The Inflectional Morphology Representation of Individual Words in the Mental Lexicon

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Models of complex word recognition can be separated into two wide groups: symbolic and connectionist. Symbolic models presume the existence of an explicit morphological representation of individual words; connectionist models do not and consider morphological effects to be a by-product of interaction between phonological, orthographic and semantic information. This study aimed to test whether there are explicit mental representations of inflected lexical units in the

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Acknowledgements. To my dear participants!

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mental lexicon. Accordingly, the method of inflected suffix morphological and semantic priming of nouns in the Serbian language was used. In the morphological priming condition, the prime and the target shared the same inflectional suffix. In Experiment 1 overt priming was used, while in Experiment 2, masked priming. The results showed no significant effects of inflected suffix morphological priming, while significant semantic priming effects were recorded. The results obtained in this research are in line with predictions of the connectionist models.

Keywords: lexical representation, morphological representation, inflectional morphology, morphological priming, semantic priming.

Highlights:

- Inflected suffix overt morphological priming does not facilitate word recognition.
- Inflected suffix masked morphological priming does not facilitate word recognition.
- In both overt and masked, semantic priming facilitates word recognition.
- Results do not support the existence of an explicit morphological representation.
- Results support connectionist models of isolated word recognition.

The smallest language units conveying meaning are morphemes (e.g., Booij, 2012; Butz & Kutter, 2016; Baayen et al., 2018). While morphologically simple words consist of a single morpheme, morphologically complex words consist of at least two.

Morphemes of complex words are further divided into root and affixes. While the root represents the core meaning of the word, the affixes modulate that core meaning in some way. These affixes can be located at the beginning of the word (prefix), at the end of the root (suffix) or, within the word (infix).
Functionally, there are at least two types of affixes: derivational and inflectional. Derivational affixes change the meaning of the root word (ex. sleepiness – sleep and ness). On the other hand, inflectional affixes do not change the basic meaning of the root word, but rather modulate it grammatically (work – worked). In the case of inflectional affixes, the root is usually treated as a stem of the word, but sometimes these terms are used interchangeably.

A broad area of psycholinguistics is known as isolated word recognition, closely related to the concept of a mental lexicon (Harley, 2007). A mental lexicon is the memory subsection in which all relevant information concerning individual words is stored. A subset of this broader area is complex word recognition (Harley, 2007; Diependaele et al., 2012), within which several models/hypotheses have been developed.

According to the whole-listing hypothesis (Manelis & Tharp, 1977; Butterworth 1983), complex words are integrally represented in the mental lexicon. For example, the word “refresh” is one word with one entry, while “fresh” has an independent entry.

On the other hand, according to the decomposition hypothesis, there is an obligatory decomposition of the complex word into its stem and affixes (Taft & Forster, 1975; Taft, 1979). Each word is first divided into constituents (“re” and “fresh”), subsequently each constituent is recognized, and finally, constituents are integrated on the semantic level. Evidence of this is found in the effects of surface- and base-word frequency. Two words that have the same surface frequency (like “seeming” and “mending”) will be recognized differently (Taft, 2004) since the first word has a higher base frequency (the frequency of its stem).

There are, however, models between these two extremes. Generally, these models presume whole-word representations for high-frequency or familiar complex words, while low-frequency or unfamiliar words are divided into components and further processed independently. The most
important models from this group are the Augmented Addressed Morphology model – AAM (Caramazza et al., 1988), the Morphological Race model (Schreuder & Baayen, 1995), and the Supralexical Decomposition model (Giraudo & Grainger, 2000; Giraudo & Voga 2014).

Another approach specifically developed for the recognition of inflected word forms is the Informational Approach (Kostic, 1991; Kostic, 1995). According to this model, recognition of inflected forms depends on the amount of information that each of these forms caries, derived from the frequency of each form type (not token), and on its number of grammatical/syntactical functions.

