Journal of Memory and Language 72 (2014) 59–84

Contents lists available at ScienceDirect

Journal of Memory and Language

journal homepage: www.elsevier.com/locate/jml

Effects of primary and secondary morphological family size in monolingual and bilingual word processing

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ARTICLE INFO

Article history:
Received 10 July 2012
revision received 25 December 2013
Available online 4 February 2014

Keywords:
Morphological family size
Cognates
Bilingual word processing
Discriminative learning

ABSTRACT

This study investigated primary and secondary morphological family size effects in monolingual and bilingual processing, combining experimentation with computational modeling. Family size effects were investigated in an English lexical decision task for Dutch–English bilinguals and English monolinguals using the same materials. To account for the possibility that family size effects may only show up in words that resemble words in the native language of the bilinguals, the materials included, in addition to purely English items, Dutch–English cognates (identical and non-identical in form). As expected, the monolingual data revealed facilitatory effects of English primary family size. Moreover, while the monolingual data did not show a main effect of cognate status, only form-identical cognates revealed an inhibitory effect of English secondary family size. The bilingual data showed stronger facilitation for identical cognates, but as for monolinguals, this effect was attenuated for words with a large secondary family size. In all, the Dutch–English primary and secondary family size effects in bilinguals were strikingly similar to those of monolinguals. Computational simulations suggest that the primary and secondary family size effects can be understood in terms of discriminative learning of the English lexicon.

Introduction

Reading a word is not just looking up this word in a dictionary. If it were that simple, word processing would be affected only by the number of words that share their beginnings and not by the word's more complex relationships to other words in the lexicon on dimensions such as orthographic or semantic relatedness. It turns out that during reading a word activates not only its own representation in the mental lexicon, but many other lexical representations as well, via a system of relationships that are not necessarily strictly word-form related. Words are not isolated units, but parts of larger networks. In the present study, we focus on the activation of morphological networks in the monolingual and bilingual mental lexicon during visual word processing.

Many behavioral and neurolinguistic studies have investigated the processing consequences of various relationships between words in the mental lexicon, with a great deal of attention directed towards orthographic relations between words (see Andrews, 1997, for an overview of studies on orthographic neighborhood size). Recently, research has also focused on morphological relationships between words in the lexicon. One of these morphological relationships, called 'morphological family size', is defined as the number of morphologically related complex words in which a given word occurs as a constituent (Schreuder & Baayen, 1997). For instance, *heartless* and *heartache* are

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http://dx.doi.org/10.1016/j.jml.2013.12.004

family members of the word *heart*. Words can differ considerably in their productivity in terms of the number of their morphological family members. For instance, the word *house* occurs in more than 30 morphologically related complex words (among which, for example, *house hold*, *garden house*, and *housing*), whereas the morphological family of *horizon* is restricted to only a few words (such as *horizontal*).

Schreuder and Baayen (1997) showed that Dutch words with larger morphological families were processed faster and more accurately in a Dutch visual lexical decision task than Dutch words with smaller morphological families. The facilitatory effect of family size has been replicated for Dutch (Bertram, Baayen, & Schreuder, 2000; De Jong, 2002; De Jong, Schreuder, & Baayen, 2000; Kuperman, Schreuder, Bertram, & Baayen, 2009), German (Lüdeling & De Jong, 2002), and English (Baayen, Lieber, & Schreuder, 1997; De Jong, Feldman, Schreuder, Pastizzo, & Baayen, 2002; Juhasz & Berkowitz, 2011). Moreover, several non-Germanic languages also revealed similar effects of family size (see Feldman & Siok, 1997, for Chinese; Kuperman, Bertram, & Baayen, 2008; Moscoso del Prado Martín, Bertram, Häikiö, Schreuder, & Baayen, 2003, for Finnish; Moscoso del Prado Martín et al., 2005, for Hebrew; Boudelaa & Marslen-Wilson, 2011, for Arabic). Importantly, the family size effect is observed to be predictive over and above other lexical properties such as word frequency, morpheme frequency, word length, orthographic neighborhood size, bigram frequency (De Jong et al., 2000; Schreuder & Baayen, 1997), and age of acquisition (De Jong, 2002).

