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THE COGNITIVE PROCESSING OF DERIVED NOUNS WITH AMBIGUOUS SUFFIXES: BEHAVIORAL AND EYE-MOVEMENT STUDY

The primary aim of this research has been to investigate whether the suffix ambiguity affects the lexical processing of derived nouns in Serbian. Consequently, in the Experiment 1, the derived nouns were presented isolated to participants in the visual lexical decision task. Bearing in mind that the sentence context was important for the lexical processing, the Experiment 2 was designed as an eye-movement study with the sentences (with derived nouns from the Experiment 1) as stimuli. To the best of our knowledge, the similar experimental study was not performed before in the Serbian language, and therefore this study represents the first attempt to investigate this phenomenon in Serbian. An identical statistical analysis was used to analyze the data collected in both experiments, the Generalized Additive Mixed Models (GAMMs). The final results of all GAMMs analyses suggested that the suffixal ambiguity did not affect the lexical processing of derived nouns in Serbian, regardless of whether they were displayed isolated or in the sentence context. The observed results supported the a-morphous perspective in the morpho-lexical processing, as well as the distributed morphology insights from the theoretical linguistics.

Key words: a-morphous morphology, derivational and distributed morphology, eye-movement study, lexical processing, suffix ambiguity

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Introduction

The ambiguity of linguistic units is a complex phenomenon, which appears at all language levels (Piantadosi, Tily, & Gibson, 2012). It is defined as a feature of any sentence, phrase, word, or morphemes to be realized through different meanings, although they are characterized by identical phonological, orthographic, and morpho-syntactic structure (Gortan-Premk, 2004). Although this definition seems straightforward, it is not always so easy to make a clear distinction between meanings. Previous theoretical studies have proposed linguistics tests, which help diagnosing a number of meanings, as well as the type of relations between meanings (e.g., semantically related, semantically unrelated etc.) (Lakoff 1970; Langacker 1987; Quine, 1960). One constant thing in all these linguistics tests is the importance of the linguistic context. In the case of ambiguous words without sentence context, it is unclear if the noun *bank* means a financial institution, or a land at a river edge (Tuggy, 1993). The same goes for ambiguous sentences. For instance, the syntactic structure makes the following sentence ambiguous "*The monkey wrote a poem on its favourite banana.*" and there are two possible meanings: (i) the monkey wrote about the banana, and (ii) the surface of the banana was written on (Adger, 2003). Similarly, morphemes (e.g., suffixes) are ambiguous, and the whole words are needed to convey a particular meaning (e.g., –*er* could serve both as a deverbal suffix [e.g., -*er* in *worker*], as well as a comparative form of adjectives [e.g., -*er* in *longer*]) (Davis & Gillon, 2004). According to previous empirical studies, ambiguous words, phrases, and sentences have been processed slower than unambiguous ones (Ferreira & Henderson, 1990; Foss, 1970; Gernsbacher, 1984)[2]. However, it is important to note that both in linguistics and psycholinguistics studies, a context plays the main role in the organization of lexicon (Jones, Dye, & Johns, 2017), even in the case of morphological processing (e.g., Bertram, 2011; Hyönä, Vainio, & Laine, 2002; Rayner, 1998).

Suffix Ambiguity in Previous Psycholinguistics Studies

Following traditional models of morphological processing (e.g., Butterworth, 1983; Taft, 2004; Taft & Forster, 1975), morphologically complex words are made up of several different types of morphemes (roots, affixes etc.). The phenomenon of ambiguous inflectional suffixes is considered as syncretism, which means that one inflectional suffix can play e more than one morpho-syntactic role (Catasso, 2011). For example, in Serbian, the inflectional suffix -*a* can refer to both nouns in genitive case (e.g., Volela sam priče svog *druga* [eng. I loved the stories of my

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[2] Even though the aim of the present study is not to deal with the lexical ambiguity, it is important to note that there are two groups of researchers interested in the two types of lexical ambiguity: (i) polysemy (e.g., Rodd, Gaskell, & Marslen-Wilson, 2002), and (ii) homonymy (e.g., Berreta, Fiorentino, & Poeppel, 2005). The first group of authors claims that polysemous words are processed faster than unambiguous words, while the second group suggests that homonymous words are processed slower than unambiguous words.

