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Morpho-semantic properties of Serbian nouns: Animacy and gender pairs

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In this study we investigated whether and how the cognitive system uses morphological markedness of animacy and gender pairs. In the Serbian language masculine nouns are marked for animacy (i.e., genitive-accusative syncretism), while for feminine nouns the animacy distinction is purely semantic. Thus, in Experiment 1 we used this natural, linguistic differentiation to test whether morphological markedness of animacy influences lexical processing. In the same experiment, we tested whether the cognitive system is sensitive to the fact that some animate nouns have a sibling in the other gender (e.g., *dečak* /"boy"/ – *devojčica* /"girl"/), while others do not have it (e.g., *vojnik* /"soldier"/ or *žirafa* /"giraffe"/). We labeled this indicator *sibling presence*. The analysis did not confirm the effect of animacy, neither between nor within genders. However, animate nouns with a sibling were processed faster than those without a sibling. Since the majority of sibling nouns are morphologically related (like *konobar* /"waiter"/ – *konobarica* /"waitress"/), while the rest are not (e.g., *petao* /"rooster"/ – *kokoška* /"hen"/), in Experiment 2 we tested whether morphological relatedness contributed to the effect of sibling presence. Results showed that this is not the case: morphologically related and unrelated masculine-feminine pairs of nouns (siblings) were processed equally fast. Furthermore, an interaction between the target's frequency and the frequency of its sibling was observed: nouns with a more frequent sibling benefited more from their own frequency than those with a less frequent sibling. We argue that sibling support is realized through semantic, not morphological relations. Taken together, our findings suggest that morphological markedness is not used in lexical processing, which is in line with an *amorphous* approach to lexical processing.

Keywords*: lexical processing, animacy, gender pairs*

In many languages, semantic information about individual words can be expressed through morphological cues. For example, in Serbian, animacy – the distinction between animate (living) and inanimate (non-living) entities – represents such a morphologically marked semantic property. The same property can be observed in all Slavic languages[1], as a specific affixal variation

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1 The exception being Bulgarian and Macedonian which do not have inflective case system.

between animate and inanimate nouns. This makes animate nouns overtly coded. However, an affixal difference between animate and inanimate nouns exists only in the masculine gender. For feminine nouns, the animacy distinction is purely semantic, i.e., there is no morphological cue for animacy in feminine nouns.

The animacy markedness of Serbian masculine nouns is realized as the same inflected variant of the genitive singular and accusative singular cases for animate nouns (with the exponent **-a**). In traditional linguistics this phenomenon is labeled *genitive-accusative syncretism* (henceforth: GA syncretism). At the same time, for inanimate masculine nouns the accusative singular shares its inflected variant with the nominative singular (having an unmarked, *zero* exponent **-Ø**). As mentioned, this markedness for animacy is present only in the masculine gender. There is no difference in declension of feminine nouns depending on their animacy. An example of these morphological differences is presented in Table 1, with the critical cases (nominative, genitive and accusative) for the feminine animate noun *sestra* ("sister"), the feminine inanimate noun *kašika* ("spoon"), the masculine animate noun *brat* ("brother"), and the masculine inanimate noun *nož* ("knife").

Table 1. GA syncretism for Serbian masculine nouns and its absence for Serbian feminine nouns

	Feminine		Masculine	
	Animate	Inanimate	Animate	Inanimate
Nominative	sestr-**a**	kašik-**a**	brat-**Ø**	nož-**Ø**
Genitive	sestr-**e**	kašik-**e**	brat-**a**	nož-**a**
Accusative	sestr-**u**	kašik-**u**	brat-**a**	nož-**Ø**

We found the observed difference in realization of animacy between masculine and feminine genders in the Serbian language to be attractive for experimental evaluation of lexical processing. It would be interesting to understand whether and why we need this specific morphological markedness present in the masculine gender, and how we behave in case of its absence in the feminine gender. By comparing processing of animate and inanimate nouns in both masculine and feminine genders, we could draw conclusions about lexical processing in general and particularly about the role morphology plays in it.

Theories of lexical processing do not agree on the status of morphology in the mental lexicon. The classical view of lexical processing assumes that words consist of discrete constituents - *morphemes*, which are minimal meaning-bearing units. Morphemes could be either free (*dark* in *darkness*) or bound (*-ness* in *darkness*), but both are represented in the mental lexicon and used in lexical processing for computing the meaning of the whole word (e.g., Taft & Forster, 1975; Taft, 2004; Rastle, Davis, & New, 2004). On the other hand, there are researchers who argue that morphological structures do not play an important role in lexical processing, and that effects claimed to be morphological in nature could be accounted for by other lexical variables, such as orthographic, phonological and semantic features of words, with which morphology is highly correlated (Harm & Seidenberg, 1999, 2004; Plaut & Gonnerman, 2000; also, recently discussed in Baayen et al., 2011, etc.). In other words, morphological relations are seen as emergent from correlations between orthography/phonology and semantics.

Ideas consistent with this *amorphous* view of lexical processing can be found in theoretical linguistics too. For example, the *Word and Paradigm* approach assumes that the whole words forms, organized into paradigms, are the basic units of the language system (for details, see, e.g., Anderson, 1992; Aronoff, 1994, Blevins, 2003, 2006). Similarly, Bybee's (1985) *Examplar Model* assumes that words, not morphemes, are the basic units of morphological analysis. Within this framework, morphological relations emerge from the categorization involved in storage which is based on orthographic/phonological and semantic similarities.

The present experimental outcomes can aid the dispute between morphology-based and amorphous models of lexical processing. In case that morphological markedness is used during word recognition, the results must show some advantage for masculine nouns: the animacy effect could be present in the masculine gender, but not in the feminine or, the animacy effect could be observed in both genders, but be stronger in masculine. If morphology does not play a role in lexical processing, we can expect some early orthographic/phonological effects, as well as some semantic effects, but no difference in these effects between masculine (animacy marked) and feminine (animacy unmarked) nouns.

