Are morphological effects modulated by semantic similarity? A study of priming in Quebec French

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Abstract

Graded effects in morphological processing have been shown in lexical decision tasks in English (e.g., Gonnerman et al., 2007; Quémart et al., 2017). However, most studies in other languages support a decomposition view of the processing of complex words (e.g., Longtin and Meunier, 2005). To determine whether graded priming effects for morphologically complex words can be found in other languages, Quebec French speakers participated in a cross-modal lexical decision task in which auditory primes varied in degree of semantic similarity with visual targets (*e.g., bergerie-berge; infirmerie-infirme; fromagerie-fromage*). Results indicate that morphological priming requires the prime and target to be both semantically and phonologically similar, with semantic similarity modulating priming effects in morphologically related words. This pattern of results is similar to graded morphological priming previously reported for English and supports an emergentist view of morphological processing (Gonnerman et al., 2007).

Keywords: Morphology; priming; French; semantic similarity; psycholinguistics.

Introduction

In many languages, words overlap in form and meaning and these regularities are often encoded as morphemes. Typically, morphemes are known as the smallest units of language which contain meaning. For example, the complex word *painter* can be broken down into two morphemes, the root, *paint*, and the agentive suffix, *er*. When these morphemes are combined to form the word *painter*, the meaning of the complex word can be determined based on the meanings of its parts. The impact of the morphological structure of a word on processing is not always this straightforward, however. Take the words *painter*, *walker*, and *dreamer*, for example. These three words all contain the agentive suffix *–er* added to the roots *paint*, *walk*, and, *dream*. But what about words such as *archer* and *carpenter*, which both seem similar to the other three words containing the agentive suffix *–er*. The word *carpenter* cannot be broken down into constituent morphemes because *carpent* bears no meaning in English. Furthermore, words like *archer* can be broken down to constituent morphemes *arch* and *–er*, but the meaning of *arch* does not contribute to the meaning of *archer* in the same way that *walk* relates to *walker*. Morphological processing theories therefore need to account for all words, not only for the clear cases of transparent morphemes.

Morphological priming effects have been observed in a number of studies (e.g., Frost, Forster, & Deutsch, 1997; Gonnerman, Seidenberg, & Andersen, 2007; Grainger, Cole, & Segui, 1991; McCormick, Rastle, & Davis, 2008; Smolka, Preller, & Eulitz, 2014). While there is little question that these effects exist, the question of why morphological effects arise persists. One school of thought is that discrete morphological representations lead to morphological processing effects (e.g., Baayen, Feldman, & Schreuder, 2006), another suggests that morphological effects arise from an interaction between semantic and orthographic or phonological similarity (Seidenberg & Gonnerman, 2000, Gonnerman et al., 2007). In examining morphological processing, several lexical characteristics have been identified that contribute to the presence of morphological priming effects, including frequency, semantic factors, and formal factors (see Amenta and Crepaldi (2012) for an overview), but as yet no single model of morphological processing has been agreed upon.

The idea that morphemes are represented in memory as individual components is called the lexical decomposition hypothesis (Taft & Forster, 1975). According to this theory, words are stored in memory as their component morphemes, and in order to comprehend a word it must be decomposed into its component morphemes. This theory accounts for the ability to form new words out of the morphemes that already exist in the lexicon. While the exact process of decomposition is debated (Amenta & Crepaldi, 2012), morphological decomposition has been shown to be an early, automatic process by many researchers using behavioural and ERP techniques (e.g., Beyersmann, Castles, & Coltheart, 2011; Lavric, Clapp, & Rastle, 2007).

One alternative to the lexical decomposition theory is an emergentist approach which posits that morphological effects arise from the regularities in interactions between form and meaning (Gonnerman et al., 2007; McClelland et al., 2010; Seidenberg & Gonnerman, 2000). This theory argues that networks of sound, spelling, and meaning units exist and connections between them are involved in the use of language (comprehension and production). Morphology then arises from the regularity across words in the relationships between form and meaning. The weight of the mapping between units can account for clearly defined morphemes like *walk* in *walker* or the less clear example of

carpenter. Based on this approach, morphological effects should be graded based on the weight of the interaction between form and meaning.