Finally, since the 1980-ies, many connectionist models have been developed in cognitive psychology that tried to explain cognitive phenomena without symbolic descriptions. These models explained cognitive phenomena by the use of neural networks that simulated learning and the production of desired output based on the connection-weights between nodes in the network layers. In the psychology of word reading, the most important model is the parallel distributed processing model (PDP) developed by Seidenberg and his associates (Seidenberg & McClelland, 1989; Plaut et al., 1996; Plaut & Gonnerman, 2000; Harm & Seidenberg, 2004; Plaut, 2011). The word recognition system is a triangular model consisting of phonological, orthographic and semantic constituents, connected via a hidden layer between each of them. Additionally, the semantic level is connected to the context level, by which priming effects are explained.

This model is trained by the use of various types of inputs (phonological, orthographical or semantic) which gradually produce the desired output. Once the network is trained, each input causes the network to produce output at the other two levels (for example the orthographically presented word “house” produces sounds and meaning through an appropriate pattern of activation).
According to this model, there is no complex word division and there are no separate morphological representations. Morphological effects are produced by the interaction between phonological, orthographic and semantic entities.

Another framework of complex word recognition was developed by Milin, Smolka & Feldman (2017) which proposes two groups of models of lexical access: combinatorial models and learning-based models. Combinatorial models correspond to what we named as symbolic models, while learning-based models include the PDP model and the Naïve Discriminative Learning model (NDL), developed by the same group of authors (Baayen et al., 2011; Milin et al., 2017). Similar to the PDP model, the NDL model does not consider the existence of explicit morphological representation.

In the remainder of this study, the PDP model will primarily be referred to as an alternative to symbolic (combinatorial) models.

**Priming Paradigm and Complex Word Recognition**

One of the most frequently used methods in word recognition research is the “priming” paradigm.

The most frequently used priming method is semantic priming. Semantic priming occurs when the target word is preceded by a semantically related word (Balota et al., 2006). Previous research (Meyer & Schvaneveldt, 1971; Neely, 1977) showed consistent facilitation of target-word processing, in the lexical decision task, when preceded by the semantically related prime word. Furthermore, semantic priming effects were obtained in complex word recognition and can be separated from the effects of morphological or orthographic priming (for example Feldman et al. 2012).
On the other hand, morphological priming has been mostly used in complex word recognition. The morphological priming paradigm involves a prime and a target that are somehow morphologically related. Previous research (Murrel & Morton, 1974; Stanners et al., 1979; Feldman & Moskovljevic, 1987; Grainger et al., 1991) showed that presenting a morphologically related prime facilitates the processing of the target in the lexical decision task. Furthermore, this effect can be isolated from purely semantic or orthographic priming. It is expected that if the priming effect is produced, the morphological property that two words share is represented in the memory.

The prime and the target in morphological priming can share the same stem (worked – work) (Diependaele et al., 2012; Cortese & Balota, 2012) or the same affix (worked – watched). There are significantly more studies exploring the priming effects of the stem, only a few exploring affix priming. One such study (Chateau et al., 2002) presented the morphological priming effects of prefixes. Results showed that words sharing the same prefix with the prime word were processed significantly more quickly compared to words of the same frequency and length but not sharing the same prefix. Furthermore, these effects are independent of semantic and orthographic priming effects.

Another study used a similar methodology (Giraudo & Grainger, 2003) and replicated the results from the previous study as far as the prefix priming is concerned, but the effects of suffixed priming were not recorded. These authors explained this effect by left-to-right primacy of word reading in Indo-European languages.

However, there is a study that managed to obtain derivational suffix priming effects in Spanish (Dunabeitia et al., 2008). In this study, a target that shared a derivational suffix with the prime word was recognized significantly more quickly compared to those that did not share the
same suffix. Furthermore, these effects were obtained even when the root of the prime word was masked and only the suffix exposed. It is worth noting that these suffixes in Spanish were significantly longer (up to 8 letters) compared to most of the suffixes in English or French, the languages in which most of the psycholinguistics studies were conducted.

All of these affix-priming studies were conducted on derivational affixes. Following the similar logic from the previous research, we can ask whether there are similar effects of morphological priming on inflected word recognition.

This expectation follows from most of the symbolic complex word recognition theories cited above. Each of these theories postulates the existence of a mental lexicon in which morphological information is explicitly stored, whether as a whole word or as the appropriate inflectional affix representation. Consequently, we can expect that the presentation of a prime word of a specific morphological form will arouse the representation of other morphological forms of the same type. This would lead to faster recognition of the appropriate morphological form of the target.