Animacy as a semantic property

Most studies that have investigated the effect of animacy as a semantic property were conducted in the English language, in which the distinction between animate and inanimate nouns is purely semantic. Animacy is extensively investigated in order to draw conclusions about semantic/meaning processing (e.g., Cappa, Perani, Schnur, Tettamanti, & Fazio, 1998; Grabowski, Damasio, & Damasio, 1998; Moore & Price, 1999; Mummery, Patterson, Hodges, & Price, 1998; Tyler & Moss, 2001; Tyler, Moss, Durrant-Peatfield, & Levy, 2000; Warrington & McCarthy, 1987, etc.). However, findings regarding the cognitive effects of animacy, observed using behavioral and/or neuroimaging techniques, are rather inconsistent. There are studies which reported significant differences in processing of animate and inanimate entities (Martin, Wiggs, Ungerleider, & Haxby, 1996; Perani et al., 1995; 1999, etc.), as well as those which failed to demonstrate any difference (Devlin et al., 2002; Pilgrim, Fadili, Fletcher, & Tyler, 2002; Tyler et al., 2003a, etc.). Comparing these inconsistencies Tyler and her associates (2003b) claimed that they could occur due to uncontrolled characteristics of stimuli such as familiarity, imageability, and frequency, rather than differences between the mental representations of animate and inanimate entities.

We assume it is likely that inconsistent operationalizations of animacy also contributed to such mixed results. On the one hand, the most common animacy distinction includes animals vs. tools. All of the above-mentioned studies which reported differences in processing of animate and inanimate entities used only these two categories as representative for all animates and inanimates, respectively. On the other hand, studies that failed to demonstrate the effect of animacy used several categories of entities to instantiate animate and inanimate classes. Hence, it seems that only a specific and narrow selection of animate/ inanimate categories generates the processing effect, while a wider selection - one that includes various categories - fails to replicate this effect. Members of various categories of entities differ in how representative they are for classes of animates or inanimates. For example, animals and tools are typical categories of their animacy classes. They might be able to generate a processing difference because they are important for us and we might have more information about them. Conversely, including a wider selection of exemplars across classes would include entities that belong to less typical and less important categories of animate and inanimate classes, which would, consequently, obscure the processing difference.

From our point of view, a thorough empirical justification is needed to use a particular category (e.g., animals) as representative for the whole class of animate entities. An a priori and/or implicit hypothesis might lead to unexpected if not wrong conclusions. From a naïve viewpoint, including various categories of words ought to assure the generalizability of any finding of differences between animate and inanimate entities in general.

Animacy as a morpho-semantic property

For languages in which, unlike English, there is also a distinction between animate and inanimate nouns on a morphological level, the effect of animacy has not been so extensively investigated. The study of Radivojević and Kostić (2003) seems to be the only empirical study that has offered some understanding about cognitive processing of noun animacy in any Slavic language. It was conducted in the Serbian language and it showed that animate masculine nouns are processed faster than inanimate. Unfortunately, as stated by the authors, word frequency was not controlled for, and this might have confounded the effect of animacy. Additional analysis showed that one paradigm – the paradigm of animate nouns – determines processing of all masculine nouns, irrespective of their animacy. This would suggest that the cognitive system is not sensitive to morphological differences regarding animacy, which are present in the masculine gender of Serbian nouns.

The study of Radivojević and Kostić (2003) served as a point of departure for the present study. We aimed at a somewhat different research question and, thus, modified their methodology. We were interested in whether the cognitive system is sensitive to the semantic distinction between animates and inanimates, to the additional morphological markedness in the masculine gender, or both. Therefore, we selected both masculine and feminine nouns for Experiment 1. In this way we made it simple and easy to answer the question whether the cognitive system uses the morphological markedness of animacy, as a morphology-based approach would suggest. We also included a wider variety of nouns to make any results about differences between animate and inanimate generalizable. Finally, we controlled for the fact that some animate nouns have a sibling in the other gender (e.g., *glumac* /"actor"/ – *glumica* /"actress"/), while others do not (like *mornar* /"sailor"/ or *žirafa* /"giraffe"/).

Interplay between grammatical and semantic information in noun gender

Grammatical gender is a syntactic category which, in most cases, has arbitrary semantics (Corbett, 1991). However, for some nouns whose referents have a biological sex, grammatical gender is based on semantics. Namely, these nouns receive their grammatical gender by means of the natural one. All these nouns have a sibling in the other gender, i.e., there is a corresponding noun which is equal in all characteristics except in gender (e.g., *glumac* /"actor"/ – *glumica* /"actress"/). Contrariwise, nouns without a sibling (like *mornar* /"sailor"/ or *žirafa* /"giraffe"/) have only a specified grammatical gender. The natural gender of a referent can be either. Therefore, the grammatical gender of these nouns is strictly a lexical property, not related to the natural gender of the referent.

To our best knowledge, the presence of a sibling in the other gender was not taken into account in previous studies of the animacy effect. However, Deutsch, Bentin, & Katz (1999) reported an effect of information about natural gender on grammatical gender agreement in Hebrew, thus showing that semantic information about gender can affect syntactic processing. These authors compared the effect of subject-predicate gender agreement violation in sentences in which the subject was animate (both grammatical and semantic mismatch present) and in sentences with an inanimate subject (only grammatical mismatch present). The results showed that the congruity effect on naming latencies was larger when the same predicate was coupled with an animate subject than when it was coupled with an inanimate one. The effect was later confirmed using ERP and eye-tracking techniques (Deutch & Bentin, 2001).

Similarly, Vigliocco and Franck (1999) observed the same effect in French and Italian using a constrained sentence completion task (for more details on the task see Vigliocco, Butterworth, & Semenza, 1995). Authors showed that errors in subject-predicate gender agreement were more frequent when the subject was inanimate, i.e., in cases when the natural gender of a subject was not specified, than when the subject was animate. Since nouns that have natural gender denote animate entities and nouns with grammatical gender usually refer to inanimate entities, the animacy of the referent might have confounded the results. Therefore, in the second experiment, the authors compared animate and inanimate entities, both without natural gender specified. An effect of animacy was not observed. Therefore, the advantage for nouns having both grammatical and natural gender in comparison to those having only grammatical gender is not due to their animacy status, but to the presence of information about the biological gender.

Finally, an ERP experiment in German by Schiller and collaborators (2006) showed the facilitation effect of semantic information for the decision about grammatical gender of visually presented noun stimuli. In this experiment, participants were faster in making a gender decision about written German inanimate nouns which were semantically marked for gender than when this was not the case[2]. This result shows that semantic information is taken into account during grammatical processing.