Semantic similarity has been found to play an important role in morphological priming in multiple studies (Chateau, Knudsen, & Jared, 2002; Drews & Zwitserlood, 1995; Marslen-Wilson et al., 1994; Rastle & Davis, 2008). Semantic similarity is treated as a binary variable in most studies. The words selected are coded as either semantically related or unrelated. Gonnerman et al. (2007) treated semantic similarity as a continuous variable by obtaining semantic similarity ratings for the word pairs used in a cross-modal morphological priming study. By varying semantic similarity in morphologically related pairs, the emergentist approach can be tested as priming effects are predicted to be influenced by the magnitude of semantic similarity. Gonnerman et al. (2007) did in fact find a correlation between semantic similarity rating and priming magnitude, lending support to the connectionist approach.

Studies of morphological processing have dealt mostly with English, although more languages have been explored in recent years (e.g., de Oliveira and dos Reis Justi, 2017; Carlson and Gerfen, 2017). Some studies have examined the nature of morphological effects in adult French speakers (e.g., Beyersmann, Cavalli, Casalis, & Cole, 2016; Cavalli et al., 2016; Giraudo & Grainger, 2000; Giraudo & Voga, 2016; Giraudo, 2005; Longtin & Meunier, 2005; Longtin, Segui, & Halle, 2003; Meunier & Segui, 2002). However, among those studies, none has searched for graded morphological priming effects to determine whether a connectionist account of processing is viable; generally, a decomposition account of morphological processing has been assumed (cf. Diependaele and Grainger, 2005; Meunier and Longtin, 2007). French morphological representations may lead to greater facilitation in conditions with less semantic overlap than would be found in English as the French language is more morphologically regular.

The Present Study

The present study examines whether French speakers display the same graded morphological priming effects as English speakers (Gonnerman et al., 2007). To test this hypothesis, stimuli were selected with morphologically related word pairs ranging from low to high semantic similarity. These word pairs contain a complex prime composed of a stem and a derivational suffix, and a target composed of the stem alone (*e.g., chanceux - chance*). The magnitude of priming effects is predicted to be positively related to the degree of semantic similarity of the word pairs. Two additional conditions were examined with pairs related in form only (*barbecue – barbe*) and meaning only (*chandelle – bougie*). Priming effects in these conditions were added to confirm that an overlap in form alone or meaning alone is not sufficient to elicit a priming effect.

This experiment involves a lexical decision task with cross-modal priming. Lexical decisions were used as they elicit a response that requires the participant to access the meaning of the word. A cross-modal priming paradigm was chosen to reduce visual repetition. This paradigm also allowed for comparison with Experiment 1 from Gonnerman et al. (2007).

Method

Participants

Thirty-eight native French speaking adults from the McGill University and University of Montreal communities participated in this study. Participants had a mean age of 30.6 years and included 27 women and 12 men.

Materials

70 prime-target pairs were selected as test items for this study. These word pairs were selected to fit into 5 conditions containing 14 pairs each. The form only condition includes prime-target pairs that overlap in phonology but are not related semantically (*e.g., barbecue – barbe*), the prime does not end with a suffix. The low semantic condition is similar to the first group as the prime-target pairs that overlap in phonology but are not related semantically, but the prime ends in a suffix (*e.g., tortueux – tortue*). The mid semantic condition pairs overlap phonologically, and the primes end in a suffix; they were chosen to have a moderate amount of semantic overlap (*e.g., infirmerie – infirme*). The high semantic condition pairs overlap phonologically and the prime ends in a suffix; these pairs were chosen to have high semantic similarity (*e.g., chanceux - chance*). All pairs in the low mid and high semantic conditions are morphologically related, with the primes ending in a variety of derivational suffixes. The semantic only condition pairs were chosen to have high semantic similarity but do not overlap phonologically (*e.g., chandelle – bougie*). For each test pair, a control pair was created with the same target word and an unrelated prime word. The control primes were matched with the test primes on both word frequency and number of syllables to minimize the effect of those factors on reaction time. Control pairs had no semantic or phonological overlap between the prime and the target. See Table 1 for sample items from each condition.

As this experiment was conducted in Montreal, all items were selected to be matched for phonological similarity in Quebec French, with primes and targets varying only in the addition of the stems. Auditory primes were recorded by a native Quebec French speaker.