On the contrary, we cannot derive such expectations based on connectionist models: since morphological information is not explicitly stored in the triangular model, an inflected word will not create any context in which another similarly inflected word is recognized.

**Inflectional Morphology of the Serbian Language**

Most previous research related to complex word recognition was conducted in the English language, along with some in French or Italian. None of these languages is highly inflective, so the research was mostly conducted on derivational morphology.
On the other hand, Serbian is a highly inflective language. There are seven noun cases, singular and plural, which makes possible 14 distinct forms of each noun. However, some of these forms are syncretic depending on the noun declension, so the total number of different inflective forms is 4 to 7 (Table 1). This property makes the Serbian language appropriate for the study of inflected word recognition, since the meaning of a noun is constant, while inflective endings vary.

(Table 1 here)

Aims and Predictions

The aim of this study is to test whether there are explicit mental representations of inflected lexical units in the mental lexicon. More specifically, to test which of the existing groups of theories, symbolic or connectionist, better explains the process of inflexed word recognition.

For that purpose, we designed two experiments involving the lexical decision-priming task. In the first experiment, effects of overt inflected morphological priming were tested and compared to no priming and semantic priming effects. In the second experiment, the design was the same except that instead of overt priming, masked priming was used.

According to the decomposition hypothesis, inflected morphological priming effects are expected, since the prime and the target share the same element (suffix), and both stem and affixes are independently represented in the lexical memory. A similar expectation could be derived from the whole-word and hybrid hypothesis, since the presentation of an affix would lead to a facilitated recognition of the word that shares the same affix.

Conversely, according to connectionist models, no effects from morphological priming are expected since morphological information is not explicitly stored in the memory.
Experiment 1

In this experiment, the effects of overt inflected morphological priming were tested.

Method

Participants

The participants were 30 university students divided into 6 groups of 5. The native language of all participants was Serbian. One participant was replaced because he made more than 15% of errors in total.

Design and Stimuli

In this experiment, the lexical decision task with an overt priming procedure was used.

The stimuli presented were 60 third-declension feminine nouns of the Serbian language and 60 pseudo-nouns with appropriate endings (presented in Serbian Latin script). Prime stimuli were only feminine nouns (120). Each noun was presented in six different inflected forms. Each participant viewed each word, but different groups viewed different forms constructed from the same root word. All the words were equalized for length (two syllables). All stimuli in the experiment were counterbalanced.

The prime-target relationship was either: morphological and semantic, morphological, semantic, or not related. Consequently, there were the following four priming conditions: Morphological & Semantic, Morphological, Semantic, and Neutral.

A morphologically related prime and target shared the same ending (ex. kuć-om – škol-om / (with) the house – (with) the school). A semantically related prime and target were semantically
or associatively related (ex. kuća – soba / house – room). The selection of semantically associated words was conducted by the author and confirmed by two independent evaluators.

A morphologically and semantically related prime and target were both morphologically and semantically related (ex. kuć-om – sob-om / (with) the house – (with) the room). Finally, a neutral prime and target were neither semantically nor morphologically related (ex. kuć-om – kos-a / (with) the house – hair).

The average target word frequency for each priming condition was equalized (differences were not significant) (Kostić, 1999).

Concerning the orthographic similarity of the prime and target, the Levenshtein distance was calculated for each pair (as suggested by Yarkoni et al., 2008). There were no statistically significant differences in Levenshtein distance between priming conditions for the base words ($F(3, 56) = 0.249, p = .862, \eta^2 = .013$).

**Procedure**

The fixation point was presented for 500 ms on the computer screen, followed by the prime word presented for 250ms. The next followed the inter-stimulus interval of 300ms. Finally, the target string of letters was presented for 1500ms or until the participant’s response (Figure 1). Participants responded by pressing the appropriate key: answering whether the presented string of letters was a word or not. Participants received feedback in the case of incorrect selection (red letter “X” over the target).