The aforementioned studies showed that semantic information about gender influences syntactic processing, both on the sentence level and on the word level. Here, we posed a question whether the presence of semantic information about gender is used in a task in which gender information does not need to be processed (i.e., lexical decision). In other words, we asked whether information about natural gender affects word recognition in general, or whether this effect is task dependent. Since the natural gender for animate nouns with a sibling in the other gender is transparent, there is a match between semantic and grammatical information about gender and so, the availability of semantic information can facilitate processing. On the other hand, for nouns without a sibling, a similar match between natural and grammatical gender is not present, and this can make processing more difficult.

Interplay between members of gender pairs

Baayen, Dijkstra, and Schreuder (1997) showed that processing of monomorphemic nouns is determined, not only by their own frequencies, but also by the frequencies of their plural inflections. This finding suggests that lexical processing is influenced by morphologically related words; in this case, words that share form and have all properties equal, except number.

Bearing in mind the abovementioned finding, we considered whether nouns with a sibling could have a similar property. In Serbian, as in many other languages with a gender system, the majority of these masculine-feminine pairs consist of nouns that share both stem (they have the same word base) and meaning (they denote animate entities equal in all characteristics except in gender); e.g., *konobar* (“waiter”) – *konobarica* (“waitress”). However, there are also masculine-feminine pairs whose members do not share the stem, but only the meaning; e.g., *petao* (“rooster”) – *kokoška* (“hen”). Both these groups of gender pairs were included in the Experiment 2. On the one hand, we used morphologically related gender pairs to test whether different types of morphologically related words – those that differ in gender, not in number – can

2 German inanimate nouns can be semantically marked for gender, i.e., certain semantic categories are biased towards a certain grammatical gender (Zubin and Köpcke, 1986).

create an effect similar to the one observed by Baayen and collaborators. On the other hand, using morphologically unrelated gender pairs made it possible to test whether this effect is truly morphological as Baayen and his associates suggested. If there would be no difference between nouns from morphologically related and morphologically unrelated pairs regarding the support they get from a sibling, that would suggest that this support is due to semantic, not morphological, connection between siblings. Going one step further, Experiment 2 can be taken as an additional test for the question posed in Experiment 1: whether morphological markedness is used in lexical processing. If there is indeed support from a sibling in nouns that mark gender, as in nouns that mark number (Baayen et al., 1997), it should be stronger for morphologically related gender pairs in comparison with morphologically unrelated gender pairs.

PROBLEM

In the present study we were looking into whether the cognitive system uses morphological markedness of animacy and gender pairs. We adressed this question in two interconnected experiments. In Experiment 1, we tested whether the cognitive system uses morphological markers of animacy present in Serbian masculine nouns. In the same experiment we tested whether the cognitive system is sensitive to sibling presence, controlling for the fact that some animate nouns have a sibling in the other gender. These nouns, unlike nouns without a sibling and inanimates, have a match between natural and grammatical genders which might facilitate their processing. Since the majority but not all sibling nouns are also morphologically related, i.e., they share the same stem, in Experiment 2 we tested whether this additional morphological relatedness affects lexical processing as well. In the same experiment, we investigated in more detail the effect of sibling presence by examining the interplay of the animate nouns and their siblings.

EXPERIMENT 1

The present experiment aimed at answering whether the cognitive system uses semantic, morphological or both types of information about animacy. We selected feminine and masculine nouns, both animate and inanimate, for a visual lexical decision experiment. Additionally, to test whether there is a difference in processing between animate nouns depending on the presence of siblings, we included an equal number of nouns with and without a sibling in the other gender. We selected various categories of nouns to obtain variability of stimuli. Within animates there were humans and animals, while for inanimates we selected plants, artificial (man-made) and natural objects (river, mountain etc.). In categorizing groups of nouns into animates and inanimates we followed the morphological markedness of animacy present in masculine gender. For example, we considered plants to be inanimate because masculine nouns denoting plants have the same declension as other inanimate groups of nouns such as tools. The abstract nouns were excluded from inanimates to control for concreteness, which is known to be a factor that co-determines lexical processing (Kounios & Holcomb, 1994; West & Holcomb, 2000).

Method

Participants. Fifty undergraduate students (mostly females) at the Department of Psychology, University of Novi Sad, participated in the experiment as part of their academic requirements. All participants were native speakers of Serbian, with normal or corrected-to-normal vision.

Materials. We selected 168 Serbian nouns: 84 masculine and 84 feminine nouns, which were presented in nominative singular case. Within each gender group we included an equal number of animate and inanimate nouns. Also, within the group of animate nouns there was an equal number of nouns with a sibling in the other gender and those without it. The word frequencies were retrieved from the *Frequency Dictionary of Contemporary Serbian Language* (Kostić, 1999)[3]. The same number (168) of Serbian pseudonouns (following Serbian orthographic and phonotactic rules) was added to the list. Pseudonouns were constructed using the pseudoword generator *Wuggy* (Keuleers & Brysbaert, 2010).

Design and procedure. Two factors were manipulated in the experiment: *animacy* (animate, inanimate) and *gender* (masculine, feminine). In addition, we included word length and word frequency as control covariates. Since half of the animate nouns had a sibling in the other gender, we created two experimental lists to prevent priming between these nouns. Animate nouns with a sibling were separated – the masculine noun from a particular pair was in one, while the feminine noun was in the other list. Each list consisted of an equal number of masculine and feminine nouns, and within each there were equal numbers of animate nouns with a sibling, animate nouns without a sibling and inanimate nouns. Lists were also matched in word category (human, animal etc.). Participants were randomly assigned to one of these experimental lists.

Stimuli were presented in a visual lexical decision task using DMDX software (Forster & Forster, 2003), on a standard PC configuration (PC AMD Sempron 2600+ processor / 1.61GHz / 256MB RAM, with standard video-card and monitor set to 70Hz vertical refresh rate and 1024 x 768 pixels resolution). Participants were verbally instructed to decide whether the presented string of letters is a word in the Serbian language or not (pressing the left mouse button for "yes" and right for "no"). They were instructed to answer as quickly and accurately as possible. The presentation of all stimuli (words and pseudo-words) was preceded by a 500 ms presentation of the fixation dot. The stimuli remained on the screen until the response, or until the time limit of 1500 ms. Stimuli were presented in black, 40 pt Times New Roman capital letters, in the middle of the screen on a light grey background. The experiment was preceded by 8 practice trials, with 4 nouns and 4 pseudonouns. The presentation sequence was randomized per participant.

