Irregularity *and* decomposability of inflected verbal forms

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In this article we investigated the issue of stem representations of French inflected verbs in the lexicon by the means of a lexical decision task and the manipulation of the cumulative and surface frequencies. Briefly stated, there are two major psycholinguistic hypotheses about the representation of polymorphemic words in the mental lexicon. Some models postulate that morphology is not explicitly represented in the lexicon. This is for example the case of the whole-word representation hypothesis (e.g. Butterworth, 1983; Manelis & Tharp, 1977), which posits that all words have a unitary representation that does not take into account their internal morphological structure. This class of models also includes connectionist models, in which morphology is not represented *per se*, but rather in terms of weighted connections between distributed whole-word orthographic, phonological and semantic representations (e.g. Rumelhart & McClelland, 1986; Seidenberg & McClelland, 1989; Sereno & Jongman, 1997). Words belonging to the same morphological family tend to share some or much of their orthographic and phonological forms, as well as their semantics. Models with whole word representations capture this regularity by postulating (or implementing learning algorithms that lead to) links that are stronger between the representations of these related words than between words that are solely orthographically or phonologically related. The alternative models postulate morpheme-decomposed representations. In this type of models, polymorphemic words are stored in the lexicon in terms of their morphemic constituents (Taft & Forster, 1975). Morphology is explicitly represented in the sense that access to a word like *painter* is mediated by the activation of the stem representation for *paint-* and the suffix representation for *-er*. Consequently, polymorphemic words do not have their own lexical entry; rather, they share a stem representation with all the words from the same morphological family.

One profitable experimental method to test these contrastive hypotheses has been to measure the influence of the frequency of the representations postulated by the different models on polymorphemic word recognition, as measured for instance in the classic lexical decision task. The frequency of whole-word representations, referred to as *surface frequency*, is

defined as the word's frequency of occurrence as a free-standing lexical item. The frequency of a morphological component such as the stem can be defined as the sum of the frequencies of all the affixed words that carry that stem (e.g. for the stem *paint*: the surface frequency of *paint* + the surface frequency of *painter* + the surface frequency of *unpainted* + etc). This measure, referred to as *cumulative frequency*, captures the hypothesis that each time a morphologically complex word comprising the stem is used, the stem representation is activated. The manipulation of these variables in a lexical decision paradigm allows testing the role played by whole-word and stem representations during the recognition of polymorphemic words.

Using priming paradigm it has been shown that English *regular* inflected verb form primes the recognition of its stem (e.g., *walked* - *walk*). By contrast, no priming effect (or a priming significantly smaller than that obtained in the case of regular verbs) is observed between *irregular* inflected forms and their stem (e.g., *drove* - *drive*; see for example Kempley & Morton, 1982; Napps, 1989; Stanners, Neiser, Hernon, & Hall, 1979). This result has also been interpreted as evidence for a decomposition procedure of the prime, a procedure that would only operate with regular forms. In this interpretation, processing the prime *walked* leads to its decomposition and to the activation of the stem *walk.* In the case of English irregular verb forms, no priming effect is observed, thus no decompositional procedure is hypothesized. This interpretation suggests that lexical access for irregular verbs can only be achieved through their whole-word representation. In French, Meunier and Marslen-Wilson (2004) reported two verbal priming experiments in French, one involving masked priming and the other cross-modal priming. In masked priming, the prime is presented visually for a very brief duration followed by a pattern mask (e.g. random alphanumeric characters). In this situation, the prime word is not consciously detected by the participants (Forster & Davis, 1984; Forster, 1998). In cross-modal priming, the prime is presented auditorily while the target is presented visually (see for example Marslen-Wilson, Tyler, Waksler & Older, 1994). Meunier and Marslen-Wilson (2004) reported results that were rather different from the English results described above (see also Orsolini & Marslen-Wilson, 1997, for similar results in Italian, a Romance language that has an inflectional system close to French). They found similar priming effects across regular, irregular, and morpho-phonological verb targets. In other words, the priming observed between irregular pairs such as *buvais* – *boire* ('you drunk' – 'to drink') and morpho-phonological pairs such as *sèment* – *semer* ('they sow' – 'to sow') did

not differ from the priming observed between regular pairs such as *mangeons* – *manger* ('we eat' – 'to eat').

The priming effect observed in French with the regular class of verbs can be explained with the same rationale that was used to account for the results observed with English regular verbs. Following Marslen-Wilson and Zhou (1999), the priming effect observed with the morpho-phonological class of verbs can be explained with the hypothesis that the stem alternations of the morpho-phonological variants of a verb share an abstract representation. By contrast, the priming effect observed for irregular verbs is more difficult to account for. This is because the stem included in a prime like *buvais* overlaps only minimally with the target *boire*. Thus if *buvais* is decomposed, the remaining stem *buv-* do not overlap with the target stem *boir-* as in the case of regular verbs (e.g. *mangeons* – *manger*). Consequently, the representation of irregular verbs in French remains unresolved.

In the experiments reported, we attempted to clarify the representation of French verb stems. To address this issue, we used a simple lexical decision task where we manipulated the surface and the cumulative frequencies of the verbs.

We began by testing regular verbs which have only one stem. We manipulated the cumulative frequency effect by selecting pairs of verb forms that have similar surface frequencies but whose stems have different cumulative stem frequencies (for example *mangeas* 'you have eaten' and *grimperas* 'you will climb' have the same surface frequency but different cumulative frequencies). We also manipulated the surface frequency. We expected to observe a cumulative frequency effect. In the logic developed earlier, such effect would be suggestive of stem activation during the processing the inflected verb forms.

In the second experiment, we investigated the morpho-phonological class of verbs, to test whether allomorphic variants activate an underspecified stem (following Marslen-Wilson and Zhou, 1999). For this purpose, we selected verbs whose two surface forms were contrasted in cumulative stem frequency. For example, the two stems of the verb *semer* have respectively a high cumulative frequency (*sem-*) and a low cumulative frequency (*sèm-*). We contrasted verb forms that had low cumulative frequency and were contrasted on surface frequency (e.g. *sème* vs. *sèmerai*), as well verb forms that had high cumulative frequency and were contrasted on surface frequency (e.g. *semais* vs. *semée*). If representations are shared and phonologically underspecified, no cumulative frequency effect should be observed. By contrast, if the two variations of the stem have distinct representations, we predict a cumulative frequency effect similar to that predicted for regular verbs.

Finally, we tested the irregular class of verbs. For this purpose, we selected verbs whose two idiosyncratic stems were contrasted in cumulative frequency. For example the two stems of the verb *boire* have respectively a high cumulative frequency (*boir-*) and a low cumulative frequency (*buv-*). If irregular inflected forms have a single shared representation for irregular and canonical stems, then we should not observed a cumulative frequency effect. By contrast, if there are distinct representations for the two stems, we should observe a pattern of results similar to that expected for regular verbs, namely a cumulative frequency effect.

Our results revealed that the surface and cumulative frequencies influence the recognition of inflected verbal forms for the three classes of verbs. This suggested that, in French, all verbal forms are decomposed during visual recognition, be they regular or not. This leads to the idea that morphological decomposition is trigged by the decomposability of verbal forms more than by their regularity *per se*.

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