friend]), and in accusative case (e.g., Volela sam *druga* [eng. I loved my friend]). Although nouns with syncretic suffixes are orthographically and phonologically identical, the genitive and accusative cases in Serbian have different meanings (Stanojčić & Popović, 1992). In the field of psycholinguistics research, there are only a few studies dealing with the question of cognitive processing of ambiguous inflectional suffixes, and almost all of them have been conducted in the Slavic languages. The aim of the study conducted by Xiang and colleagues (Xiang, Harizanov, Polinsky, & Kravtchenko, 2011) is to examine the cognitive processing of a specific type of syncretic nouns in Slavic languages: nouns with paucal plural that denote the former duality. An example of such plurality in Serbian occurs in the paucal syntagmas, where the genitive singular is the same as accusative plural. The numbers two, three, and four go with nouns in plural (e.g., dva/tri/četiri pauka [eng. two/three/four spiders]), where the same suffix –*a* appears in the noun *pauka* (eng. spider), which is the same as genitive singular of the word *spider* in Serbian (pauka) (Belić, 2008). The results of this study suggest that the nouns with the paucal plural and syncretic suffixes are processed slower than nouns with a paucal plural and suffixes that are not syncretic (Xiang et al., 2011). In other words, it has been shown that the suffix ambiguity slows down the processing of syntagmas with inflected nouns. The results consistent with this one were also observed at the level of lexical processing in Serbian (Kostić, 1991, 1995; Kostić, Marković, & Baucal, 2003). The results of these studies conducted by Kostić and colleagues (Kostić, 1991, 1995; Kostić, Marković, & Baucal, 2003) suggested that inflectional nouns with syncretic suffixes slow down the lexical processing.

Another line of research does not consider the phenomenon of suffixal ambiguity separately for the inflectional and derivational suffixes (Bertram, Hyönä, & Laine, 2000a; Bertram, Laine, Baayen, Schreuder, & Hyönä, 2000b; Bertram, Laine, & Karvinen, 1999; Bertram, Schreder, & Baayen, 2000c). These authors define the phenomenon of suffixal ambiguity as the phenomenon where a suffix can have both roles, inflectional and derivational, in the same language (e.g., in English -*er* has a derivational role [e.g., -*er* in *worker*], as well as an inflectional [e.g., -*er* in *smaller*]). The first experiment in the series of these studies was conducted in Finnish in order to examine the cognitive processing of nouns with ambiguous suffixes (Bertram et al., 1999; Bertram et al., 2000b). The results suggested that nouns with unambiguous suffixes were processed faster than ambiguous ones. One of the potential explanations offered by the authors was that the suffixal ambiguity was a difficult problem for the parsing process in Finnish, due to the extremely productive morphology that this agglutinative language had. The same group of authors replicated the study in Dutch (Bertram et al., 2000c). The Dutch results confirmed the Finnish ones. Having in mind that all these experiments were visual lexical decision experiments, where the stimuli were presented isolated without a sentence context, and that the importance of the sentence context in the lexical processing was underlined many times before (e.g., Bertram, 2011; Hyönä et al., 2002; Rayner, 1998), Bertram and colleagues (Bertram et al.,

2000a) conducted an eye-movement experiment in Finnish. The stimuli used in this study were taken from the visual lexical decision experiments conducted in Finnish (Bertram et al., 2000b), but this time the stimuli were presented to participants in a sentence context. The results suggested that the effect of the suffix ambiguity did not reach statistical significance when the stimuli were presented in the sentence context (Bertram et al., 2000a). Defining suffixal ambiguity in this way would mean that it could not be investigated in all languages, given that some languages, such as Serbian, did not have suffixes with both inflectional and derivational roles. Moreover, only strictly inflectional suffixes were the subject of previous psycholinguistic studies, and therefore it was necessary to propose the third perspective in empirical investigation of this phenomenon, which would consider only derivational suffixes.

The third perspective in the psycholinguistics studies was interested in the phenomenon of nouns with strictly ambiguous derivational suffixes, without specifying the semantic relations between them (polysemy, homonymy, etc.). Although a lot of theoretical studies deal with this phenomenon (e.g., Arcodia, 2012; Lehrer, 2000), to the best of our knowledge, there are no empirical studies interested in the investigation of the cognitive processing of strictly ambiguous derivational suffixes in any language. Hence, the first step in this study was to precisely define the phenomenon of ambiguous derivational suffixes. In this study, ambiguous derivational suffixes were defined as derivational suffixes with more than one meaning (e.g., the suffix -*ica* can be used as a motion suffix in the noun *lavica* [eng. lioness], or as a diminutive in the noun *dušica* [eng. little soul], or as a suffix for description of human characteristics in the noun *dobrica* [eng. do-gooder]). Contrary, unambiguous suffixes were defined as suffixes with one meaning (e.g., the suffix –*nje* that can be used only as a deverbal suffix). Consequently, the definition proposed in this study did not take into account the specific subtypes of ambiguity in the case of derivational suffixes (the one with strictly semantically related, or unrelated meanings), and the focus was only at derivational suffixes with more than one meaning.

