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THE TIME COURSE OF WORD RECOGNITION: EVIDENCE FROM BRAZILIAN PORTUGUESE

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ABSTRACT: This article describes a study that aims at verifying the weight of structural patterns in the processing of multi-morphemic words, by observing the phenomenon in different conditions which allowed measuring what is at stake when it comes to the storage and retrieving of these words. We conducted a masked priming lexical decision experiment, in which the target was kept constant and the prime varied so as to meet three different relations to it: (1) morphological; (2) semantic only; (3) phonological only. The results were compared to those of a baseline condition. Morphologically related pairs obtained the shortest response times.
KEYWORDS: morphology; lexical processing.

INTRODUCTION

It is practically common sense that a word is more easily recognized if another word, morphologically related to it, has been recently processed. In the last few decades, a large number of studies has been dedicated to discover whether this significant facilitation can be attributed to morphology alone or if it is an effect of form and meaning overlap. The discussion has to do with the older and broader question of how words are represented and retrieved. That is, in order to recognize a word, do we necessarily need to look into its constituents? Are we talking about a rule-based processing mechanism or are we talking about some sort of complete storage device? This relates to the question of what would be more efficient. Would it be more efficient to store only what cannot be derived by rules – and rely

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on the operation of derivational rules to access information that is not stored – or to store every single piece of information and thus depend on memory space and on efficient procedures to retrieve, in a few milliseconds, the critical information among everything that is stored.

The literature provides both types of answers. There are models which defend a *top-down* heuristic – direct access (Butterworth, 1993; Seidenberg & McClelland, 1989) – and models which support the idea of a *bottom-up* algorithm – access is the final product of smaller procedures that involve morpheme segmentation (*Affix-Stripping* – Taft & Foster, 1975; Taft, 1979). There are also studies that present evidence for a dual model, which combines *bottom-up* and *top-down* elements. In the *Augmented Addresses Morphology* (Caramazza, Laudanna & Romani, 1988), for example, familiar words would be accessed as a whole, whereas the unfamiliar ones would undergo decompositional processes. For Schreuder & Baayen (1995), there is a dual-route model which posits a morphological parsing route and a direct route, which would be set to action in parallel from the beginning of the lexical recognition process. Pinker's model – Words and Rules – (1991) predicts that regular forms (e.g. -ed past in English) would be accessed via morphemic concatenation whereas the irregular ones would be fully stored in the lexicon. Stockall & Marantz (2006) conversely present evidence for a single mechanism of morphological concatenation, in English, which would account for irregular and regular pasts. The model proposed by Marslen-Wilson, Tyler & Older (1994) suggests that morphological decomposition is more likely to happen when the relationship between the complex word and its stem is transparent, which posits the idea that morphological decomposition must be guided by semantic relations. However, it had remained unclear whether these results reflect an inherent factor in word recognition or if it they are the result of processing when the input is auditory rather than visual. Rastle et al. (2004) attempt to solve this question by running experiments in which prime and target are visually presented. In order to verify whether semantic transparency affects morphological priming from the very beginning of visual word recognition, their experiments vary the stimulus onset asynchrony from a condition in which the stimulus is masked to a condition in which it is completely overt and thus consciously perceived. Results suggest the existence of a moment in which morphemic segmentation happens irrespectively of semantic transparency (refer to Longtin, 2003, for similar results in French). Fiorentino & Fund Resnicek (2009) report analogous results for compounds. Maia, Lemle & Franca (2007) examine the question by means of *Stroop effect* experiments and eye tracking. The *Stroop* task indicates the perceptual relevance of transparent and opaque morphemes, which act as facilitators for the

levels of accuracy and response times, as opposed to the conditions with words containing only orthographically related morphemes. Therefore, there would be morphological processing inside the word, as predicted by the full parsing theories. The eye tracking of the same words indicated a greater eye activity (fixations and saccades) in the conditions with transparent morphemes than in the ones with opaque or pseudo-derived words. Alternatively, there was also the occurrence of eye patterns indicating direct lexical access, bringing forward some evidence in favor of double-route models, which admit not only the computation but also the direct access to the word.

