of derived forms. Note, however, that several other masked-priming studies (Feldman et al., 2010; Coughlin & Tremblay, 2014, Voga, Anastassiadis-Symeonidis & Giraudo, 2014) have found significant morphological priming effects in L2 speakers even for inflected forms. Also, at least one masked-priming study (Clahsen & Neubauer, 2010) reports substantial L1-L2 differences for derived forms.

Another possibility is that L1 and L2 speakers might show similar priming effects for morphologically complex words, but for different reasons. Recall that prime-target pairs such as *walked-walk* in a morphological priming experiment are not only morphologically related, but are necessarily also related with regard to surface form. It is at least conceivable that L2 speakers, during word recognition, might focus relatively more on surface form properties of a word, such as its orthography. As a result, even if L2 speakers do not decompose complex words, they might still show a priming effect for prime-target pairs such as *walked-walk*, but not because *walked* and *walk* are both based on the same stem, but simply because they share a number of letters. Feldman et al. (2010) initially considered this possiblility a serious problem, and argued that morphological priming paradigms in which primes and targets occur in the same modality, such as masked priming, might be unsuitable for L2 processing research. However, as discussed above, morphological and form-based priming effects can be disentangled through appropriate control conditions. A good example of this is Heyer & Clahsen's (2015) masked-priming study, which compared morphological versus orthographic priming effects in native speakers and L2 learners of English. For morphologically related prime-target pairs such as *darkness-dark*, both subject groups showed significant priming effects. However, the L2 group, but not the L1 group, also showed significant priming effects for purely orthographically related prime-target pairs which were morphologically and semantically unrelated, such as *scandal-scan*. Indeed, L2-specific orthographic priming effects also emerged in at least some of the L2 processing studies which have reported similar morphological priming effects in L1 and L2 (Feldman et al., 2010; Diependaele et al., 2011). Heyer & Clahsen (2015) thus argue that, even though the L2 processing of complex words might indeed rely less on morphological decomposition and more on storage of full-word-form representations, L2 speakers might nevertheless still show priming effects for complex words. However, unlike for the L1 group, these priming effects are actually unrelated to morphological structure, and are instead orthographically mediated. Note, however, that the above-mentioned L2-specific difference between derived and inflected forms is difficult to explain along these lines, given that the degree of orthographic overlap between primes and targets was very similar for derived and inflected items in all three studies in which this difference emerged (Silva & Clahsen, 2008; Kırkıcı & Clahsen, 2013; Jacob et al., 2017). Also, at least some L2 processing studies have not found evidence for an L2-specific orthographic priming effect in their orthographic control conditions. For instance, in Jacob et al. (2017), L2 speakers showed significant priming for derived nominalisations, but no such effect for morphologically unrelated items in which primes and targets shared the same number of letters as in the derived condition.

Conclusion

In sum, the morphological priming paradigm represents a highly informative tool to study the mechanisms involved in the processing of complex words in bilinguals. The paradigm is suitable for comparisons between different morphological phenomena (such as derivation vs. inflection or regular vs. irregular inflected forms), and allows direct comparisons between these. Also, morphological priming effects can, at least in principle, be compared across different subject groups, even when these groups differ with regard to overall mean reaction times or the amount of variation in the data. While previous morphological priming studies have considerably increased our understanding of morphological processing in L2 speakers, a lot of open questions remain. For instance, the role of language-specific properties (such as whether an L2 is fusional or agglutinating) and properties of the individual (such as age of acquision onset, L2 proficiency, or L1 background) is so far not fully understood. Also, only relatively few studies have so far directly compared the processing of different morphological phenomena (such as derivation vs. inflection). In this respect, the field offers rich possiblities for future research.

References

Baayen, H. R. (2007). Storage and computation in the mental lexicon. In: Jarema, G., & Libben, G. (Eds.), *The Mental Lexicon: Core Perspectives*, Elsevier, 81–104.

Basnight-Brown, D. M., Chen, L., Hua, S., Kostić, A., & Feldman, L. B. (2007). Monolingual and Bilingual Recognition of Regular and Irregular English Verbs: Sensitivity to Form Similarity Varies with First Language

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Experience. *Journal of memory and language, 57(1)*: 65–80.

Clahsen, H., & Neubauer, K. (2010). Morphology, frequency, and the processing of derived words in native and nonnative speakers. *Lingua, 120,* 2627–2637.

Coughlin, C. E., & Tremblay, A. (2014). Morphological decomposition in native and non-native French speakers. *Bilingualism: Language & Cognition*, doi: 10.1017/S1366728914000200.