Models of Morphological Processing

The morphological complexity of words, as well as the range of different results observed in the psycholinguistics studies in different languages, inspired researchers interested in morphology to propose several different models of morphological processing. One group of authors supported the traditional models of morphological processing, which accentuated the importance of the characteristic of a single morpheme in the lexical processing. According to these models (Taft, 2004; Taft & Forster, 1975), morphemes were represented as independent lexical units in the mental lexicon, and their characteristics (e.g., suffix frequency, suffix ambiguity, etc.) affected the lexical processing. Although this perspective was very popular, it could not explain a lot of observed language phenomena, especially in languages with rich morphology such as Serbian (Kostić, 2010). Fol-

lowing this problem, the other group of authors proposed an opposite perspective in the lexical processing. They supported a belief that morphemes did not play an important independent role, and that morphology delt with relationships between whole words, not morphemes in particular (Anderson, 1992; Bybee, 1985). This perspective was called a-morphous morphology. Following this theoretical standpoint, the cognitive scientists proposed a few models for the interpretation of results observed in the psycholinguistics studies. One of the models that was the most successful in interpreting a very large number of effects recorded in the morpho-lexical processing was Naïve Discriminative Learning (NDL) model (e.g., Baayen, 2011; Milin, Feldman, Ramscar, Hendrix, & Baayen, 2017). This model was a learning-based model with the basic idea that during lexical processing a form was mapped onto a meaning. In other words, morphology was not present as a single level of processing per se, but it was a product of the mentioned mapping processing. The Naïve Discriminative Learning (NDL) model demonstrated the success of this a-morphous perspective in the lexical processing in a larger number of research, in both inflectional and derivational morphology (Milin, Divjak, Dimitrijević, & Baayen, 2016; Milin et al., 2017; Plag & Winter Balling, in press). Finally, it is important to mention that this a-morphous perspective in the lexical processing in the field of derivational morphology is very similar to distributed morphology, a derivational morphology perspective from theoretical linguistics (Halle, 1990, 1997). Both perspectives reject the single morpheme characteristics as the influential in the lexical processing. Taking this into consideration, one could expect that in the case of lexical processing of derived nouns with ambiguous suffixes a-morphous and distributed morphology approaches could have a significant advantage.

The Present Study

The aim of the present study was (i) to investigate the effect of suffix ambiguity in the processing of derived Serbian nouns in the visual lexical decision task (Experiment 1), (ii) to investigate the existence of the same effect in an eye-movement study (Experiment 2). To the best of our knowledge a similar study has not been conducted in Serbian, so this study is a first attempt to investigate the phenomenon of suffixal ambiguity defined in this manner. However, based on the suffixal ambiguity studies with different definitions, some expectations have been formed. First, according to the findings of Bertram and colleagues (Bertram et al., 1999; Bertram et al., 2000a), it has been expected that the derived nouns with ambiguous suffixes, presented in the visual lexical decision task, could be processed slower than unambiguous ones. Furthermore, as reported by the same group of authors (Bertram et al., 2000a) those results are not expected to be replicated in the eye-movement study. Differently put, it has been expected that the suffixal ambiguity would not affect the cognitive processing of nouns presented in the sentence context.

Experiment 1

The present experiment aimed to test if there were any effects of suffix ambiguity in the cognitive processing of derived nouns in Serbian. The stimuli were presented isolated in the visual lexical decision task.

Method

Participants. Forty-six students (mostly female bachelor students ([mean age = 23] at the Department of Psychology, Faculty of Philosophy, University of Novi Sad) participated in this experiment. The experiment was carried out according to the ethical rules specified by the Helsinki declaration. The students participated in the experiment as a part of their academic requirements, and every participant signed the consent form (approved by the Ethical Committee of the Department of Psychology, Faculty of Philosophy, University of Novi Sad)[3]. All participants were native speakers of Serbian, with normal or corrected-to-normal vision.

Design. A factor that was manipulated in this experiment was Suffix ambiguity, and it had two levels: ambiguous suffix (with more than one meaning), and unambiguous suffix (with a single meaning). The meanings of suffixes were listed according to the theoretical linguistics literature (Klajn, 2005). The following covariates were included in the experimental design: Word length (measured in letters), Lemma frequency from srWac corpus (Ljubešić & Klubička, 2016), Suffix length (measured in letters), Suffix frequency and Suffix productivity from database with quantitative measures for Serbian derivational suffixes (Gatarić & Filipović-Đurđević, 2015). The dependent variables in this experiment were the Response time (measured in milliseconds) and Accuracy (correct/incorrect answer).