In light of the conflicting results reported above, this study aims at systematizing the factors that are presumed to be at stake during lexical activation. To this end, our experiment is conceived so as to enable these conflicting factors to be confronted in a single design. By these means we intend to effectively examine whether morphological structure plays a significant role in the early visual recognition of Portuguese words that is independent of both semantic and formal relatedness. In addition to this empirical question, we also ask whether this distinct contribution of morphology in lexical access can be attributed to a mechanism of syntactic relevance in our linguistic system – an attempt to give the facts explanatory adequacy, which is expanded in the section below.

1. DISTRIBUTED MORPHOLOGY

In the recent years, Distributed Morphology has stood out as a possible model to interface linguistic theory with the neural mechanisms, especially when it comes to lexical access, a field that has given rise to a considerable number of studies (Stockall & Marantz, 2006; Pylkkanen& Marantz, 2002, 2003). As opposed to lexicalist models – according to which the words exist as listemes in the lexicon,, Distributed Morphology postulates the existence of three lists (Figure 1) by means of which the words are dynamically formed. List 1 comprises the units syntax is going to operate with. These units consist of morphosyntactic features and predictions for stem insertion. List 2 – the vocabulary – contains the phonological forms for the terminal nodes of syntax/morphology, presenting the connections between phonological and syntactic features. There is a competition for the insertion, in which the vocabulary item that will convert is the one which contains the greatest number of shared features with the ones specified in the terminal nodes. After the filling of these nodes, the

pairing between form and meaning takes place in List 3. This list, known as the Encyclopedia, is responsible for listing the meanings of specific stems within a given syntactic domain.

França (2005) reports recent empirical evidence on lexical access, emphasizing the prevalence of modular models in an attempt to account for the facts. Among the models for the lexical access, it is common sense that a number of mental representations of suppressed words in human mind would be activated in order to access the mental representation of a given word, whether read or heard. There is empirical evidence (Marslen-Wilson, 1990) that orthographic (phonological) similarity may be a criterion for this activation. An undesirable characteristic of this process, though, would be the fact that in a fraction of seconds, many representations would be activated while only one would be the target. We find hence a controversy regarding the mechanisms that would efficiently rule out the competitors in a matter of milliseconds (França, 2005). Some new insights on this matter began to appear when recent psycholinguistics studies reported longer lexical decision times for pairs in which prime and target were phonologically but not morphologically related (Isel & Bacri, 1999; Rastle et al., 2000; Soto-Faraco, 2001). These results suggest that the recognition of the word FILÉ (steak) would defer the recognition of the word *fileira* (row), since the latter would be suppressed during the activation of the former. The same does not happen when prime and target are morphologically related because both words share the same root, which remains activated – hence the shorter response times for these pairs.

Under this view, there are two distinct factors that affect word recognition in different levels, namely, similarity – which would account for the effects observed in phonologically related pairs – and identity – which accounts for words that are morphologically related and thus share the same root. Our hypothesis in the present study is based on the concept of identity, since we expect to obtain shorter response times for morphologically related words which cannot be attributed to phonological coincidence.

Under this theory the explanation for the faster response times is that morphologically-related words share the same root merged to the same categorizing morpheme *n* and undergo the same semantic negotiation at this internal layer.

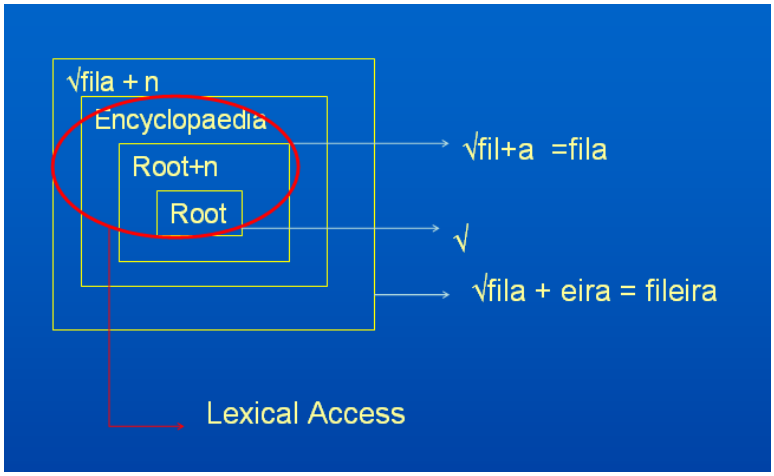

Figure 1: At a certain moment of the derivation, *fileira* was *FILA*.