De Grauwe, S., Lemhöfer, K., Willems, R. M., & Schriefers, H. (2014). L2 speakers decompose morphologically complex verbs: fMRI evidence from priming of transparent derived verbs. *Front. Hum. Neurosci. 8*:802. doi: 10.3389/fnhum.2014.00802

Diependaele, K., Duñabeitia, J.A., Morris, J., & Keuleers, E. (2011). Fast morphological effects in first and second language word recognition. *Journal of Memory and Language, 64,* 344–358.

Feldman, L. B., Kostić, A., Basnight-Brown, D. M., Filipović Đurđević, D., & Pastizzo, M. J. (2010). Morphological facilitation for regular and irregular verb formations in native and nonnative speakers: Little evidence for two distinct mechanisms. *Bilingualism: Language and Cognition, 13,* 119–135.

Foote, R. (2015). The storage and processing of morphologically complex words in L2 Spanish. *Studies in Second Language Acquisition*, 2015, 1–33.

Gor, K., & Cook, S. (2010). Non-native processing of verbal morphology: In search of regularity. *Language Learning, 60.1*, 88–126.

Gor, K., & Jackson, S. (2013). Morphological decomposition and lexical access in a native and second language: A nesting doll effect. *Language and Cognitive Processes, 28.7*, 1065–1091.

Heyer, V., & Clahsen, H. (2015). Late bilinguals see a scan in scanner AND in scandal: Dissecting formal overlap from morphological priming in the processing of derived words. *Bilingualism: Language and Cognition, 18,* 543–550.

Jacob, G., Heyer, V., & Veríssimo, J. (2017). Aiming at the same target: A masked priming study directly comparing derivation and inflection in the second language. *International Journal of Bilingualism*. https://doi.org/10.1177/1367006916688333

Jacob, G., Fleischhauer, E., & Clahsen, H. (2013). Allomorphy and affixation in morphological processing: A cross-modal priming study with late bilinguals. *Bilingualism: Language and Cognition*, *16*, 924–933.

Jacob, G., & Kırkıcı, B. (2016). The processing of morphologically complex words in a specific speaker group: A masked-priming study with Turkish heritage speakers. *The Mental Lexicon, 11, 2*, 308–328.

Kırkıcı, B., & Clahsen, H. (2013). Inflection and derivation in native and non-native language processing: Masked priming experiments on Turkish. *Bilingualism: Language and Cognition, 16,* 776–794.

Longtin, C.-M., Segui, J., & Hallé, P. A. (2003). Morphological priming without morphological relationship. *Language and Cognitive Processes, 18,* 313–334.

Marslen-Wilson, W. D. (2007). Morphological processes in language comprehension. In: G. Gaskel (Ed.). *The Oxford handbook of psycholinguistics* (pp. 175–193). Oxford: Oxford University Press.

Marslen-Wilson, W.D., Bozic, M., & Randall, B. (2008). "Early decomposition in visual word recognition: Dissociating morphology, form, and meaning." *Language and Cognitive Processes, 23(3)*, 394–421.

Meunier, F., & Longtin, C. M. (2007). Morphological decomposition and semantic integration in word processing. *Journal of Memory and Language, 56,* 457–471.

Neubauer, K., & Clahsen, H. (2009). Decomposition of inflected words in a second language: An experimental study of German participles. *Studies in Second Language Acquisition, 31,* 403–435.

Rastle, K., Davis, M.H., & New, B. (2004). The broth in my brother's brothel: Morpho-orthographic segmentation in visual word recognition. *Psychonomic Bulletin & Review, 11,* 1090–1098.

Rastle, K., Davis, M. D., Marslen-Wilson, W. D., & Tyler, L. K. (2000). Morphological and semantic effects in visual word recognition: A time-course study. Language and Cognitive Processes*, 15,* 407–437.

Raveh, M., & Rueckl, J. G. (2000). Equivalent effects of inflected and derived primes: Long- term morphological priming in fragment completion and lexical decision. *Journal of Memory and Language, 42,* 103–119.

Rueckl, J. G., & Aicher, K.A. (2008). Are CORNER and BROTHER morphologically complex? Not in the long term. *Language and Cognitive Processes, 23,* 972–1001.

Silva, R., & Clahsen, H. (2008). Morphologically complex words in L1 and L2 processing: Evidence from masked priming experiments in English. *Bilingualism: Language and Cognition, 11,* 245–260.

Stanners, R. F., Neiser, J. J., Hernon, W. P., & Hall, R. (1979). Memory representation for morphologically related words. *Journal of Verbal Learning and Verbal Behavior, 18(4)*, 399–412.

Stockall, L., & Marantz, A. (2006). A single route, full decomposition model of morphological complexity: MEG evidence. *The Mental Lexicon, 1:1*.

Voga, M., Anastassiadis-Symeonidis, A., & Giraudo, H. (2014). Does morphology play a role in L2 processing? Two masked priming experiments with Greek speakers of ESL. *Lingvisticae Investigationes 37,* 338–352.