If a response was not provided within 1500ms, participants were warned that the response was too slow. Trials in which participants did not respond in time or responded incorrectly were excluded from the analysis.
Reaction time was measured from the onset of the target stimulus. In addition to reaction time, the number of errors was measured (percentage of accuracy).

Prior to the start of the experiment, participants performed an exercise in which all prime and target combinations were presented (24 trials in total). The experiment began only after this training was completed and participants confirmed that they understood the instructions.

Results and Discussion

Reaction time

Reaction time results (by participants) are presented in the following chart (Figure 2) and the table (Table 2).

A one-way within-subject ANOVA was conducted with the priming condition as a within-subject factor ($F^1$) with four levels. Results showed the priming condition had a main effect on

$^2$ $F_1$ is the value of F statistic for by-participants ANOVA (standard value of F statistic), while $F_2$ is the value of F statistics by-items ANOVA, commonly used in psycholinguistic research.
reaction time for $F1$ ($F1(3, 27) = 4.871, p = .004, \eta^2=.144$). Post-hoc power analysis using G*Power (Faul et al., 2007) revealed the size of power for $F1$, $\beta = .79$.

Post-hoc analysis of F1 indicated significantly different results for the Morphological & Semantic priming condition, compared with the Morphological and Neutral priming conditions ($p = .004$ and $p = .001$ respectively), while it was not significantly different from the Semantic priming condition ($p = .564$). Furthermore, results for the Semantic priming condition were significantly different from those for the Morphological ($p = .045$) and Neutral priming condition ($p = .030$). Results for the Morphological and Neutral priming conditions were not significantly different ($p = .771$).

In F2 (by-items analysis) a one-way between-item ANOVA was conducted with four levels. The results were not significant ($F2(3, 56) = 1.009, p = .396, \eta^2 = .051$). One reason could be that the language sample was not sufficiently large. However, on the descriptive level, the distribution pattern was similar as in the by-subject analysis (Mean (ms): MorphSem = 617.29, Morph = 644.18, Sem = 620.05, Neutr = 641.93).

**Accuracy**

Results of accuracy analysis are presented in the following table (Table 3):

(Table 3 here)

Again, a one-way within-subject ANOVA was conducted with the Group as a within-subject factor (F1) with four levels. Results showed the priming condition had a main effect on accuracy ($F1(3, 27) = 5.283, p = .002, \eta^2 = .154$).
Post-hoc analysis (for F1) indicated that results from the Morphological & Semantic priming condition were significantly different from those for the Morphological \((p < .001)\) and the Neutral priming condition \((p = .003)\), while not significantly different from those for the Semantic group. Other comparisons were not significant.

Similar to the reaction-time analysis, results from \(F2\) were not significant \((F2(3, 56) = 1.835, p = .151, \eta^2 = .090)\), even though, on the descriptive level, the distribution pattern was similar to that from the F1 analysis (Mean (% correct): MorphSem = 98.10, Morph = 91.31, Sem = 95.24, Neutr = 92.38).

**Non-words**

Some of the non-words shared the same “suffixes\(^3\)” with prime words and some did not, so the additional analysis was conducted to examine whether there were any differences between these two groups. A t-test revealed that there were no significant differences in reaction time between non-words that shared the same “suffixes” with the prime words \((M = 666.47, SD = 86.14)\) and those that did not \((M = 668.93, SD = 83.17)\), \((t(29) = -.367, p = .716)\). From this, we can conclude that there were no inhibitory effects on target non-words rejection when they shared the same “suffix” with the prime word.

From our results, we can conclude that semantic priming has significant effects, while the effects of morphological priming on inflected word recognition were found to be insignificant. Furthermore, we can conclude that the effects recorded in the Morphological & Semantic group can be explained by semantic priming, solely.

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\(^3\) Suffix of a non-word cannot be considered as a genuine suffix. Thus it is written underquotes.
Experiment 2

One of the shortcomings of the previous experiment is the usage of overt priming. Most of the previous research used masked morphological priming (i.e., Grainger et al., 1991, Chateau et al., 2002) to avoid the development of implicit strategies by the participants. Furthermore, masked priming was used to avoid the recording of the prime in episodic memory, which would lead to long-lasting priming effects (Forster & Davis, 1984).