The above model posits the pairing between form and meaning that takes place in the third list (Encyclopedia), when an arbitrary meaning is assigned to the compound [stem + categorizing morpheme]. In such case, *fileira* and *FILA* share the same stem merged to the same categorizing morpheme *n* and undergo the same semantic negotiation at this point. That is, regardless of the most external morphological layer, which renominalizes the noun *FILA*, it is as if these two words were the same, since, at a certain moment of the derivation, *fileira* was *FILA*. The faster response times for these morphologically related words would represent exactly this gain in the moment of semantic negotiation.

2. EXPERIMENT

The aim of the current experiment was to verify the role of combinatorial operations in the processing of multi-morphemic words. By observing the phenomenon in different conditions, it was possible to check what is actually at stake when it comes to the storage and retrieval of these words. To that end, we carried out a masked priming with lexical-decision experiment, in which we tested the relationship between prime and target in different contexts: (1) morphologically related; (2) semantically related only; (3) phonologically related only; (4) a baseline condition in which prime and target were unrelated. Our hypothesis was that we would obtain the strongest facilitation in the condition with morphologically related words.

Taft & Foster (1975; 1976) initiated the tests that aimed at observing this kind of phenomenon, which led them to the BOSS model, a model based on orthographic and morphological factors (Taft, 1979). The studies about perceptual parsing of words offer

contradictory evidence: on the one hand, connectionist studies such as Seidenberg & McClelland (1989) argue for the fact that the effects found in sub-lexical structures are nothing but epiphenomena of orthographic redundancy; on the other hand, studies as Marslen-Wilson et al. (1994) present results of priming experiments which attest that words are indeed morphologically represented on the level of the lexical entry, although the recognition of a target is facilitated only when its relation to the prime is semantically transparent. Rastle et al. (2000) showed that morphological structure indeed plays a significant role in the early visual recognition of English words, dissociating it from orthographic and semantic relatedness by varying the stimulus onset asynchrony (SOA). The authors also varied the stimuli in terms of semantic transparency.

The main purpose of this experiment is to disentangle the roles of these factors in the activation of morphologically complex words in Brazilian Portuguese (BP) as a means to verify whether the activation of a word involves, at a first and more automatic level, its decomposition into morphemes. This basic research question is of paramount importance in order to establish the existence of morphological processing in BP and to set parameters for future psycholinguistics and neurolinguistics research in this language. An important empirical issue when it comes to these questions is whether the experiment can be properly designed in a way to rule out overlapping effects of form and meaning so that the results can be unequivocally attributed to morphology alone. In the study reported here we manipulated the influence of the main factors assumed to be involved in word recognition. Our design made it possible to measure the relevance of these factors with a large level of accuracy by comparing their influence in relation to the same target – a derived word. The primes varied in three different experimental conditions in relation to the target: (1) morphologically related; (2) semantically related only; (3) phonologically related only. The response times were compared to a baseline condition (4) in which prime and target were non-related.

We did not manipulate the stimuli in terms of semantic transparency, since several previous studies have consistently reported that early visual morphological priming effects hold equally for semantically transparent and semantically opaque primes (Longtin et al., 2003; Rastle et al., 2004; Feldman & Soltano, 1999; Feldman, 2000; Boudelaa & Marslen-Wilson, 2005). All morphologically-related pairs here were thus semantically transparent. The semantically-related pairs had no morphological relationship whatsoever and the approach that we took to measure the level of semantic similarity was twofold. First, we selected prime-target pairs that were very close semantically speaking to the point that there was always the possibility of creating an abstract minimal syntactic structure between them (Gomes, 2009).