Results

Following Baayen and Milin (2010), an inverse transformation was applied to response latencies, while word frequencies were log-transformed. These transformations ensured a better approximation of the normal distribution

3 The word frequencies were given per million.

(Gaussian). In a preliminary analysis of reaction times, 0.5% of extreme outliers were excluded from further analysis.

We modeled response latencies using linear mixed-effect modeling (Bates, 2005, 2006; Baayen, Davidson, & Bates, 2008). Log-frequency, word length and gender were included as fixed-effects, while participants and word items were taken as random-effect factors. Animacy and sibling presence were collapsed into a new, three-level factor: animates with a sibling, animates without a sibling and inanimates. This factor was also treated as fixed-effect. We also tested for possible non-linear effects and by-stimulus and/or by-participant random slope adjustments. Only participants required additional adjustments for the word length slope, as they showed significant differences in sensitivity to this covariate: the linear coefficient of length estimated for animates with a sibling (taken as reference level) was 0.0161, and with additional adjustments it ranged from -0.0003 to 0.0318 across subjects. Finally, we refitted the model by removing datapoints with absolute standardized residuals greater than 2.5 standard deviations.

The final model revealed significant effects of the control predictors, in the expected directions: facilitation from word frequency and inhibition from word length. While the contribution of gender (beta=0.021, *SE*=.017; *t*=1.26; *p*=.1732) was not statistically significant, the factor that was a combination of sibling presence and animacy was. Animates with a sibling were processed the fastest, as compared with animates without a sibling and inanimates. The difference between animates with a sibling and inanimates was borderline significant. These results are summarized in Table 2 and in Figure 1 (the estimates of coefficients and p-values are based on 10000 samples from the posterior distribution of the parameters by the Markov chain Monte Carlo sampling).

Table 2. Estimated coefficients, standard errors, t-values and p-values for the model fitted to response latencies elicited from Experiment 1. Reference level for Sibling presence was Animates with a sibling.

	Value	*SE*	*t*	*p*
Intercept	-1.8431	.0485	-37.95	.0001
Word frequency	-0.0282	.0066	-4.25	.0001
Word length	0.0156	.0055	2.84	.0020
Animacy + Sibling presence = Animates without a sibling	0.0688	.0229	3.00	.0012
Animacy + Sibling presence = Inanimates	0.0348	.0200	1.75	.0582

The significance of the difference in response latencies between animates without a sibling and inanimates was tested using Wald's test for contrasts. The test showed that the difference between these two groups of nouns was marginally significant (Chi-square=3.04, df=1, *p*=.0813). Wald's test was also used in order to test whether there is a difference in processing between animates in general (considering both animates with a sibling and those without it) and inanimates. The test showed that the processing of these two groups of nouns did not differ significantly (Chi-square=0.001, df=1, *p*=.9763).

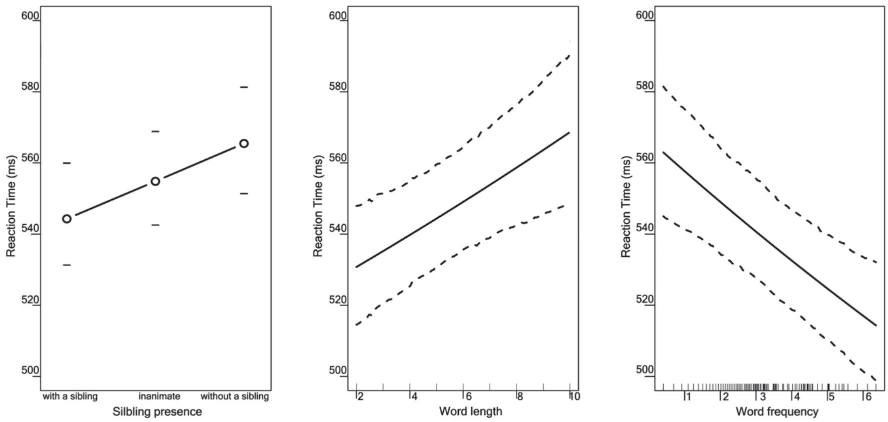

Figure 1. Effects of the sibling presence (reference level = Animates with a sibling), the word length and the word frequency (log-transformed). Lower and upper marks in the left panel and dashed lines in the middle and right panels represent 95% highest posterior density intervals based on 10000 samples from the posterior distribution of the parameters (Markov chain Monte Carlo sampling).

The absence of an animacy effect suggests that the cognitive system is not sensitive to the morphological markers present in the masculine gender. This finding also suggests that the semantic distinction between animate and inanimate nouns is not cognitively relevant. On the other hand, we showed that the presence of a sibling in the other gender influences lexical processing – the nouns with a sibling are processed fastest of all. Since both animate nouns without a sibling and inanimate nouns have only grammatical gender while animate nouns with a sibling have both grammatical and natural gender, this result might suggest that information about natural gender facilitates word recognition.

EXPERIMENT 2

In Experiment 1 we observed that members of masculine-feminine pairs are processed faster than other two types of nouns (animate without a sibling and inanimate). Although we included both morphologically related and unrelated gender pairs in the Experiment 1, we did not test whether morphological relatedness of pair members contributed to the faster processing of nouns with a sibling. If morphological properties of pair members contributed to the sibling presence effect observed in Experiment 1, morphologically related gender pairs are expected to be processed faster than nouns that have different stems. Contrariwise, if morphological relatedness is not used in lexical processing, there should be no difference in processing between morphologically related and unrelated gender pairs. Therefore, we selected both morphologically related (e.g. *lav* /"lion"/ – *lavica* /"lioness"/) and morphologicaly unrelated (e.g. *otac* /"father"/ – *majka* /"mother"/) masculine-feminine pairs of animate nouns as stimuli in the Experiment 2.

In Experiment 1 we considered nouns with a sibling individually – apart from their siblings. However, in the Experiment 2, we aimed to explore the potential interplay between members of a gender pair.

Method

Participants. Participants were 86 undergraduates at the Department of Psychology, University of Novi Sad. They were mainly females and took part in the experiment for partial course credits. All participants were native speakers of Serbian, with normal or corrected-to-normal vision. None of them participated in Experiment 1.