Stimuli. The stimuli were 88 derived Serbian nouns with ambiguous and unambiguous derivational suffixes. Each noun had its pair, with the same stem, but with a different suffix: one of two suffixes was ambiguous (e.g., –*če* in the noun *anđelče* [eng. A little angel]), and the other one was unambiguous (e.g., –*ak* in the noun *anđelak* [eng. a little angel]). Pairs of the derived nouns were used in order to control for the effects that could arise from the characteristics of a stem (e.g., morphological family size, etc.), which quantitative measure is still not available for the Serbian language. The same number of pseudo-nouns (*N* = 88) were formed by taking Serbian phonotactic constraints into account. All stimuli were randomly divided into two experimental groups with the Latin square design.

Procedure. The stimuli were presented in a visual lexical decision task by using OpenSesame software (Mathôt, Schreij, & Theeuwes, 2012), on a standard

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[3] The present research was done while I was affiliated with the Department of Psychology, Faculty of Philosophy, University of Novi Sad, which was the reason why this research was approved by the Ethical Committee of that Department.

PC configuration (Pentium® Dual-Core CPU E6600 processor/3.06 GHz/2.00 GB RAM, with monitor set to 75Hz vertical refresh rate and 1600x1200 pixels resolution). The participants were instructed to answer as quickly as possible whether the presented string of letters was a word in Serbian or not. They answered by pressing the buttons of the keyboard: "M" for words, and "C" for non-words (a positive answer was mapped to the dominant hand). The presentation of all stimuli (words and non-words) was preceded by a 1000ms fixation point, and they remained on the screen until the participants' response, or until 3000ms had passed. The interstimulus interval was 500ms. The stimuli were written in white (font mono), capitalized, and presented on the black screen. The stimuli materials were preceded by eight practice trials (four nouns and four pseudo-nouns), and they were not included in the data analysis. The order of stimuli presentation was randomized for each participant.

Results

The first step in the preparation of data for statistical analysis was the exclusion of participants and stimuli with more than 25% of errors. In total, fourteen noun items were excluded from further analysis, but none of the participants crossed that limit of errors. The data were analyzed in *R* (R Core Team, 2017), free software for Statistical Computing, by using the packages *mgcv* (Wood, 2006, 2011) and *itsadug* (van Rij, Wieling, Baayen, & van Rijn, 2016). Following Baayen and Milin (2010), reaction times were transformed by applying an inverse transformation (-1000/RT), while the Lemma frequency, Suffix frequency, Suffix length, Suffix productivity, and Noun length were log-transformed. Furthermore, all numeric predictors were standardized by centring to zero and dividing by the standard deviation (Gelman & Hill, 2007). The collinearity between predictors was tested with the Cohen's kappa coefficient (Belsley, Kuh, & Welsch, 1980), and it was shown that it was high (κ = 38.82). Therefore, we excluded the predictors Suffix frequency and Suffix length from further analysis, for which it was shown that they correlated very highly with other predictors from the set (r = .91; r = .62). After that, we tested the collinearity again, and the Cohen's kappa coefficient significantly reduced (κ = 29.17). Having in mind that still this collinearity was close to high, processing latencies were fitted with the Generalized Additive Mixed Model (Wood, 2006, 2011), because this statistical analysis was less sensitive to collinearity. In addition to test the significance of the fixed effects, two random effects were controlled: the random effect of stimuli, as well as random effect of participants (Subject in Table 1). The random effect of participants was included with by-participant factorial smooths over trials from the experiment (Table 1), which increased the level of control of the effects that could result from trials characteristic in the case of different participants from the experiment. After this preparation of predictor and the creation of GAMMs model, standardized residuals that exceeded the range of –2.5/+2.5 standard units were excluded. This final model

was refitted, and the model criticism (Baayen & Milin, 2010) suggested that the final model was vigorous, and that there were no significant differences between the model before and after removing of residual values. The best final refitted GAMMs model is presented in the Table 1.