For example, the pair *ORDEM* (order) and *fileira* (row) can be instantly inserted in a prepositional phrase presented in Figure 1.

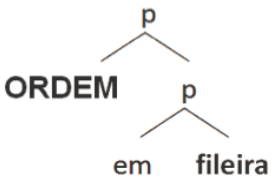

Figure 2: PP formed by the semantically related prime-target pair (order/row).

Second, we asked 50 subjects to rate on a 7-point scale the degree to which prime and target were related in meaning (1 = very similar; 7 = unrelated). We used as experimental pairs the ones rated from 1 to 4.

3. MATERIALS AND METHODS

3.1.1 STIMULI AND DESIGN

The experimental stimuli consisted of four lists with 16 prime-target pairs of words controlled for length and frequency. We assessed the priming effects upon words following the four conditions aforementioned. Below are listed examples of the four types of prime-target pairs:

(1) Morphologically related: FILA/fileira (line/row);

(2) Semantically related only: ORDEM/fileira (order/row);

(3) Phonologically related only: FILÉ/fileira (steak/row);

(4) Unrelated (baseline): MATO/fileira (weed/row)

In all pairs, the prime is the shortest word and the target the longest (derived) one. In addition to the 16 experimental items, we also included 32 fillers, among which were nonwords to justify the task. The Latin Square design allowed for all the subjects to be exposed to the four conditions, with a distribution between subjects in four groups.

3.1.2 PROCEDURE

For each trial, a fixation cross remained on the screen for 1500ms and was immediately followed by a pre-prime consisting of a sequence of stars (******), which remained on the screen for 500ms before the prime was presented (in capital letters, Arial, size 20). It remained on the screen for 38ms and was followed by another sequence of stars (******), which remained on the screen for 50ms and was followed by the target (lower case, Times New Roman, size 20). The target remained on the screen for 200ms and, after that, the subject had 1500ms to perform the lexical decision. This time window was limited as a means to avoid episodic factors associated with more general strategies of the cognitive system.

The experiment was run on a Macintosh computer using Psyscope software, with randomization of the trial order. Participants used their dominant hand for the *yes* response and reaction times were measured from the presentation of the second word to the pressing of the key.

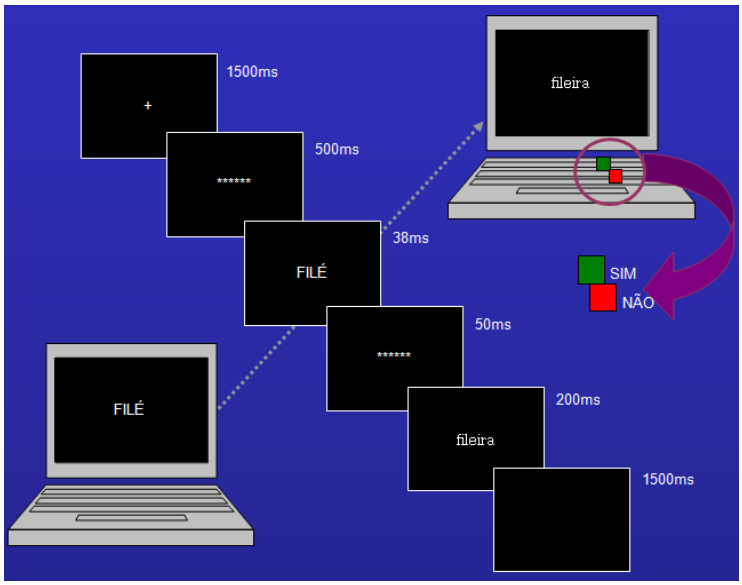

Figure 3: Priming experiment

The subjects were told that they would have to decide as quickly and accurately as possible whether the letter string presented was a Portuguese word or not, by pressing the green key (letter O on the keyboard) for *yes* or the red key (letter L) for *no*. They were seated in front of a computer screen in a quiet room and were allowed to perform a practice task before the actual experiment, in which the words did not correspond to the ones to be tested. The total duration of the experiment was about 10 minutes.