Materials. A total list of 480 stimuli were presented: 120 nouns and 120 pseudonouns, with additional 120 abstract nouns that served as fillers and an equal number of corresponding pseudonouns. Target nouns were animates with a sibling in the other gender. There were 96 morphologically related and 24 morphologically unrelated nouns with a sibling[4]. Stimuli were presented in the nominative singular case. Since some of them were not attested in the *Frequency Dictionary of Contemporary Serbian Language* (Kostić, 1999), we used the number of *Google* hits per million as an estimation of the word frequency. We restricted *Google* search to both the Serbian domain and the Serbian language. Then, the size of the Google corpus was estimated using the word count prediction algorithm developed by Grefenstette & Nioche (2000). Additionally, we verified that the correlation for the subset of nouns that were retrieved both from the frequency dictionary and from the Google search engine was acceptably high and positive ($r = .62$; $N=416$; $p=.01$). As in Experiment 1, the pseudoword generator *Wuggy* (Keuleers & Brysbaert, 2010) was used to construct pseudonouns.

Design and procedure. We varied one factor in this experiment: *morphological relatedness* of members of masculine-feminine pairs (related, unrelated). As in Experiment 1, we created two experimental lists to prevent priming between members of gender pairs. In addition, the relation with the word frequency of a sibling was introduced as *sibling dominance*. The sibling of a target noun was *dominant* if its word frequency was higher than the frequency of the target; otherwise, the sibling was *non-dominant*. Again, word length and the target's word frequency were included as covariates. Experimental apparatus and procedure was the same as in the Experiment 1.

4 The ratio between morphologically related and unrelated masculine-feminine pairs was close to the ratio attested in the corpus. Since the unequal group sizes could have caused an artificial effect (participants might have developed a particular strategy), a "control" experiment was conducted, with an equal number of morphologically related and unrelated masculine-feminine pairs. Results from this experiment revealed exactly the same structure of effects as the main experiment with unbalanced group sizes. This assured the reliability of our main findings.

Results

As in the previous experiment, response latencies and word frequencies were transformed to approximate normality, and extreme outliers were excluded (0.6%). We used the same statistical approach for data analysis as in Experiment 1. A mixed-effect model was tested, with the log-frequency and the word length as control covariates, and the morphological relatedness and sibling dominance as fixed-factors. Participants and stimuli served as random-effects. The listed covariates did not show non-linear contributions, but word length required additional by-participant adjustments for the slope. The same structure of random-effects was attested in Experiment 1 as well. The linear coefficient of length estimated for words with a less frequent sibling (taken as a reference level) was 0.0407, and with additional adjustments it ranged from 0.0035 to 0.0909 across subjects.

The refitted model (with extreme outlying residuals removed) did not show a significant contribution of morphological relatedness (beta=-0.019, *SE*=.003, *t*=-0.35, *p*=.7032). Control covariates, again, showed the same pattern of results, with inhibition from word length and facilitation from word frequency. Furthermore, we observed an effect of sibling dominance: words with a more frequent sibling, i.e., those that are the less frequent member of their pair, were processed slower. Since words with dominant and those with non-dominant siblings were not matched by frequency, we tested an interaction between the target's frequency and dominance of a sibling. This interaction was statistically significant: nouns with a more frequent sibling benefited more from their own frequency than nouns with a less frequent sibling. The estimates of coefficients, as well as corresponding p-values, are based on 10000 samples from the posterior distribution of the parameters (Markov chain Monte Carlo sampling). They are given in Table 3, and presented in Figure 2.

Table 3. Estimated coefficients, standard errors, t-values and p-values for the model fitted to response latencies elicited for Experiment 2. Reference level for Sibling dominance was Non-dominant sibling.

	Value	*SE*	*t*	*p*
Intercept	–1.8240	.0506	–36.03	.0001
Word frequency	–0.0351	.0095	–3.70	.0002
Word length	0.0407	.0052	7.81	.0001
Sibling dominance = Dominant sibling	0.1224	.0486	2.52	.0104
Word frequency : Sibling dominance = Dominant sibling	–0.0377	.0139	–2.72	.0050

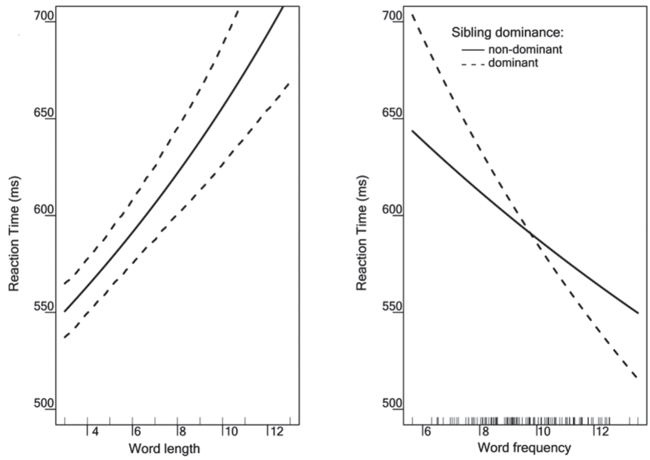

Figure 2. The effects of word length and the interaction of log word frequency and the dominance of a sibling (reference level = Non-dominant sibling). Lower and upper marks on the left panel represent 95% highest posterior density intervals based on 10000 samples from the posterior distribution of the parameters (Markov chain Monte Carlo sampling).

The above findings suggest that morphological relatedness of members of masculine-feminine pairs does not contribute to the effect of sibling presence. It seems that the cognitive system does not get an advantage for morphologically related gender pairs. This is in harmony with the finding from Experiment 1 that morphological markedness of animacy does not influence the processing of Serbian masculine nouns. The interaction between word frequencies of the members of gender pairs suggests that these nouns are tightly connected. Since this interaction is the same for both morphologically related and unrelated gender pairs, it suggests that the cognitive system is not sensitive to their morphological, but rather semantic relations.

DISCUSSION

In the present research we examined whether morphological markedness of animacy and gender pairs is used in lexical processing. While the animate/inanimate distinction was not cognitively relevant, the presence of a sibling in the other gender influenced lexical processing, irrespective of the morphological relatedness of the pair members.

The absence of an animacy effect in the masculine gender suggests that its morphological markedness is not cognitively relevant. We showed that processing is the same irrespective of the specific inflectional variations for animate as opposed to inanimate Serbian masculine nouns. Hence, the present findings are in line with those of Radivojević and Kostić (2003), who showed the dominance of the same (animate) inflective class for both animate and inanimate Serbian masculine nouns.

