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Cross-linguistic perspectives on morphological processing: An introduction

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The appreciation that morphological factors are essential building blocks in any model of lexical organisation is now widely accepted. Morphological structure is a necessary component in natural languages. It introduces into a language, elements of complexity as well as factors of redundancy. From an historical perspective, the classical models of visual word recognition that were laid out two or three decades ago, regarded lexical processing as an interplay between orthographic, phonological, and semantic information (e.g., Forster, 1976; Morton, 1969; Seidenberg & McClelland, 1989; and see Frost, 1998, for a review). Interestingly, the study of morphology has evolved in parallel to these models with few attempts to generate a general theory of word recognition that takes morphological structure into account. One important motivation for pursuing such a theory stems from the abundant research conducted in different languages. Morphological complexity is created in different languages according to different principles. Thus, our models of representation, storage and processing of words in a language should be tuned to these principles.

It is in this perspective that a group of researchers investigating morphological processing were brought together in the summer of 1999 for a workshop in Aix-en-Provence, France. The theme of this workshop was "Cross-Linguistic Perspectives on Morphological Processing". The papers presented in the workshop, which form the basis for the present special issue, brought evidence from Hebrew, French, Italian, Spanish, Catalan, Dutch, German, Finnish, Chinese, and English. We mention English last

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for the purpose of making a point that is not ideological but theoretical. For obvious reasons many if not most studies of morphological processing have been conducted in English (e.g., Fowler, Napps, & Feldman, 1985; Manelis & Tharp, 1977; Marslen-Wilson, Tyler, Waksler, & Older, 1994; Stanners, Neiser, Hernon, & Hall, 1979; Taft & Forster, 1975). Since these studies did provide us with important findings, the potential contribution of studies from other languages is not necessarily transparent. Although we naturally assume that all lexicons were created equal, have equal rights to be investigated, and that no single lexicon is more important or interesting than another, our workshop was not aimed at merely providing other descriptions of other lexical systems. Rather, we assumed that studies in other languages could produce converging or contrasting evidence that would allow the formulation of a more general theory of morphological processing; a theory that takes into account the specific characteristics of the orthography, phonology, and morphology of each language, and determines their implications for modelling the mental lexicon. Such a meta-theory should be able to predict systematic variations in morphological analyses given systematic variations in morphological structures.

One general theoretical stance represented in the aims of the Aix workshop is that models of word recognition should seek an "ecological" validity. Whether the perception of isolated words is concerned, whether they are presented in the visual or the auditory modality, whether those words are embedded in sentences or text, the mapping of cognitive events involved in their processing should depend on the linguistic environment of the native speaker. One important factor, which determines this linguistic environment, is the morphological structure of a language. As mentioned above, morphological complexity is created in different languages according to different principles. Some languages like Chinese or Vietnamese are monomorphemic, whereas languages like Spanish, English, or French are multimorphemic. In some languages like Turkish or Finnish, morphological elements are always appended to a base form to create inflections or derivations, and the morphemic units are always transparent to the reader. In contrast, in languages with nonconcatenated morphology such as Hebrew or Arabic, morphemic boundaries are not always transparent. In some languages, like English, morphological derivations often involve some phonological variations in the base form (e.g., steal-stealth), whereas in languages like Serbo-Croatian they do not. In languages like English, Italian, or Dutch, a potential morphemic unit, such as the stem *sharp* in English, is not only morphologically related to derived forms such as *sharpness* or *sharpened*, but is also semantically and phonologically related. Furthermore, for these languages it is very often the case that forms such as *sharp,* function not only as morphemes in complex forms, but are also free word-forms on their own account. In contrast, in languages like Hebrew or Arabic, the roots and word-pattern morphemes that compose a word are abstract entities and cannot appear on their own. Moreover, words derived from the same root morpheme do not necessarily overlap in meaning.

These are just a few examples of the rich variety in types of morphological structure across languages. Since all these structural contrasts could have implications for the salience of a word's morphemic components, and therefore for their analysis in the recognition process, researchers in the field of morphological processing could consider the various languages as well defined experimental conditions in which a native speaker operates for achieving optimal performance. Cross-linguistic research is seen, by this view, as providing a plethora of experimental manipulations which are necessary for understanding the general principles which guide lexical organization. Our special issue, thus, presents evidence from many languages having different morphological structures.