A subset of the participants who participated in this study also rated each test pair on semantic similarity. Each prime-target pair was rated on a scale of 1 (unrelated) to 7 (highly related). Participants were presented with three practice word pairs to rate and told that they were allowed to use the whole scale when evaluating the word pairs. Feedback was given for the practice items to ensure that participants understood the instructions prior to beginning the task. Mean similarity ratings for each pair type are shown in

Table 1: Prime – target pair types with example items and mean semantic similarity ratings of the target and the related prime out of 7 (1 = not similar; 7= highly similar)

		Primes		Semantic similarity rating	
Condition	Target	Related	Unrelated	M	SD
Form only	*barbe*	*barbecue*	*cornichon*	1.06	.11
Low semantic	*tortue*	*tortueux*	*esthetique*	1.39	.26
Mid semantic	*infirme*	*infirmerie*	*grenadine*	3.70	.77
High semantic	*chance*	*chanceux*	*discret*	5.53	.24
Semantic only	*bougie*	*chandelle*	*cactus*	6.28	.43

Table 1. Using the semantic similarity scores, the condition placement of each item was validated. Results of the semantic similarity test showed that items in the form only and low semantic categories had ratings below 2. The mid semantic category had ratings between 2 and 5, the high semantic and semantic only categories had ratings above 5.

Only one pair was moved to a different group based on the mean semantic similarity rating it received. The pair *pommette - pomme* originally selected for the high semantic group was moved to the mid semantic group due to a mean semantic similarity rating of 2.9.

In addition to the 70 test pairs and 70 control pairs, 70 filler pairs were created. These pairs had non-word targets. While these pairs contained non-words, they were created to resemble the test pairs. Some of the fillers were phonologically related (*e.g., buveur – buve*), and others were not (*e.g., terminus – clige*). Some phonologically overlapping filler items like *esprit - espe* mirrored those in the form only condition (*e.g., barbecue – barbe*); in both of these cases there is no sequence that could act as a suffix at the end of the prime. Other phonologically related filler items such as *frileux – frile* are similar to the low semantic items (*e.g., tortueux – tortue);* both of these primes end with a sequence that could function as a suffix in other words (*e.g., chanceux – chance*). To ensure that participants did not learn to respond to all phonologically overlapping or suffix-containing pairs as members of the French language, for example, the proportion of filler items that overlapped in formal similarity matched that of the real word pairs.

To limit order effects, four presentation orders were created. First, the real word pairs were separated into two lists; the first list contained half of the control-prime pairs and half of the test-prime pairs for a total of 70 items. The second list contained the remaining 70 real word pairs. To each of these lists, the 70 filler pairs were added. Both of these lists were put into two pseudorandom orders, creating a total of four lists, with 140 items in each list.

Procedure

A lexical decision task with cross-modal priming was conducted. This task requires participants to answer "yes" if the target is in fact a word that exists in the French language, or answer "no" if the word does not exist in French. The lexical decision task was administered to participants individually, in a quiet room. During the task, participants sat in front of a Macintosh computer, on which stimuli were presented via PsyScope software (Cohen, MacWhinney, Flatt, & Provost, 1993). The audio primes were played on speakers placed in front of the participant. Responses to the lexical decision task were indicated by pressing a button on a button box placed on the table in front of the participant.

Before beginning the experiment, participants were instructed to respond to the lexical decision task by indicating their decision on the button box. A series of practice items were presented first and the participant was given the opportunity to ask questions about the instructions before beginning the test trials. Participants were instructed to attend to the auditory primes. Attention to the primes was tested by periodically presenting the on-screen instruction to "repeat what you just heard"; those responses were recorded by the experimenter.

At the beginning of each trial, three asterisks appeared in the center of the screen as a fixation mark for 1 second. The auditory prime then played over the speakers. At the offset of the audio prime, the target appeared on the screen for 200 ms at which point the participant would respond using the button box. Once the response was recorded, there was a delay of 500 ms before the onset of the next trial.

Results and Discussion

All analyses were conducted using R version 3.2.2 (R core team, 2017). Accuracy rates were calculated for each participant and each item. All participants had accuracy rates greater than 90% on the lexical decision task and all items were answered above chance.