Table 1

Coefficients from the Generalized Additive Mixed Model fitted to transformed re-sponse latencies[4]

Parametric coefficients	Estimate	Std. Error	T	Pr(>|t|)
Intercept	-1.41	.02	-48.05	.00***
Trial order (order of presentation)	-.00	.01	-.85	.39
Suffix ambiguity = ambiguous	-.01	.01	-.92	.35
Smooth terms	edf	Ref.df	F	p
s(Noun length): Suffix ambiguity (ambiguous)	3.965e+00	4.50	4.80	.00**
s(Noun length): Suffix ambiguity (unambiguous)	4.528e+00	5.23	9.04	.00***
s(Lemma frequency)	-2.545e+00	3.11	-53.67	.00***
s(Suffix productivity)	2.912e+00	3.48	1.63	.14
s(Stimuli)	1.132e-04	1.00	.00	.79
s(Trial order, Subject)	1.210e+02	413.00	2.71	.00***

Notes. s - thin plate regression spline smooth.
** *p* < .01. *** *p* < .001.

The final model suggested the existence of the following effects. As expected, an inhibitory effect of Noun length was observed on both levels of Suffix ambi-guity factor (ambiguous, and unambiguous suffixes), which means that longer derived nouns, regardless of the suffix ambiguity, were processed slower than shorter ones. Also, the facilitatory effect of the Lemma frequency was observed, which suggested that the more frequent stimuli were processed faster. Further-more, the main effect of Suffix ambiguity proved to be statistically insignificant, which means that there were no differences in the processing latencies of derived nouns with ambiguous, and unambiguous suffixes.

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[4] The final GAMMs model presented in each of the analyses (from both experiments) represents the best possible model (with all its predictors and their relations), which is a product of step-by-step statistical modelling. Furthermore, the predictors which effects are not statistically significant are included in the table, and their presentation (as well as elimination) has not distorted the structure of the final results. More precisely, their ejection from the model hasnot led to a change in the results, and their presence does not break the final results structure.

Experiment 2

The experiment was created following the findings from the previous studies interested in the phenomenon of suffixal ambiguity, which suggested that the effect of suffix ambiguity was present when stimuli were presented isolated (in the visual lexical decision task), but this effect was not present when the stimuli were within the sentence context (Bertram et al., 2000a). In order to check these inconsistent results, Experiment 2 was created with the sentence context and the derived nouns with ambiguous, and unambiguous suffixes used in Experiment 1.

Method

Participants. Thirty-six students (mostly females, bachelor students (mean age = 22) at the Department of Psychology, Faculty of Philosophy, University of Novi Sad) participated in the second experiment. None of the participants in this experiment participated in the previous experiment. The experiment was carried out according to the ethical rules specified by the Helsinki declaration. Furthermore, the students took part in this experiment as a part of their academic requirements, and every participant signed the consent form (approved by the same Ethical Committee as in the previous experiment). All participants were native speakers of Serbian, with normal or corrected-to-normal vision, and they were randomly divided into one of two experimental groups.

Design. Following the suggestions about the most efficient early and late measures in an eye-movements studies interested in the investigation of cognitive processing of morphologically complex words (Bertram, 2011), the following measures were collected in this experiment: Gaze duration, Dwell time, and the First fixation duration. The factor and the covariates were the same as in Experiment 1.

Stimuli. The stimuli were couplets of identical sentences (*N* = 88) that contained the pairs of derived nouns presented in the Experiment 1 (e.g., *Na jelci je anđelak sa zlatnim krilima* [s1]; *Na jelci je anđelče sa zlatnim krilima* [s2] [eng. On the Christmas tree, there is an angel with golden wings]). The pairs of sentences with an identical context were selected in order to control for the effects that could arise from syntactic characteristics of the sentences. Furthermore, all the sentences had the same syntactic structure. The critical word (a noun with ambiguous/unambiguous suffix) always appeared at the third place in the sentence (e.g., *anđelak* [eng. a little angel]). An adverbial of place was at the first place (e.g., *Na jelci* [eng. On the Christmas tree]), followed by an auxiliary verb (e.g., *je* [eng. is]), and the prepositional phrase always appeared after the critical word, at the last position (e.g., *sa zlatnim krilima* [eng. with golden wings]). Except for the stimuli, the filler sentences (*N* = 88) were also included in the experiment. They had a different syntactic structure from the stimuli sentences, in order to prevent the development of the expectations of a critical word at a particular place in the

sentences. All stimuli were randomly divided into two experimental groups with the Latin square design, the same as in the Experiment 1.