Yet another factor to be considered is the rich variety of experimental tasks that are used in this domain. Obviously, the theoretical conclusions concerning the role of morphology in lexical organisation should generalise across different experimental tasks. In this context, providing findings while using a rich array of experimental procedures enhances our confidence in the ecological validity of our theory. The papers described in the present volume offer a wide array of experimental procedures. The most common method for examining the role of morphemic units in word recognition involves priming. Typically, facilitation in processing a target word when preceded by a constituent morpheme or by an inflected or derived word (compared to when no such unit is presented in the prime), is taken as evidence that the morphemic unit that is shared between the prime and the target has been activated, thereby influencing processing of the target. Making this inference, however, is not completely straightforward, because priming between morphologically related words normally involves the partial repetition of form as well as semantic or grammatical information, and all of these features could determine the size of morphological effects. Disentangling the individual contribution of these components is crucial to the determination of how morphemic units are recognised and how they influence lexical access. Some of the papers in this special issue illustrate current attempts to do so within a language. This could also be done by systematically investigating different languages characterised by different degrees of overlap in orthographic, phonological, and semantic features, between morphologically related words. Over and above the use of priming techniques, our present volume presents a significant variety of experimental methods. It includes conscious priming at various SOAs, masked priming, the monitoring of simple lexical decision, speech production in picture naming, eye movement tracking, measuring parafoveal preview benefits, and last but not least, computer simulations in artificial languages.

The special issue comprises nine papers, which explore and investigate central issues in morphological processing. All papers involve the presentation of printed words, and therefore their conclusions are constrained to cognitive processes within the visual modality. The first paper by De Jong, Schreuder, and Baayen examines the morphological family size effect in Dutch. Since the essence of morphological productivity involves the creation of families of words through inflections, derivations or compounding, models of morphological representation need to provide a detailed description of how such immense redundancy in a language is represented and processed. Several frequency measures such as Surface and Base Frequency (e.g., Baayen, Dijkstra, & Schreuder, 1997), or Cumulative Root Frequency (Colé, Beauvillain, & Segui, 1989), have been reported to affect response latencies in visual lexical decision. De Jong and her colleagues report a series of experiments that investigate how the size of a morphological family affects lexical decisions. Their present paper charts the effect of morphological structure on the activation of family members, aiming at disentangling family frequency from family size, looking across word-class, verbs and nouns. The papers by Giraudo and Grainger, and Forster and Azuma, also touch on the issues of productivity and morphological family size.

Next follow two papers which use eye movement methodology. These papers address the question of morphological decomposition looking at two very different languages, Finnish and English. A major controversy in morphological theory concerns the decomposition of polymorphemic words into their morphemic constituents. Does the primary unit of analysis correspond to the surface word, or is it the base morpheme of complex words which serves as access units in the process of word recognition? Current opinion is moving towards a view that both types of lexical representation may exist simultaneously. However, the actual process by which a specific word is accessed is a function of various factors, such as the familiarity and frequency of the whole word, as well as the frequency of its morphological components (e.g., Caramazza, Laudanna, & Romani, 1988; Laudanna & Burani, 1985). Bertram, Hyönä, and Laine explore this question in Finnish. Their study focuses on inflections, as Finnish is a highly inflected language. The method of investigation is based on examining whether the base frequency or the surface frequency of words, affect patterns of eye movements in reading. This study provides converging evidence to previous results obtained in visual lexical decision (Bertram, Laine, Baayen, Schreuder, & Hyönä, 2000), and suggests that base frequency has a lagged effect in word recognition, whereas effects of surface frequency can be shown in both early and late phases of word perception. Thus, in Finnish, the full form of inflectional nouns becomes quickly available, whereas the morphologically decomposed form is available only later.

A similar experimental approach is adopted by Niswander, Pollatsek and Rayner who provide contrasting and converging results from English. Again, the logic of the investigation is straightforward: Target words differing in root frequency or whole-word frequency are embedded in sentences. Eye movement indices are monitored to examine whether they are affected by root frequency or whole-word frequency. Effects of root frequency suggest that morphological decomposition has occurred, whereas effects of whole-word frequency point to lexical access that is based on surface forms. The advantage of eye movement research in the study of morphological processing is two-fold. First, it reveals a window onto the processing of morphemically complex words during text reading as opposed to single word presentation, thereby enhancing the ecological validity of the results. Second, different eye movement indices like first fixation, second fixation, gaze duration, or spillovers provide information regarding both early and late phases of print processing. Niswander and her colleagues focus on the decomposition of derivations as well as inflections, and their analysis of the time course of decomposition provides an interesting contrast to the results obtained in Finnish by Bertram et al. Their findings suggest that both whole-word and root morphemes play a role in visual word processing.

The paper by Giraudo and Grainger investigates effects of prime word frequency and cumulative root frequency in masked morphological priming. These authors observed that increasing the surface frequency of morphologically related suffixed word primes, caused an increase in the size of morphological priming effects obtained with free root targets. In contrast, this study found no influence of the cumulative frequency of the root shared by prime and target on the size of priming effects. The authors argue, on the basis of these results, that morphemic representations are activated via whole-word representations during language comprehension in French, a theoretical position that Giraudo and Grainger refer to as a supralexical model of morphological representation. Such a position, developed to account for results obtained with French derivational morphology, would appear to be compatible with the results obtained in Finnish reported in the Special Issue by Bertram et al., mentioned above.