3.1.3 PARTICIPANTS

Thirty-two students of the Federal University of Rio de Janeiro (Brazil) participated in the experiment voluntarily. They were all right-handed native speakers of Portuguese and had normal or corrected-to-normal vision. The experiment was carried out at the Experimental Psycholiguistics Lab (Lapex) of the Federal University of Rio de Janeiro.

4. RESULTS

The results are presented in the graph below:

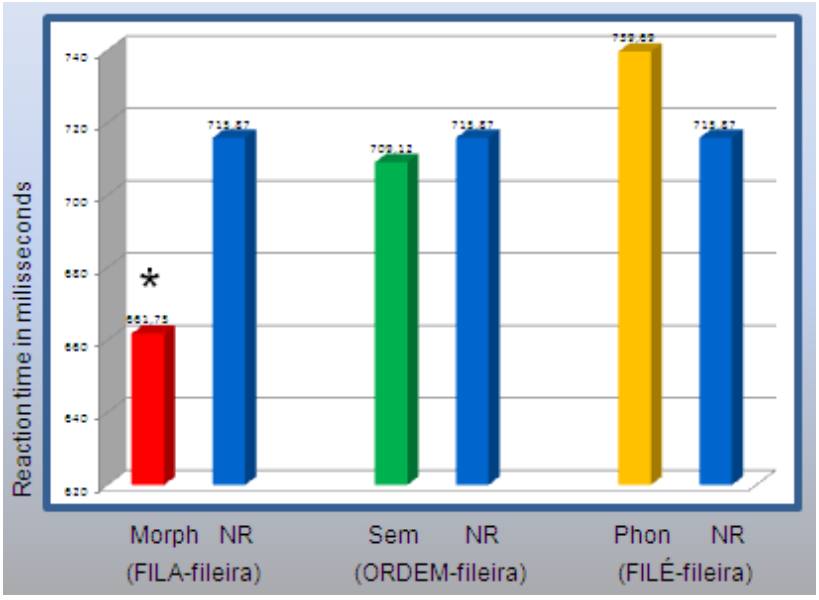

Figure 4: Mean times for each condition

Concerning the responses related to the lexical decision, accuracy rates were nearly 100% - the non-words systematically obtained the answer NO whereas the words obtained the answer YES. The decision task thus served as a guarantee that the participants understood their task and carried it out with accuracy.

Considering our hypothesis, we expected to find priming effects only for the morphological condition. The results were submitted to a t-test, which verifies if the mean times of two matrixes X and Y differ significantly. The average mean times in the morphological condition were significantly shorter than the response times obtained in the

baseline condition (MorphXBase: $t(254)=2.5$; $p<0.05$). The average mean times obtained for the semantic (SemXBase: $t(254)=1.3$; $p>0.05$) and phonological (PhonXBase: $t(254)=1.0$; $p>0,05$) conditions did not differ significantly from the baseline. Thus, facilitation was not verified in these conditions.

5. DISCUSSION AND CONCLUSION

The results of this experiment highlight the importance of structural patterns in word processing, since the words that were morphologically related to their primes obtained significant facilitation. Morphologically-related pairs such as *FILA/fileira* (line/row) obtained the shortest response times. Since we used masked priming to eliminate semantic priming effects in the morphological group, we are inclined to say that this expressive facilitation favors the *decomposition* models such as that advanced by Distributed Morphology.

Results suggest that phonological information may indeed be represented or retrieved dissociated from morphological information. Inhibitory effects were not statistically verified in the phonological condition, although phonological response times were visually higher than those of control. Semantic priming also took a slower time course than that of morphological priming.

This study has shed some light on the role of morphological processing in the recognition of words and in lexical organization. We have demonstrated the importance of morphology when it comes to the derivation of multimorphemic words, which has proved not to occur through the mere association of semantic and phonological similarity. However, the attempt to reconcile the data with the explanatory concept of identity remains in abeyance, since masked priming tends to capture across-the-board morphological decomposition, even in cases where prime and target do not share the same root (e.g. *corn* - *corner*). Therefore, in order to attribute the morphological effects to identity it would be necessary to find similar results using longer stimulus onset asynchrony. So far previous studies using a long SOA (overt priming) have not been able to signalize a distinguished role for morphology in word recognition. Likewise, the morpho-orthographic segmentation – that seems to occur in the earlier stages of lexical activation – has not been precisely characterized.