This experiment intended to overcome this shortcoming by using a masked priming methodology. Additionally, another group in the study was introduced: the case-related priming condition. In the Serbian language, declension in a given case does not always involve the noun taking the same suffix (konjem – PESMOM ([with] a horse – [with] a SONG)). This new group was introduced to identify eventual grammatical effects which would be independent of orthographic/phonological effects.

In order to keep the same number of experiment trials as in the previous experiment, the number of inflected nouns was decreased from 6 to 5 forms.

Method

Participants

The participants were 30 university students divided into 5 groups. Two participants were removed from the analysis because they made more than 15% errors in total.

Design and Stimuli

Presented stimuli were 50 third declension feminine nouns of the Serbian language and 50 pseudo-nouns with appropriate endings. Prime stimuli were only feminine nouns. Each noun was
presented in five different inflected forms. Each participant viewed each root word, but different groups viewed different forms constructed from the same root word. All the words were equalized for length (two syllables). All stimuli in the experiment were counter-balanced. The target-word base frequency for each group was equalized (differences were not significant).

As in the previous experiment, the prime-target relationship was either: semantic and morphological, morphological, semantic, case-related or unrelated. Stimuli selection principles were the same as in the previous experiment.

The average target-word frequency for each priming condition was equalized (differences were not significant) (Kostić, 1999). The Levenshtein distances for the base–words, across priming conditions, were not significantly different ($F(3, 56) = 1.317, p = .284, \eta^2 = .099$).

**Procedure**

The forward pattern mask (#####) was presented for 500ms on the computer screen, followed by the prime word presented for 40ms. Finally, the target was presented for 1500ms. The primes were presented in lowercase letters, while the targets were presented in capital letters. This was done to minimize eventual orthographic priming effects.

Participants responded by pressing the appropriate key: answering whether the presented string of letters was a word or not. Participants were not informed of the presence of the prime word and none of them reported having perceived it.

(Figure 3 here)

As in the previous experiment, prior to the start of the experiment, participants performed a training exercise.
Results and Discussion

Reaction time

Reaction time results are presented in the following chart (Figure 4) and table (Table 4). Since there was no significant difference between results from the case-related priming condition and those from the morphological priming condition, the case-related priming condition was excluded from further analysis (for simplicity and comparability with the previous experiment).

(Figure 4 here)

(Table 4 here)

A one-way within-subject ANOVA was conducted with the Group as a within-subject factor (F1) with four levels (priming conditions: Morphological & Semantic, Morphological, Semantic, and Neutral). Results showed the type of priming had a main effect on reaction time ($F(3, 25) = 5.399, p = .002, \eta^2 = .167$). Post-hoc power analysis using G*Power revealed the size of power for F1, $\beta = .78$.

Post-hoc analysis for F1 indicated that the results from the Morphological & Semantic priming condition were significantly different from those from the Morphological and Neutral priming conditions ($p = .008$ and $p = .001$ respectively), while not significantly different from those for the Semantic priming condition ($p = .280$). Furthermore, results from the Semantic priming condition were significantly different from those from the Neutral priming condition ($p = .017$) and marginally different from those from the Morphological priming condition ($p = .064$).
Results from the Morphological and Neutral priming conditions were not significantly different ($p = .540$).

As in the previous experiment, the results in F2 were not significant ($F2(3, 36) = 1.622, p = .201, \eta^2 = .119$). The most probable reason is that the language sample was not sufficiently large (10 words per condition). Again, on the descriptive level, the trend was the same as in the F1 analysis (Mean(ms): MorphSem = 662.29, Morph = 696.85, Sem = 676.67, Neutr = 707.02).

**Accuracy**

The results of the percentage of accuracy by priming condition (by participants) are presented in the following table (Table 5):

(Table 5 here)

Again, a one-way within-subject ANOVA was conducted with the Group as a within-subject factor (F1) with four levels. Results showed a main effect of the priming condition on the number of errors ($F1(3, 25) = 3.316, p = .024, \eta^2 = .109$). Post-hoc analysis (for F1) indicated results from the Neutral priming condition were significantly different from those from the Morphological & Semantic ($p = .031$) and Semantic priming condition ($p = .013$). Other comparisons were not significantly different.