Equal processing of animate and inanimate feminine nouns could suggest that the cognitive system is not sensitive to the semantic animacy distinction. However, this would be a strong claim since we applied a linguistic (i.e., morphological) criterion for animacy classification, which may not correspond with the semantic animate/inanimate distinction. In the present study, plants were treated as inanimate because of the morphological properties of assigned words. However, it is less clear whether they are mentally represented as inanimate. Although there is no consensus about the animacy status of plants, in most researches, as opposed to our study, they have been treated as animate (e.g., Moore & Price, 1999; Mummery et al., 1998; Tyler et al., 2003a). This made us consider the possibility that the treatment of plants (as inanimate) might have caused the null finding regarding the animacy effect in our study. Therefore, we conducted an additional analysis, in which plants were treated as animate. However, no difference in processing between the new animate and inanimate classes was shown, which ruled out the possibility that the animacy status of plants caused the null finding regarding the animacy effect. The results from this additional analysis are given in Appendix 1.

We believe that the absence of a processing difference between animates and inanimates in our study is due to the larger numbers of categories used. As we mentioned earlier, studies that have used more than two categories to instantiate the animate and inanimate classes, as we did, failed to observe the processing difference (e.g., Pilgrim et al., 2002; Devlin et al., 2002); while studies that compared only two categories of entities observed a processing difference (Martin et al., 1996; Perani, 1999, etc.). This would suggest there is no processing difference between classes of animates and inanimates, in general, but only between particular categories, like animals and tools. In other words, previous and present findings do suggest that the differences between entities, with regards to their animacy, are not at the level of class but rather at the level of particular categories. We believe that only categories that are typical for their animacy classes are able to generate processing differences, since these are important for us and we have more information on them.

Experiment 1 showed that animate nouns with a sibling in the other gender (e.g., *lav* /”lion”/ – *lavica* /”lioness”/) were processed faster than those without a sibling (e.g., *mornar* /”sailor”/ or *žirafa* /”giraffe”/). Furthermore, nouns with a sibling were processed faster than inanimate nouns, while the difference in processing between animates without a sibling and inanimates was only marginally significant. Since animates with a sibling have their natural gender specified, which is not the case for both animates without a sibling and inanimates, this might have facilitated their processing. It has been shown that in tasks which require grammatical gender processing, the information about natural gender indeed facilitates processing (e.g., Schiller et al., 2003). Our study showed it is likely that this information is also used in a task which does not need grammatical gender processing, but only the computation of word meaning. Degani (2007) showed that the pairs of English words, whose referents share a natural gender (e.g., *queen – cow*) are estimated as more similar in meaning than words that do not have the same natural gender (e.g., *king – cow*). If information about natural gender is indeed part of word meaning, as this result would suggest, it is not surprising that word recognition is elongated when this information is absent. Although natural gender is an inherent property of animate referents only, there are findings suggesting that people include gender in their representations of inanimate objects, as well (Boroditsky & Schmidt, 2000). If this is the case, the same hypothesis about the absence of information about natural (or, in this case, semantic) gender could be used to explain why Serbian inanimate nouns are processed slower than animate nouns that have a natural gender. However, this result needs to be taken with caution since we did not control for this property of inanimate nouns. (Mirković et al.'s (2008) corpus analysis showed that semantic category membership of Serbian inanimate nouns is indeed a cue to their grammatical gender, as in German and some other languages.)

Furthermore, Experiment 2 showed no differences in processing of nouns with a sibling whether they had the same or a different stem (i.e., morphologically related or unrelated). Additionally, both morphologically related and unrelated pair members showed the same support from the sibling. The target frequency effect was modified by the frequency of its sibling: nouns with a more frequent sibling benefited more from their own frequency than those with a less frequent sibling. Being the same, regardless of the morphological relatedness of pair members, this effect is of importance for two reasons. On the one hand, it complements the findings of Baayen et al. (1997) that processing of nouns shows support from the frequency of morphologically related forms. On the other hand, it reveals that support from a sibling is realized not by the morphological relation between the pair members, but by their semantic link.

The results of Alvarez and his colleagues (2011) suggest that nouns with a sibling are semantically more related than other pairs of nouns that are equally morphologically related. These authors showed that the impact of attenuation of N400 lasts longer for pairs of nouns that mark gender, e.g., *niño* /"boy"/ – *niña* /"girl"/ than for the pairs such as *barco* /"ship"/ – *barca* /"small boat"/, which are morphologically equally related.

Bearing in mind that gender is probably included in the representation of inanimate nouns that are semantically marked for gender, these nouns are likely to be favoured in comparison with inanimate nouns that are not semantically marked; just like animate nouns with a sibling are in advantage compared with those without a sibling. It remains open whether the effect of sibling support is an exclusive characteristic of animate nouns, or whether there are pairs of (semantically marked for gender) inanimate nouns that show similar effect.

Apparent semantic properties are sometimes morphologically marked, as is the case for animacy in masculine gender, or sibling presence in morphologically related members of masculine-feminine pairs of nouns. There are also properties that are present only on the conceptual level, as animacy in feminine gender, or sibling presence in morphologically unrelated pair members. Since Serbian offers two semantic properties that are at the same time morphologically marked and unmarked, we were able to test whether the cognitive system makes use of these specific morphological cues. According to our findings, it seems that this is not the case: morphological markedness is not used in lexical processing. In other words, it seems that semantic properties do not have any support from morphology. As for orthography/phonology, present findings do not allow for any definite conclusion. Simply stated, orthography was not attainable for experimental control, since morphologically related word pairs differed both in length and in the degree of orthographic/phonological overlap. Short words shared only two graphemes/phonems, while longer words had up to eleven shared graphemes/phonemes. With this in mind, we can conclude that present findings are in line with amorphous theories of lexical processing, which argue that morphology is a by-product of correlations between orthography/phonology and meaning. Precisely, we revealed semantic effect and no support from morphology, where orthographic and/or phonological effect were not taken into account[5]. Further examination is needed to determine whether there are graded effects of orthographic/phonological overlap between morphologically related gender pairs, as connectionist models would predict (Harm & Seidenberg, 1999, 2004; Plaut & Gonnerman, 2000). Also, it is still unclear what would be a specific function of morphological markers of animacy and sibling presence.

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5 We do not find appropriate to treat orthographic and phonological effects as being equal, because Serbian has shallow ortography.

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APPENDIX 1

Table 4. Estimated coefficients, standard errors, t-values and p-values for the model fitted to response latencies elicited for Experiment 1 with plants treated as animate. Reference level for Sibling presence was Animates with a sibling.