There are many factors involved in the apparently trivial process of recognizing a word, and these factors are captured in distinct ways by different experimental paradigms. Moreover, what we call lexical access here is a very specific moment in the time course of a word derivation – which comprehends the collective activity of a cohort of different cognitive

processes.

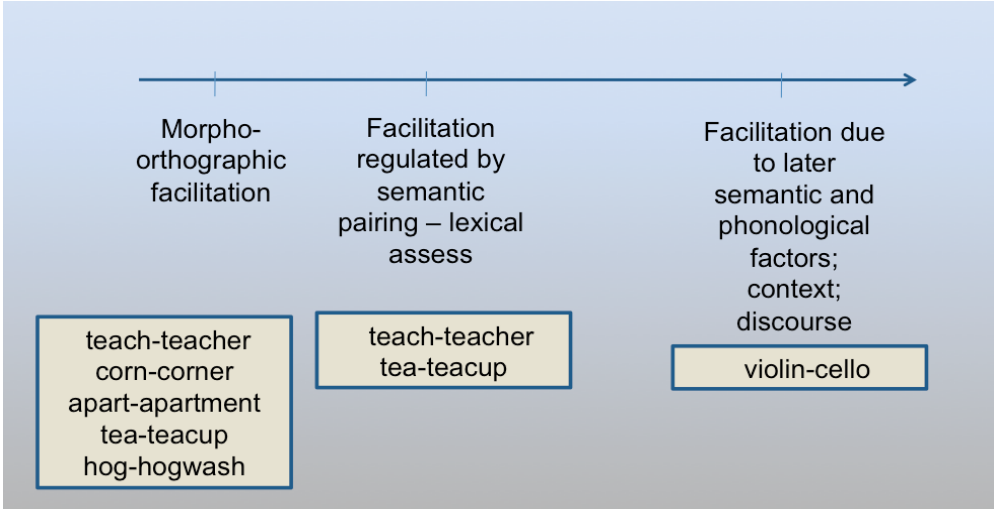

Figure 5: The time course of lexical activation – from psycholinguistic studies.

As illustrated in Figure 5, psycholinguistic studies show that there seems to be an initial moment of a word activation in which the effects of morphologic facilitation happen regardless of semantic transparency. Later on, the same effects are only detected for semantically-transparent pairs.

Even though behavioral measures such as response times can be sensitive to some of the stages involved in the recognition of a word, they do not allow one to precisely disentangle these stages by pinpointing each of them during the process. This highlights the necessity of resorting to the use of more fine-grained methods, such as electrophysiology, to map specific cognitive processes and their relation to behavioral output, distinguishing stages that precede and follow lexical access.

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RESUMO: Este trabalho descreve um experimento que examina o papel do processamento morfológico no reconhecimento de palavras e na organização lexical, verificando se a ativação de uma palavra passa, no momento mais inicial e automático, pela sua decomposição em morfemas. Utilizou-se, como metodologia, um experimento de priming encoberto, com decisão lexical, em que se testou a relação entre *prime* e alvo em quatro contextos: (1) prime e alvo relacionados morfologicamente (FILA/fileira); (2) prime e alvo com relação apenas semântica (ORDEM/fileira); (3) prime e alvo com relação apenas fonológica (FILE/fileira) e (4) prime e alvo sem nenhuma das relações anteriores. Nossa hipótese é de que haveria facilitação mais expressiva na condição em que as palavras tivessem relação morfológica, devido à identidade de raízes, o que foi confirmado pelos resultados. Essa facilitação expressiva de palavras morfologicamente relacionadas favorece os modelos de decomposição plena e pode ser interpretada a partir da proposta não-lexicalista da Morfologia Distribuída.
PALAVRAS-CHAVE: morfologia; processamento lexical.

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