Apparatus and Procedure. Eye movements were recorded with the SR Research EyeLink II system with a sampling rate of 500Hz (SR Research Ltd., 2008). The whole experiment was created in the SR Research Experiment Builder and Data Viewer software, and the viewing was binocular, but only the right eye was monitored. Following calibration, gaze-position error was less than 0.5°. The stimuli were displayed on a ViewSonic monitor (Intel Pentium Dual-Core CPU G630 processor/2.70 GHz/3.22 GB RAM, with monitor set to 85Hz vertical refresh rate and 1280x1024 pixels resolution). All the letters were lowercase (except at the beginning of the sentence and when it was necessary to put capital letters). The sentences were presented in a Courier New font, they were black on a white background. The participants were set to sit 60cm from the monitor. Before the beginning of the presentation of each sentence, a fixation point appeared on the screen, and remained there until the moment the sentence was presented to the participant. The participants' task was to read the sentences, and after they finish reading of a sentence, they should press the key. After that, the experimenter released the next sentence to the participant. Prior to the presentation of the stimuli, the right eye calibration was performed with help of three crossed points. Also, participants were displayed three sentences, which were neither found among the experimental stimuli, nor among the sentences of the fillers, but which served only as an exercise. The entire experimental procedure of displaying sentences and setting of cameras lasted for about twenty minutes on average.

Results

The data with lower than 50ms, and higher than 1000ms, were excluded from further statistical analysis. The total percentage of excluded data was 13%. For data analysis free software *R* was used (R Core Team, 2017), and the same packages as in the Experiment 1: *mgcv* (Wood, 2006, 2011) and *itsadug* (van Rij, Wieling et al., 2016). All dependent variables (Gaze duration, Dwell time, and the First fixation duration) were transformed with the log transformation, as well as all covariates (Lemma frequency, Suffix frequency, Suffix length, Suffix productivity, and Noun length). Following the procedure of pre-processing of data from the Experiment 1, all numeric predictors were standardized as in the Experiment 1 (Gelman & Hill, 2007). After testing of collinearity between predictors, the same covariates were excluded from the further analysis due to the high value of Cohen's kappa coefficient (Belsley et al., 1980). Afterwards collinearity was reduced, but still not small ($\kappa = 30.07$). Bearing in mind that the collinearity still existed, all three measures of reading were fitted with the Generalized Additive Mixed Model (Wood, 2006, 2011). First early measure of eye-movement – First fixation duration (GAMMs I) was analyzed, afterwards the later ones– Gaze duration (GAMMs II), and Dwell time (GAMMs III) were analyzed.

GAMMs I: First fixation duration. In addition to test the significance of the fixed effects, two random effects were controlled: a random effect of stimuli, as well as a random effect of participants (Table 1). The same as in the Experiment 1, the random effect of participants was included with by-participant factorial smooths over trials from the experiment. After all pre-processing of data, different GAMMs models were created, but the final one was refitted with the exclusion of standardized residuals that exceeded the range of –2.5/+2.5 standard units. After that, the model criticism was applied to the final model (Baayen & Milin, 2010), and it suggested that the final model was vigorous enough, so that there were no significant differences between the model before and after residual values were removed.

Table 2

Coefficients from the Generalized Additive Mixed Model fitted to first fixation duration time

Parametric coefficients	Estimate	Std. Error	t	$Pr(>|t|)$
Intercept	5.45	.02	203.59	.00***
Trial order (order of presentation)	-.00	.01	-.02	.98
Suffix ambiguity = ambiguous	-.00	.02	-.40	.68
Lemma frequency	-.02	.00	-2.98	.00**
Smooth terms	edf	Ref.df	F	p
s(Noun length)	1.74	2.18	.74	.57
s(Suffix productivity)	3.05	3.69	1.08	.30
s(Stimuli)	.75	1.00	3.06	.04*
s(Trial order, Subject)	56.96	323.00	.76	.00***

Notes. s - thin plate regression spline smooth.
* $p < .05$. ** $p < .01$. *** $p < .001$.

The results printed in Table 2 suggest that the main effect of Suffix ambiguity is not statistically significant, which means that there are no differences in the processing of Serbian derived nouns with ambiguous and unambiguous suffixes. Furthermore, as observed in the first data analysis (Table 1), the final model suggests that the facilitatory effect of the Lemma frequency is present in this analysis as well (Table 2).

GAMMs II: Gaze duration. The same as in the previous analysis of measure First fixation duration, the random effect of participants was included with by-participant factorial smooths over trials from the experiment. Furthermore, the random effect of stimuli was controlled, as well as a few fixed effects. After pre-

processing of data, different GAMMs models were created, but the final one was refitted with the exclusion of standardized residuals that exceeded the range of –2.5/+2.5 standard units. Moreover, the model criticism (Baayen & Milin, 2010) was applied to the final model, and it suggested that there were no significant differences between the model before and after residual values were removed.