As in the reaction time analysis, F2 results (Mean (% correct): MorphSem = 95.86, Morph = 95.17, Sem = 97.93; Neutr = 92.41) were not significant ($F2(3, 36) = 1.209, p = .320, \eta^2 = .092$), most probably due to the smaller language sample.
Non-words

As in the previous experiment, some of the non-words shared the same “suffix” with prime words and some did not, so the additional analysis was conducted to examine whether there were any reaction-time differences between these two groups. A t-test revealed no significant difference in reaction time between results for non-words that shared the same “suffix” with the prime words ($M = 793.82, SD = 108.34$) and those that did not ($M = 802.68, SD = 122.66$), ($t(27) = -1.068, p = .295$).

As in the previous experiment, this experiment showed significant effects from semantic priming, while morphological priming effects are not significant. Furthermore, significant effects from priming that were both morphological and semantic can be assigned to semantic priming, solely.

General Discussion

In Experiment 1, the results showed no significant effects of overt inflected morphological priming on inflected word recognition. At the same time, significant effects from semantic priming were detected. Additionally, non-words that shared the same “suffix” with prime words were recognized at the same speed as those that did not share the same “suffix” (no expected inhibition was detected).

In Experiment 2, the results showed a similar pattern as in the previous experiment: no significant effects from masked inflected morphological priming on inflected word recognition were detected. Again, significant effects from semantic priming were detected, even though the exposition of the prime stimuli was only 40ms in duration. Furthermore, recognition of non-words sharing the same “suffix” with the prime word was at the same speed.
In terms of empirical contributions, results obtained in this study showed no significant effects of inflected suffix morphological priming, while at the same time, significant effects of semantic priming were detected. The most notable empirical contribution is the result from both experiments that the inflected suffix has no significant effect on target-processing \((p = .771\) and \(p = .540\)), a result which was not previously published elsewhere.

One of the most significant contributions of this study is related to the theoretical views of the obtained results. As stated in the introduction, most of the *symbolic theories* would predict that if a prime word shares the same inflected suffix with the target word, the latter would be recognized more quickly. This follows from the assumption that there is an explicit morphological representation of the inflected suffix in the long-term memory.

If suffixes were represented in the memory as independent constituents, the suffix in the prime word would lead to faster recognition of the target sharing the same inflected suffix. Additionally, if the suffix represents the grammatical structure of the word, this structure would be activated and would lead to faster target word recognition.

Results from this study do not support this view. Consequently, we may conclude that neither affixes nor inflected word morphological structures are explicitly represented in the long-term memory, at least as far as the isolated words are concerned.

However, even though the insignificant results cannot be used for hypothesis rejection, the additional argument that further disputes symbolic theories view is the quite high \(p\)-value of the difference between Morphological and Neutral priming condition in both experiments \((p = .771\) and \(p = .540\)).
Another semi-symbolic explanation of inflected word recognition is the informational approach (Kostic, 1991; Kostic, 1995), which claims that the cognitive system is sensitive to grammatical-form frequency. If the cognitive system is sensitive to grammatical-form frequency for individual words, then the appropriate grammatical form is somehow represented in the memory. More specifically, there is an explicit morphological representation of the isolated words. In that case, it would be expected that a primed grammatical form would lead to faster recognition of other grammatical forms of the same type. Again, that was not the case in the present study. Accordingly, our results do not support (even though, do not reject) this type of explanation.

One study closely related to the informational approach used overt morphological priming of nouns and adjectives in Serbian, which shared the same case (lepa (beautiful) – kuća (house)): significant effects from morphological priming were obtained (for example, Lukatela, et. al, 1983). However, we can postulate that this was not due to morphological but rather grammatical or, more precisely, a syntagmatic priming. If the noun and the adjective share the same case and number, they create syntagmatic composition. In that case, we deal with syntax level composition, rather than the composition of isolated nouns which share the same inflectional suffix.