For analysis of priming effects, trials with incorrect responses making up 2.3% of the data were removed. Reaction times were then trimmed using the R package trimr version 1.0.1 (Grange, 2015). Trials on which the reaction time was greater than 2 standard deviations above the mean reaction time in each category were discarded resulting in 4.5% of the data being removed. Reaction times were log transformed to correct for positive skew.

Linear mixed-effect modelling (Baayen, 2008; Baayen, Davidson, & Bates, 2008) was used to perform analyses. A backward stepwise model procedure was used to determine whether fixed and random effects should be retained in the final models. The first model included 2 random effects factors: random intercepts for participants and items, 2 fixed effects factors: prime type (related or unrelated), and condition (phonological, low semantic, mid semantic, high

Table 2: Mean reaction times on lexical decision task and mean priming effects (difference between control and test reaction time) for each condition.

		Unrelated rt (ms)		Related rt (ms)		
Condition	Example word pair	M	SD	M	SD	Mean priming effect (ms)
Form only	*barbecue – barbe*	678	140	705	164	-27
Low semantic	*tortueux – tortue*	692	166	671	160	21
Mid semantic	*infirmerie – infirme*	672	141	634	142	39*
High semantic	*chanceux – chance*	662	137	618	141	44*
Semantic only	*chandelle – bougie*	619	107	607	115	12

* = $p < .05$

semantic, and synonyms), and the interaction between prime type and condition. Significance of the fixed effects was established by examining *t*-values and *p*-values obtained using the lmerTest package (Kuznetsova, Brockhoff, & Christensen, 2017).

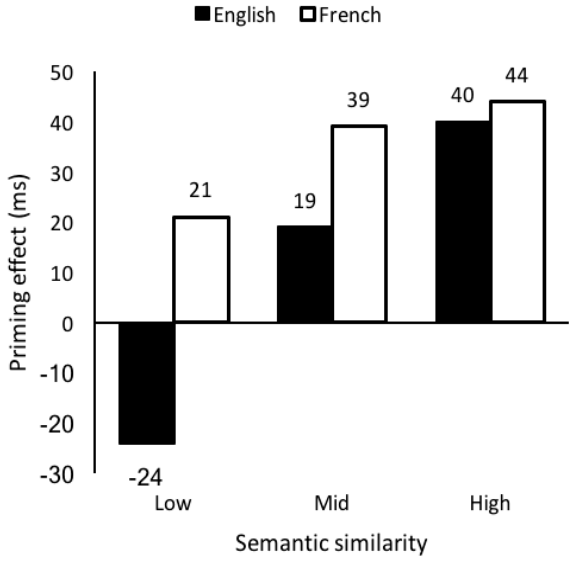

Figure 1. Comparison of the mean priming effects (difference between the reaction time of the unrelated pairs and the related pairs) from Englllish participants (Gonnerman et al., 2007) and the French participants from the present study. Mean priming effects are reported for the morphologically related items in the low (t*ortueux – tortue; hardly – hard*), mid (*infirmerie – infirme; lately – late*) and high (*chanceux – chance; boldly – bold*) semantic similarity conditions.

Pairwise comparisons were obtained by releveling the model with each of the five conditions as the baseline in order to determine whether the effect of prime type was significant in each condition. See Table 2 for mean reaction times and priming effects in each condition. There was no significant priming effect in the form only condition (t = 1.3, p = 0.18) or the low semantic condition (t = 1.88, p = 0.06). Significant priming effects were found in the mid semantic (t = 4.20, $p < 0.001$) and high semantic (t = 4.21, $p < 0.001$) conditions. The semantic only condition did not lead to significant priming effects (t = 1.46, p = 0.14). Results only revealed priming effects in the mid semantic (*infirmerie-infirme*) high semantic (*chanceux-chance*) conditions only. This indicated that for morphological priming to occur, the prime and target must overlap in both form and meaning. In this experiment, neither high semantic nor high phonological overlap alone are sufficient to induce facilitation effects. Of greatest interest were the morphologically related items in the low, mid, and high semantic conditions as these were expected to reveal different magnitudes of priming as were found in Gonnerman et al., (2007). These priming effects are compared in Figure 1 which plots the results of English participants in Gonnerman eta al. (2007) to those of the French participants from this study. Overall, these results show that the magnitude of priming is greatest in the high semantic condition, with a lower magnitude of priming in the mid semantic condition; neither priming effect is significant in the low semantic condition.