Table 3

Coefficients from the Generalized Additive Mixed Model fitted to first fixation duration time

Parametric coefficients	Estimate	Std. Error	*t*	*Pr(>|t|)*
Intercept	5.75	.02	193.73	.00***
Trial order (order of presentation)	-.02	.01	-2.01	.04*
Suffix ambiguity = ambiguous	-.04	.02	-1.64	.10
Lemma frequency	-.03	.01	-3.07	.00**
Smooth terms	edf	Ref.df	*F*	*p*
s(Noun length)	1.43	1.76	43.45	.00**
s(Suffix productivity)	1.00	1.00	5.33	.02*
s(Stimuli)	.00	1.00	.00	.32
s(Trial order, Subject)	31.09	323.00	.51	.00***

Notes. s - thin plate regression spline smooth.
*$p < .05$. ** $p < .01$. *** $p < .001$.

The results of the third GAMMs analysis (Table 3) suggest that there is no main effect of Suffix ambiguity, as expected by following the results from the previous data analysis (Table 1, Table 2). Furthermore, covariates have accomplished expected effects: the facilitatory effect of the Lemma frequency, and the inhibitory effect of the Noun length (Table 3). Also, Suffix productivity has achieved an inhibitory effect on the lexical processing, which means that the derived nouns with more productive suffixes have been processed slower.

GAMMs III: Dwell time. The pre-processing of data for the analysis of the measure Dwell time was identical as in the previous analysis of measures First fixation duration and Gaze duration.

Table 4

Coefficients from the Generalized Additive Mixed Model fitted to first fixation duration time

Parametric coefficients	Estimate	Std. Error	t	Pr(>|t|)
Intercept	6.01	.04	146.23	.00***
Trial order (order of presentation)	-.03	.01	-3.05	.00**
Suffix ambiguity = ambiguous	.01	.03	.51	.60
Lemma frequency	-.10	.01	-7.91	.00***
Smooth terms	edf	Ref.df	F	p
s(Noun length)	1.96	2.48	31.80	.00***
s(Suffix productivity)	3.21	3.87	2.76	.01**
s(Stimuli)	.94	1.00	17.79	.00***
s(Trial order, Subject)	30.00	323.00	.65	.00***

Notes. s - thin plate regression spline smooth.
* *p* < .05. ** *p* < .01. *** *p* < .001.

The results of the final GAMMs III (Table 4) suggest that again there is no main effect of the Suffix ambiguity, which fully support all the results observed in the previously described data analysis (Table 1, Table 2, Table 3). Furthermore, covariates Noun length, Lemma frequency, Suffix productivity, and Trial order have reached statistically significant effect on the processing of the derived nouns, in the directions that goes in line with findings from the previously described data analysis.

Discussion

The present study primarily aimed at answering whether there were differences in the cognitive processing of derived nouns with ambiguous and unambiguous derivational suffixes in Serbian. Two experiments were carried out to achieve this goal, the visual lexical decision task (Experiment 1) and the eye-movement study (Experiment 2). Two experiments were performed because one of the secondary goals was to investigate if the identical effect was recorded in two different experimental tasks, one in which the stimuli were exposed isolated (derived nouns only), and the other in which the stimuli were presented in the sentence context (sentences with the derived nouns). The results suggested that there were no differences in the cognitive processing of derived nouns with am-

biguous and unambiguous suffixes, regardless of whether they were presented isolated or in a sentence context.

Previous psycholinguistic studies dealing with the issues of cognitive processing of nouns with ambiguous suffixes are consistent with the finding that suffixal ambiguity slows down the lexical processing of inflectional nouns (Kostić, 1991, 1995; Kostić et al., 2003; Xiang et al., 2011), as well as the nouns with an ambiguous suffixes that can play both roles: inflectional and derivational (Bertram et al., 1999; Bertram et al., 2000b; Bertram et al, 2000c). However, these findings are constant only when the stimuli (nouns) are presented to participants isolated. Contrary, when the nouns are embedded in the sentence context, this effect is not significant (Bertram et al., 2000a). Moreover, it is important to mention that all described psycholinguistic studies are completely ignoring a special case of suffixal ambiguity, when the ambiguous suffixes are strictly derivational and have more than one meaning. However, previous theoretical studies (Arcodia, 2012; Lehrer, 2000) suggest that this type of ambiguity is important to distinguish from the other type of suffixal ambiguity, especially in the languages like Serbian, where the suffixes are strictly derivational or inflectional. Following that thought, this study has dealt only with the derived Serbian nouns with strictly derivational suffixes with one meaning (unambiguous), or more than one meaning (ambiguous).