An alternative to the symbolic theories interpretation are the connectionist (PDP) models; results from this study argue in favour of these models. PDP does not presume the existence of any morphological entity as far as single-word recognition is concerned. Inflectional morphology is implicitly encoded in the interaction between phonology, orthography and meaning. Inflectional morphology information regarding the prime word cannot affect recognition of the target since there is no explicit representation of morphology in the model. However, a PDP model explains well semantic priming effects, such as those obtained in the experiments of this study.
There are, however, some possible limitations of this study. This study did not take into consideration eventual orthographic priming effects. In the experiments conducted, there was no systematic similarity in orthography among base words in the four priming conditions. The only systematic similarity in orthography was in the Morphological, and consequently in the Morphological & Semantic priming condition (in which the prime and the target shared the same inflectional suffix). Since, in these conditions, prime and the target systematically shared inflected suffix, faster target-word recognition could be expected.

However, this was not the case. The recognition occurred equally fast in the Morphological priming condition and the Neutral priming condition. Consequently, we can presume (but not claim) that orthographic priming has no effects when the prime and the target share the same inflected suffix. This is in line with Giraudo & Grainger’s view (2003) of left-to-right primacy in word reading.

One further consideration is related to certain shortcomings of experiments using the lexical decision task with inflected or derivational suffixes in general. Since, in these, experiments non-words share the same suffix as words, to access the meaning of the presented stimuli, it is not necessary to read the entire word, but only the stem. In this sense, participants in the lexical decision task could complete the task even if they ignore the suffixes of the words.

Nevertheless, even if possible, this claim is not entirely correct. Experimental results showed systematic reaction-time differences in recognition of different inflective forms. If the aforementioned concerns were completely correct, if participants could completely ignore the suffix of the word, these reaction time differences would not exist.

In conclusion, the results obtained in this study are in line with PDP models. More generally, the obtained results support views that do not presume the existence of explicit inflectional
morbology representation for isolated complex-word recognition and processing. Consequently, it can be presumed (but not claimed) that inflected morphological representation is most probably a by-product of interaction between the structure and meaning of a word.

**Author Note**

Experiment data and stimuli can be found at:

https://osf.io/cqt2a/?view_only=3f65fc379a054756b507f3d18b63211f
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**Reprezentacija inflektivne morfologije pojedinačnih reči u mentalnom leksikonu**

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Modeli prepoznavanja složenih reči mogu se podeliti u dve velike grupe: simboličke i konekcionističke. Simbolički modeli pretpostavljaju postojanje eksplicitnih morfoloških reprezentacija pojedinačnih reči; konekcionistički modeli ne sadrže takvu pretpostavku i posmatraju morfološke efekte kao nusproizvod interakcije između fonoloških, ortografskih i semantičkih informacija. Ovo istraživanje je imalo za cilj da ispita da li u mentalnom leksikonu postoje eksplicitne mentalne predstave inflektovanih leksičkih jedinica. U skladu s tim, korišćena je metoda morfološkog i semantičkog primovanja pomoću inflektivnih sufiksa u srpskom jeziku.
U uslovu morfološkog primovanja, i prim i meta su delili isti inflektivni sufiks. U prvom eksperimentu je korišćeno otvorenog primovanje, dok je u drugom eksperimentu korišćeno maskirano primovanje. Rezultati nisu pokazali statistički značajne efekte morfološkog primovanja pomoću inflektivnih sufiksa, ali su dobijeni značajni efekti semantičkog primovanja. Dobijeni rezultati su u skladu sa predviđanjima konekcionističkih modela.

*Ključne reči:* leksička reprezentacija, morfološka reprezentacija, inflektivna morfologija, morfološko primovanje, semantičko primovanje.
Table 1

Inflection forms of the third declension of the Serbian feminine noun kuća (house)

| Case      | Singular | Plural  |
|-----------|----------|---------|
| Nominative| kuć-a    | kuć-e   |
| Genitive  | kuć-e    | kuć-a   |
| Dative    | kuć-i    | kuć-ama |
| Accusative| kuć-u    | kuć-e   |
| Vocative  | kuć-o    | kuć-e   |
| Instrumental | kuć-om | kuć-ama |
| Locative  | kuć-om   | kuć-ama |