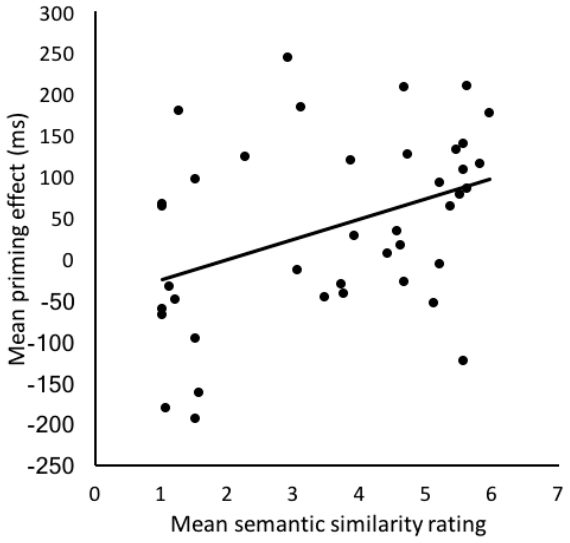

Figure 2. Relationship between the mean priming effects (difference between the reaction time of the unrelated pairs and the related pairs) of morphologically related prime-target pairs and their mean semantic similarity ratings (1 = not similar; 7= highly similar).

A second model was specified to confirm whether the magnitude of priming is influenced by the semantic similarity of the prime-target pairs. For this analysis, only the morphologically related words from the low, mid, and high semantic conditions were included. In these conditions, the degree of phonological overlap was consistent and the degree of semantic similarity varied. This model included 2 random effects factors: random intercepts for participants and items, 2 fixed effects: prime type (related or unrelated), and semantic similarity (mean ratings on a scale of 1 to 7) as well as the interaction between prime type and semantic similarity. The effect of interest, the interaction between prime type and semantic similarity, was significant (t = 2.26, $p < 0.05$). See Figure 2 for the mean priming effect of each morphologically related word pair plotted against semantic similarity. This result indicates that the magnitude of priming for the morphologically related items (from the low mid and high semantic conditions) is influenced by the semantic similarity of each pair which is in line with the findings of Gonnerman et al. (2007).

Conclusion

The goal of this study was to determine whether semantically graded morphological priming effects could be shown in Quebec French, as would be predicted by the emergentist view of morphological processing. Research in English has demonstrated graded priming effects for morphologically related words which vary in semantic similarity (Gonnerman et al, 2007), but no such results have been reported in French, a morphologically richer language.

To answer this question, stimuli were carefully selected for use in a lexical decision task with cross-modal priming. Morphologically related word pairs were selected to have the same level of phonological similarity, but to vary in semantic similarity which was evaluated by participant ratings. The morphologically related pairs belonged to three conditions: low semantic (*tortueux – tortue*), mid semantic (*infirmerie – infirme*) and high semantic (*chanceux – chance*) depending on degree of semantic similarity. Two additional conditions contained pairs related in form only (*barbecue – barbe*) and meaning only (*chandelle – bougie*). These items allowed for the detection of graded priming effects as were found by Gonnerman et al. (2007).

The results of this experiment reveal that morphological priming of Quebec French words only occurs when the prime is related to the target in both form and meaning. Neither form nor meaning alone are sufficient to elicit facilitation effects. Crucially, morphologically related words exhibit graded priming effects. The magnitude of the priming effects is modulated by the degree of semantic similarity of the prime-target pair.

These results can be accounted for by an emergentist approach to lexical processing in which representations of form and meaning are distributed across neuron-like processing units. According to this account, morphology emerges from systematic regularities of form and meaning encoded as inter-level representations. The graded priming effects measured here reflect the degree of semantic similarity among morphologically related words.

Acknowledgments

Funding for this project was provided by the Fonds de recherche du Québec – Société et culture (FRQSC) and the Centre for Research on Brain, Language and Music (CRBLM).

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