The paper by Plaut and Gonnerman stands out in its theoretical approach and methodology. Whereas most papers in the volume present what could be termed a localist view of the mental lexicon (e.g., Grainger & Jacobs, 1998), Plaut and Gonnerman offer a distributed connectionist approach to lexical structure. By this view, morphemic units are not explicitly represented, and morphological effects reflect the learned sensitivity of native speakers to the systematic correlation between the orthographic and phonological form of words and their meaning in a given language (e.g., Rueckl, Mikolonski, Raveh, Miner, & Mars, 1997; Seidenberg, 1987). Plaut and Gonnerman describe two computer simulations, in which two artificial languages are examined, one that is morphologically rich, and the other morphologically impoverished. The simulations explore the effect of semantic transparency in morphological priming, for words that are embedded in these two artificial languages. The results of these simulations provide an elegant explanation for cross-linguistic differences that emerge in the effects of semantic transparency.

The paper by Deutsch, Frost, Pollatsek, and Rayner explores Hebrew, a Semitic language characterised by nonconcatenated morphology. The experiments examine the role of the root morpheme during word recognition, by monitoring effects of parafoveal preview benefit. The presentation of information to the parafovea has characteristics that are similar to masked presentation. Indeed, the results reported by Deutsch and her colleagues converge with previous results in Hebrew using the masked priming paradigm (Frost, Forster, & Deutsch, 1997), and emphasise the role of the root morpheme in a Semitic language.

The next two papers by Rastle, Davis, Marslen-Wilson, and Tyler, and Forster and Azuma use the masked prime paradigm to investigate early automatic components of morphological processing in English. These papers deal more specifically with the thorny problem of separating out "pure" effects of morphology from effects of form and semantic overlap across prime and target that almost always covary with morphological overlap, at least in English. Rastle et al. manipulate the degree of semantic transparency across morphologically related primes and targets. Significant priming compared to an unrelated prime condition, was observed for both semantically transparent and semantically opaque pairs of morphologically related primes and targets at short (43 ms) prime exposures, while only semantically transparent pairs showed priming at longer prime exposures (72 and 230 ms). An interesting manipulation in the Rastle et al. study consisted of using prime-target pairs that overlap in form *and* meaning just as morphologically related pairs do, but without having any linguistically identifiable morphological relation. These special stimuli are found in portmanteau words (e.g., smog = smoke + fog) and phonaesthemes (e.g., glitter, glisten). No priming was found for this type of relation at the shortest prime durations, but effects appeared at the longest (230 ms) prime duration.

Forster and Azuma used primes and targets sharing bound stems in English (e.g., submit-permit) and compared priming effects observed in these conditions with priming from more semantically transparent morphological relations (e.g., fold-unfold). Priming effects were found for both types of relation and no significant difference was observed between them. Forster and Azuma's study also provides a potentially interesting means of separating out morphological effects from effects of form overlap across primes and targets. Changing the similarity of nonword targets to real words was shown to influence the size of form priming effects, while not affecting morphological priming in the masked prime paradigm with the lexical decision task. Taken together, the results of Forster and Azuma and Rastle et al. show that the masked priming paradigm with very brief prime exposure durations (40–50 ms) is sensitive to morphological overlap across primes and targets while being relatively insensitive to semantic and form overlap (at least for the degrees of overlap manipulated in these studies). Effects of morphology in these specific conditions, cannot be reduced to a simple summation of form and semantic priming.

Finally, the paper by Zwitserlood, Bölte, and Dohmes is the only one in the special issue to deal specifically with the role of morphological representations in language production. Zwitserlood et al. present an interesting means of isolating "pure" morphemic effects from form-level and semantic-level effects in speech production. The long-lag variant of the picture-word interference paradigm is shown to be insensitive to both semantic and phonological overlap across picture and word, while robust effects of morphological overlap are obtained independently of the type of morphological relation (inflection, derivation, or compound). Clearly, one major goal for research on human language processing is to provide a unified framework for understanding processes involved in perception and production. As mentioned by Zwitserlood et al., comparing results obtained with the classic paradigms used in the study of language comprehension with those obtained more recently in production paradigms is critical for the development of more general theories of morphological processing.

In conclusion, the papers appearing in this volume address important debates regarding morphological processing by examining a variety of languages and using different methodologies. However, all papers seem to illustrate one key point: that an important task for future cross-linguistic investigations of language processing will be to determine how the specific characteristics of a given language determine the architecture for lexical processing that users of that language have developed. At the intersection of orthographic, phonologic, and semantic coding, the study of morphology is likely to play a key role in this important enterprise.

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