	Value	Std. Error	t	p
Intercept	-1.8391	.0488	-37.65	.0001
Word frequency	-.0289	-.0067	-4.34	.0001
Word length	.0153	.0055	2.77	.0028
Animacy + Sibling presence= Animates without a sibling	.0532	.0221	2.42	.0094
Animacy + Sibling presence = Inanimates	.0409	.0205	1.99	.0340

Animates without a sibling vs Inanimates; Wald's test: Chi-square=0.426, df=1, p=0.5138

Animates (Animates with sibling & Animates without a sibling) vs Inanimates; Wald's test: Chi-square=0.77, df=1, p=0.3802

APPENDIX 2

Noun stimuli from Experiment 1 with their frequencies (per million), taken from the Frequency Dictionary of Contemporary Serbian Language (Kostić, 1999).

Feminine nouns			Masculine nouns		
	Noun	Word freq. (per million)		Noun	Word freq. (per million)
Ajkula	Shark	0.50	Bicikl	Bicycle	19.00
Banana	Banana	2.50	Bog	God	76.00
Baterija	Battery	4.00	Bor	Pine tree	35.00
Beba	Baby	4.00	Brat	Brother	78.50
Buba	Bug	10.00	Brod	Ship	70.50
Česma	Fountain	5.00	Buket	Bouquet	8.00
Cigareta	Cigarette	6.00	Crv	Worm	24.50
Cipela	Shoe	12.00	Cvet	Flower	152.50
Cucla	Nipple	0.50	Cvrčak	Cricket	12.00
Devojčica	Girl	24.50	Dečak	Boy	75.00
Drugarica	Friend	11.50	Delfin	Dolphin	0.50
Fabrika	Factory	71.00	Dim	Smoke	111.50
Glumica	Actress	2.50	Div	Giant	22.00
Gospođa	Lady	32.50	Drug	Friend	186.00
Gusenica	Caterpillar	3.50	Duh	Spirit	78.50
Harmonika	Harmonica	22.00	Ekser	Nail	0.50
Igračica	Player	5.00	Galeb	Seagull	18.00
Jabuka	Apple	36.50	Glumac	Actor	8.00
Kanta	Bucket	1.50	Gospodin	Mister	85.50
Kapa	Cap	5.50	Hleb	Bread	88.50
Kasa	Cash register	5.50	Igrač	Player	19.50
Kašika	Spoon	8.50	Izlog	Window	13.50
Knjiga	Book	97.00	Jelen	Deer	7.50
Kobila	Mare	5.00	Kamen	Stone	263.00
Kočija	Carriage	3.50	Kaput	Coat	34.00
Kocka	Cube	1.00	Kišobran	Umbrella	5.00
Kokoška	Hen	1.50	Klavir	Piano	47.50
Konobarica	Waitress	0.50	Kolač	Pastry	3.00
Kosa	Hair	96.00	Konac	Thread	11.00
Kraljica	Queen	7.00	Konj	Horse	32.50
Krava	Cow	20.50	Konobar	Waiter	3.00
Krtica	Mole	4.00	Kostur	Skeleton	16.00
Kruna	Crown	11.50	Kralj	King	31.50

	Feminine nouns			Masculine nouns	
	Noun	Word freq. (per million)		Noun	Word freq. (per million)
Kruška	Pear	5.50	Krov	Roof	66.50
Kuća	House	234.50	Kukuruz	Corn	15.50
Lampa	Lamp	23.50	Led	Ice	41.50
Lasta	Swallow	35.00	Lek	Medicine	14.00
Ljubavnica	Mistress	22.00	Limun	Lemon	3.00
Ljuljaška	Swing	1.50	Ljubavnik	Lover	11.00
Lopta	Ball	27.50	Lopov	Thief	10.50
Lutka	Doll	10.50	Mač	Sword	32.00
Mačka	Cat	3.50	Mačak	Tomcat	19.00
Meduza	Jellyfish	4.50	Med	Honey	17.50
Metla	Broom	1.50	Mornar	Sailor	12.00
Motika	Hoe	6.50	Mrav	Ant	15.00
Muva	Fly	6.50	Mrtvac	Dead man	14.50
Olovka	Pencil	0.50	Muškarac	Man	7.00
Pegla	Iron	1.50	Nokat	Fingernail	4.50
Pevačica	Singer	9.50	Oblak	Cloud	223.00
Planina	Mountain	84.50	Oficir	Officer	12.00
Princeza	Princess	1.50	Okean	Ocean	8.50
Ptica	Bird	341.50	Orman	Wardrobe	26.00
Puška	Rifle	33.50	Paradajz	Tomato	2.50
Reka	River	156.00	Pauk	Spider	31.50
Riba	Fish	83.00	Petao	Cock	4.00
Rukavica	Glove	4.50	Pevač	Singer	7.00
Ruža	Rose	78.00	Pijanac	Drunkard	2.50
Sestra	Sister	55.00	Potok	Stream	62.00
Sijalica	Light bulb	11.50	Predak	Ancestor	1.50
Školjka	Shell	24.00	Princ	Prince	5.00
Slika	Picture	148.50	Prozor	Window	151.00
Sova	Owl	12.50	Puder	Powder	1.00
Srna	Doe	23.50	Sapun	Soap	14.00
Starica	Old woman	18.50	Šator	Tent	8.00
Stolica	Chair	11.00	Semafor	Traffic light	0.50
Svinja	Pig	4.00	Sladoled	Ice cream	4.50
Testera	Saw	0.50	Smeh	Laughter	127.00
Torta	Cake	1.00	Starac	Old man	59.00
Trudnica	Pregnant woman	0.50	Stručnjak	Expert	12.00

	Feminine nouns			Masculine nouns	
	Noun	Word freq. (per million)		Noun	Word freq (per million)
Učenica	Schoolgirl	9.00	Suncokret	Sunflower	8.50
Učiteljica	Teacher	7.50	Svetionik	Lighthouse	4.00
Unuka	Granddaughter	11.50	Tanjir	Plate	8.00
Usna	Lip	21.50	Telefon	Phone	578.00
Vaga	Scale	5.50	Tužilac	Prosecutor	25.00
Veštica	Witch	2.50	Učenik	Student	9.00
Veverica	Squirrel	4.00	Učitelj	Teacher	26.50
Violina	Violin	18.50	Unuk	Grandson	4.00
Vila	Villa	20.00	Vitez	Knight	11.00
Vrana	Crow	14.00	Vo	Ox	5.00
Zmija	Snake	49.50	Vojnik	Soldier	42.50
Zvezda	Star	204.00	Vosak	Wax	8.50
Žena	Woman	456.00	Voz	Train	76.00
Žirafa	Giraffe	2.00	Vrabac	Sparrow	5.00
Žrtva	Victim	16.50	Zid	Wall	92.00