The traditional interpretation of the morphological family size effect holds that upon reading a word, many of its morphological family members become activated thanks to shared orthography, morphology, and semantics (Schreuder & Baayen, 1997). More specifically, activation is assumed to spread from a target word to its family members via direct semantic and orthographic connections. Schreuder and Baayen (1997) proposed to understand the family size effect along the lines of the multiple read-out model of Grainger and Jacobs (1996): Words that co-activate many other words (lemmas) give rise to more global lexical activation supporting a positive lexicality decision. By means of a computational simulation study, De Jong, Schreuder, and Baayen (2003) showed that read-out of global activation may not be necessary if activation is allowed to resonate between forms, lemmas, and meanings.

An unresolved question is whether activation can spread beyond immediately related concepts to concepts that are only indirectly linked to a target word. Studies of mediated priming have demonstrated that a target word such as *cheese* can be processed faster when it is preceded by a prime such as *cat* that is only indirectly related to the target in semantic memory via a mediating concept (*mouse*) than when it is preceded by a semantically unrelated prime (e.g., *table*; cf. De Groot, 1983). Mediated priming effects were observed in word naming (Balota & Lorch, 1986), in a double lexical decision task in which a lexical decision to both the target and prime is required and in which only indirectly related prime–target pairs were used, and in a single presentation lexical decision task in which the prime and target were presented with no obvious pairing and a lexical decision was required to both items (McNamara & Altarriba, 1988). However, a number of studies failed to find the mediated priming effect in standard lexical decision (e.g., Balota & Lorch, 1986; Chwilla, Kolk, & Mulder, 2000). As Chwilla et al. (2000) argued, mediated priming seems to occur only when the lexicality of both the prime and the target needs to be judged. In sum, these studies show that activation can spread beyond directly related concepts, albeit only under special experimental conditions. Applying this idea of spreading of activation to the case of family size, it is conceivable that activation spreads from immediate family members, which are directly related to the target in form and meaning, to more distant family members at greater distances in the lexical network, i.e., to words that are related to the target word only via their primary family members.

Recent studies (Baayen, 2010a, and Baayen, Milin, Filipovic Durdjevic, Hendrix, & Marelli, 2011) indicate that more distant morphological relatives can influence compound processing. These studies propose a new measure, the secondary family size, as a means for gauging the relevance of more distant morphological relatives. Recall that the primary family size of a given noun contains all words, both derived words and compounds (except the noun itself) that contain that noun as a constituent. Baayen (2010b) and Baayen et al. (2011) argued that although the primary family size is defined across both derived words and compound words, most of a given word's family members are compounds. In these studies, the secondary family measure was therefore operationalized on the set of compounds, and was further restricted to family members that are two-constituent compounds. In the present study, the focus is on the processing of mono-morphemic words, and hence, a definition of secondary family including both compounds and derivations is applied. Informally, the secondary family size of a word can be defined as including all words that share a constituent with a word in a word's primary family, excluding the primary family members themselves (for a formal definition of secondary family size, see the Appendix). Fig. 1 presents a schematic representation of the activation of primary and secondary family members of the target word *horse*.

If activation spreads from a target word, first into the primary family, and then on into the secondary family, the question arises whether the co-activation of secondary family members is facilitatory (just like the primary family size) or rather inhibitory. Theories restricting primary and secondary family size effects to the level of word form offer no prediction. Because activating primary family member word forms is facilitatory in lexical decision, activating even more word forms might also speed up 'yes' responses in this task. Alternatively, it is conceivable that activating many orthographically unrelated word forms (such as *hairbrush* for *horse*) would, due to feedback connections, reduce the bottom-up support from the letter layer to the word layer for the target word. For instance, the *h* and *r* in *horse* might become, due to spreading activation, more ambiguous between *horse* and *hairbrush*, and would therefore delay lexicality decisions.