The results observed in the Experiment 1 suggest that there are no differences in the processing of derived nouns with ambiguous and unambiguous suffixes when they are presented in the visual lexical decision task. This finding is in line with the a-morphous perspective in the lexical processing (Baayen, 2011; Milin et al., 2017). This perspective rejects the features of the single morpheme (e.g., suffixes) as a relevant factor in the lexical processing. More precisely, the fact that one suffix is ambiguous does not affect the processing of the entire derived nouns, because morphology is considered to be a product of mapping the form (orthography) onto the meaning (semantics) (Anderson, 1992; Bybee, 1985). Hence, the results observed in this study fully support the idea proposed by the authors of a-morphouslexical processing models. However, although there are no previous similar empirical studies that deal with this topic, it is important to notice that those results are the opposite from the ones observed in Dutch and Finnish (e.g., Bertram et al., 1999; Bertram et al., 2000b; Bertram et al., 2000c). The first explanation is that Dutch and Finnish experiments treat the suffixal ambiguity in a different way, and take into consideration only specific types of ambiguous suffixes (the one that can be both inflectional and derivational at the same time). Having in mind the fact that there are no such suffixes in Serbian, the results of these studies are in that sense incomparable. However, there is one more viable explanation, which is related to semantic features of Serbian derived nouns. The pair of derived nouns that have been used as stimuli (e.g., *anđelak-anđelče*) have the same meaning: they both refer to diminutives. According to the a-morphous perspective in the language processing, the semantics of derived nouns is a feature of a noun that could affect its lexical processing (Anderson, 1992). Having in mind

that fact, it is possible that the lack of any differences in the cognitive processing of these derived nouns is caused by this similarity. For the final conclusion about this the further study is needed, the one where the semantics features of the derived nouns will be controlled in more details.

The results observed in the Experiment 2, on both early and late measures, are in line with the results observed in the Experiment 1. The result suggests that there are no differences in the processing of sentences with the derived nouns with ambiguous and unambiguous suffixes. Furthermore, the final results are the same at the both levels of language processing (early and late), which further strengthens the findings of this research. As it has been mentioned in the previous paragraph, the fact that suffix ambiguity phenomenon defined like in this study is not comparable with all the others from psycholinguistics studies (Bertram et al., 2000b), and thus, it is impossible to compare in detail the results from the previous studies and from this one. However, those results are very similar in general, suggesting that the effect of suffix ambiguity is not present when the entire sentences, not only isolated words, were presented to readers in the experiment. Once again, those results highlight the importance of a language context in the psycholinguistics interested in morpho-lexical processing, like it was mentioned many times before (Bertram, 2011; Hyönä et al., 2002; Rayner, 1998). Moreover, the final results in general suggest the importance of the more rigorous control of the semantic features of derived nouns in further morpho-lexical studies interested in the similar linguistics phenomenon.

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KOGNITIVNA OBRADA DERIVIRANIH IMENICA SA VIŠEZNAČNIM SUFIKSIMA: BIHEJVIORALNA I STUDIJA OČNIH POKRETA

Primarni cilj ovog istraživanja bio je da ispita da li višeznačnost sufiksa utiče na leksičku obradu deriviranih imenica srpskog jezika. Shodno tome, u Eksperimentu 1 su derivirane imenice predstavljene ispitanicima izolovano u zadatku vizuelne leksičke odluke. Imajući u vidu to da je rečenični kontekst važan za leksičku obradu, Eksperiment 2 je dizajniran kao studija očnih pokreta sa rečenicama kao stimulusima (rečenicama u kojimasu se nalazile derivirane imenice iz Eksperimenta 1). Prema našim saznanjima, slično eksperimentalno istraživanje nije do sada sprovedeno na srpskom jeziku, tako da ova studija predstavlja prvi pokušaj istraživanja ovog fenomena u srpskom. Identična statistička analiza korišćena je za analizu podataka prikupljenih u oba eksperimenta - Generalizovani Aditivni Mešoviti Modeli (GAMMs). Finalni rezultati svih GAMMs analiza ukazuju na to da višeznačnost sufiksa ne utiče na leksičku obradu deriviranih imenica srpskog jezika, bez obzirana to da li su stimulus i prikazani izolovano ili u rečeničnom kontekstu. Dobijeni rezultati u potpunosti podržavaju a-morfnu perspektivu morfološko-leksičke obrade, kao i distributivni morfološki pristup iz teorijske lingvistike.

Ključne reči: a-morfna morfologija, derivaciona i distributivna morfologija, leksička obrada, studija očnih pokreta, višeznačnost sufiksa