Note. There are 7 noun cases in the Serbian language, both in singular and plural. This implies 14 possible distinct forms, but some forms overlap. As a result, there are 6 different inflection forms for each noun of the third declension in the Serbian language: kuć-a, kuć-e, kuć-i, kuć-o, kuć-u, kuć-om, kuć-ama.
Table 2

Average reaction time results by priming condition in Experiment 1

| Priming condition   | N  | M(ms) | SD  | Priming effect | 95% CI        |
|---------------------|----|-------|-----|----------------|---------------|
| Morph&Semantic      | 30 | 614.20| 79.98| -29.47         | [585.58, 642.82] |
| Morphological       | 30 | 646.73| 96.27| 3.07           | [612.28, 681.18] |
| Semantic            | 30 | 620.43| 79.16| -23.23         | [592.11, 648.76] |
| Neutral             | 30 | 643.67| 87.19| .00            | [612.47, 674.87] |

Note. Descriptive results for four different priming conditions by participants, with sample-size = N; mean = M; standard deviation = SD; and 95% Confidence interval = CI in Experiment 1. Additionally, the priming effect is reported as the reaction-time difference between the respective condition and the Neutral priming condition.
Table 3

Percentage of correct responses by priming condition in Experiment 1

| Priming condition   | N  | % correct | SD  |
|---------------------|----|-----------|-----|
| Morph&Semantic      | 30 | 97.56     | 3.71|
| Morphological       | 30 | 90.89     | 8.30|
| Semantic            | 30 | 94.44     | 7.02|
| Neutral             | 30 | 92.44     | 8.16|

Note. Percentage of correct responses and standard deviation by participants in each of four priming conditions in Experiment 1.
Table 4

Average reaction time results by priming condition in Experiment 2

| Priming condition     | N  | M (ms) | SD  | Priming effect | 95% CI               |
|-----------------------|----|--------|-----|----------------|----------------------|
| Morph&Semantic        | 28 | 663.00 | 103.30 | -35.25        | [624.74, 701.26]     |
| Morphological         | 28 | 691.14 | 102.14 | -7.11         | [653.31, 728.97]     |
| Semantic              | 28 | 672.32 | 111.91 | -25.93        | [630.87, 713.77]     |
| Neutral               | 28 | 698.25 | 111.09 | .00           | [657.10, 739.40]     |

Note. Descriptive results for four different priming conditions by participants, with sample-size = N; mean = M; standard deviation = SD; and 95% Confidence interval = CI in Experiment 2. Additionally, the priming effect is reported as the reaction-time difference between the respective condition and the Neutral priming condition.
Table 5

*Percentage of correct responses by priming condition in Experiment 2*

| Priming condition     | N  | % correct | SD |
|-----------------------|----|-----------|----|
| Morph&Semantic        | 28 | 93.93     | 6.85|
| Morphological         | 28 | 96.07     | 6.29|
| Semantic              | 28 | 97.50     | 5.18|
| Neutral               | 28 | 91.79     | 9.83|

*Note.* Percentage of correct responses and standard deviation by participants in each of four priming conditions in Experiment 2.
Figure 1
Trial structure of Experiment 1

After fixation cross (500ms), a prime noun is presented (250ms) followed by an inter-stimulus interval (300ms) with an empty screen and the target (presented for 1500ms or until response). During the presentation of the target, the participant needed to press the appropriate key (yes or no) indicating whether the target was a word or not.
Figure 2
Average reaction time by priming conditions in Experiment 1

The chart presents average reaction time by participants per priming condition (in milliseconds) in Experiment 1 with standard error of the mean (of the respective priming condition).
Figure 3
Trial structure of the Experiment 2

After the pattern mask, composed of hash-tags (500ms), a prime noun is presented (40ms) immediately followed by the target (presented for 1500ms or until response). During the presentation of the target, the participant needed to press the appropriate key (yes or no) indicating whether the target was a word or not.
Figure 4
Average reaction time by priming conditions in Experiment 2

The chart presents average reaction time by participants per priming condition (in milliseconds) in Experiment 2 with standard error of the mean (of the respective priming condition).