APPENDIX 3

Noun stimuli from Experiment 2 with their frequencies (per million), estimated by Google hits, and word frequencies, taken from the Frequency Dictionary of Contemporary Serbian Language (Kostić, 1999)

	Feminine nouns				Masculine nouns		
	Noun	Google hits (per million)	Word freq. (per million)		Noun	Googlehits (per million)	Word freq.(per million)
Balerina	Ballerina	26.31	3.00	Baletan	Ballet dancer	1.44	-
Bibliotekarka	Librarian	0.94	-	Bibliotekar	Librarian	4.95	1.00
Ćerka	Daughter	45.57	11.50	Bik	Bull	93.72	7.00
Čistačica	Cleaning woman	4.14	2.50	Brat	Brother	203.45	78.50
Ćurka	Turkey	1.12	0.50	Čistač	Cleaner	6.18	1.00
Devojčica	Little girl	72.02	24.50	Ćuran	Turkey cock	1.53	0.50
Devojka	Girl	344.51	133.50	Dečak	Boy	72.02	75.00
Domaćica	Housewife	34.72	10.00	Domaćin	Host	110.00	6.00
Drugarica	Friend	66.60	11.50	Drug	Friend	146.49	186.00
Glumica	Actress	107.02	2.50	Glumac	Actor	108.24	8.00

Feminine nouns				Masculine nouns			
	Noun	Google hits (per million)	Word freq. (per million)		Noun	Googlehits (per million)	Word freq.(per million)
Golubica	Dove	2.71	5.00	Golub	Pigeon	16.28	28.50
Gospođa	Lady	35.27	32.50	Gospodin	Mister	145.13	85.50
Guska	Goose	3.21	1.50	Gusan	Gander	0.74	-
Igračica	Player	15.46	5.00	Igrač	Player	181.75	19.50
Kobila	Mare	5.51	5.00	Jarac	Capricorn	55.34	1.00
Kokoška	Hen	3.70	1.50	Jelen	Deer	86.40	7.50
Konobarica	Waitress	7.08	0.50	Konj	Horse	31.33	32.50
Košuta	Doe	4.80	12.50	Konobar	Waiter	27.94	3.00
Koza	Goat	83.01	3.00	Kralj	King	139.70	31.50
Kraljica	Queen	58.46	7.00	Kuvar	Cook	43.95	4.50
Krava	Cow	44.49	20.50	Labud	Swan	7.23	7.50
Kuja	Bitch	2.73	1.00	Lav	Lion	143.77	7.50
Kuvarica	Cook	17.90	3.00	Leptir	Butterfly	20.35	29.00
Labudica	Swan	0.38	-	Lisac	Fox	12.57	0.50
Lavica	Lioness	6.70	0.50	Ljubavnik	Lover	9.60	11.00
Leptirica	Butterfly	7.04	4.00	Mačak	Tomcat	14.65	3.50
Lisica	Fox	12.74	2.50	Momak	Guy	93.72	15.50
Ljubavnica	Mistress	13.70	22.00	Muškarac	Man	110.41	7.00
Maćeha	Stepmother	3.36	3.00	Nastavnik	Teacher	41.64	18.50
Mačka	Cat	39.33	19.00	Očuh	Stepfather	1.80	0.50
Majka	Mother	382.49	201.50	Odbojkaš	Volleyball player	6.10	0.50
Nastavnica	Teacher	6.52	2.50	Otac	Father	214.30	130.50
Odbojkašica	Volleyball player	10.69	0.50	Ovan	Ram	56.56	5.00
Ovca	Sheep	14.51	5.50	Pas	Dog	133.74	47.50
Patka	Duck	22.65	1.50	Patak	Drake	23.60	0.50
Paunica	Peahen	22.52	-	Paun	Peacock	2.47	3.00
Pčela	Bee	10.85	22.50	Petao	Cock	5.10	4.00
Pevačica	Singer	82.20	9.50	Pevač	Singer	51.41	7.00
Pravnica	Lawyer	3.08	-	Pravnik	Lawyer	39.47	2.00
Predsednica	President	86.81	0.50	Predsednik	President	1030.83	361.00
Princeza	Princess	58.19	1.50	Princ	Prince	113.26	5.00
Prodavačica	Saleswoman	5.94	0.50	Prodavac	Seller	377.07	4.00
Profesorka	Professor	21.57	1.50	Profesor	Proffesor	326.88	69.50
Radnica	Worker	23.33	11.50	Radnik	Worker	146.49	37.50
Šefica	Chief	14.78	-	Šef	Chief	291.62	63.00
Sekretarica	Secretary	22.92	0.50	Sekretar	Secretary	273.98	117.00

Feminine nouns				Masculine nouns			
	Noun	Google hits (per million)	Word freq. (per million)		Noun	Googlehits (per million)	Word freq.(per million)
Sestra	Sister	179.04	55.00	Sin	Son	259.06	108.50
Slikarka	Painter	13.16	-	Slikar	Painter	48.42	19.50
Slonica	Elephant	0.90	-	Slon	Elephant	13.33	3.50
Starica	Old woman	11.95	18.50	Starac	Old man	26.99	59.00
Strina	Aunt	4.50	0.50	Stric	Uncle	12.46	6.00
Svekrva	Mother in law	7.39	0.50	Svekar	Father-in-law	3.07	2.00
Tigrica	Tigress	1.65	0.50	Tigar	Tiger	94.94	9.00
Učenica	Schoolgirl	10.15	9.00	Trut	Drone	0.93	-
Učiteljica	Teacher	10.53	7.50	Učenik	Student	34.59	9.00
Ujna	Aunt	1.91	1.00	Učitelj	Teacher	21.57	26.50
Unuka	Granddaughter	14.65	11.50	Ujak	Uncle	11.56	2.50
Žaba	Frog	7.49	5.00	Unuk	Grandson	14.78	4.00
Zečica	Doe (rabbit/F)	12.38	-	Žabac	Hoptoad	4.42	0.50
Žena	Woman	769.05	456.00	Zec	Rabbit	31.47	7.00