The facilitation effect of associative and semantic relatedness in word recognition

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In this study we addressed three issues concerning semantic and associative relatedness between two words and how they prime each other. The first issue is whether there is a priming effect of semantic relatedness over and above the effect of associative relatedness. The second issue is how difference in semantic overlap between two words affects priming. In order to specify the semantic overlap we introduce five relation types that differ in number of common semantic components. Three relation types (synonyms, antonyms and hyponyms) represent *semantic* relatedness while two relation types represent associative relatedness, with negligible or no semantic relatedness. Finally, the third issue addressed in this study is whether there is a symmetric priming effect if we swap the position of prime and target, i.e. whether the direction of relatedness between two words affects priming.

In two lexical decision experiments we presented five types of word pairs. In both experiments we obtained stronger facilitation for pairs that were both semantically and associatively related. Closer inspection showed that larger semantic overlap between words is paralleled by greater facilitation effect. The effects did not change when prime and target swap their position, indicating that the observed facilitation effects are symmetrical. This outcome complies with predictions of distributed models of memory.

Key words*: associative priming, semantic priming, lexical relations, lexical decision task, Componential analysis*

Numerous studies indicate that word recognition is faster when a target word is preceded by associatively and/or semantically related prime (cf. Meyer & Schvaneveldt, 1971; Koriat, 1981; Neely, Keefe, & Ross, 1989; Schelton & Martin, 1992; Thompson-Schill, Kurtz, & Gabrieli, 1998; Lisac & Milin, 2006). Although there were attempts to delimit the effects of associative vs. semantic relatedness, the results were often equivocal and sometimes conflicting. In the forthcoming paragraphs we give a brief outline of the studies that addressed this issue.

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Some authors claim that there is no effect of semantic priming per se. Thus, for example, Schelton and Martin found automatic semantic priming only when word pairs were also associatively related (Schelton & Martin, 1992). In ERP studies Rhodes and Donaldson obtained the N400 effect[1] for associative but not for the semantic relatedness (Rhodes & Donaldson 2007). A similar outcome was shown for taxonomic vs. thematic relatedness[2] (Sachs, Weis, Zellagui, Huber, Zvuagintsev, Mathiak, & Kircher, 2008).

On the other hand, there are studies which demonstrate the effect of pure semantic relatedness. Thus, for example, Fischler found facilitation effect for word pairs that were not directly associatively related but had been judged as similar in meaning (Fischler, 1977), while results reported by Thompson-Schill et al. suggest that there is only automatic semantic priming (Thompson-Schill, Kurtz, & Gabrieli 1998). Finally, Lucas in her review based on 26 studies, concluded that semantic priming could be obtained if stimuli are not associatively related, but not the other way round (Lucas, 2000).

A middle ground between these groups of findings could be found in results from Lupker's study. Lupker pointed out that semantic priming is somewhat limited and task dependent. His experiments showed that semantic overlap (he presented word pairs that share the same superordinate category) elicited weak priming effect in a naming task, whereas in a lexical decision sequential priming experiment he obtained a stronger effect with pure semantic relatedness (Lupker, 1984). Lupker also showed that semantic relatedness did not boost the associative priming effect either in naming or in a lexical decision task. However, some authors reported that semantic and associative relatedness, put together, elicit a stronger priming effect compared to pure semantic relatedness. This phenomenon is referred to as *associative boost* (Moss, Hare, Day, & Tyler, 1994; Lucas, 2000).

Finally, there are also studies that indicate the effect of both semantic and associative priming (Ferrand & New, 2003). In ERP studies Koivisto and Revonsuo demonstrated that N400 effect occurs for both types of relatedness (Koivisto and Revonsuo, 2001). Other authors found no difference in the N400 effect for semantic and associative relatedness (Hagoort, Brown and Swaab, 1996), nor for thematic and taxonomic relations between words (Maguire, Brier, & Ferree, 2010). Although there are effects of both types of relatedness, there is

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1 Kutas and Hillyard using event-related potentials (ERP's) found that semantically incongruent word in a sentence context causes a negative brain wave, around 400 ms after stimulus onset. The stronger semantic incongruity is followed by larger amplitude of the wave. This phenomenon is referred to as N400 component (Kutas and Hillyard, 1980). The same effect was obtained in experiments where a word was presented in the context of another content word (Hagoort, Brown and Swaab, 1996). For words that were preceded by semantically or associatively related word a reduction in N400 amplitude was observed (Hagoort et al., 1996; Koivisto and Revonsuo, 2001). This phenomenon is known as N400 effect.

2   Taxonomic relatedness refers to words that share the same category and are therefore semantically related, while thematic relations imply pure associative relatedness.

a difference in the time window of the N400 priming effect, semantic appearing earlier and being shorter than the associative priming (Koivisto & Revonsuo, 2001; Maguire et al., 2010).

There were various attempts to account for the conflicting results. While Lupker suggested that equivocal findings may be due to task variation, some authors emphasize the *type* of semantic and associative relatedness (Hutchison, 2003). The other important note came from McRae and Boisvert who found that the magnitude of facilitation depends on the *amount* of semantic similarity (McRae & Boisvert, 1998). Thus, the absence of facilitation in semantic priming, observed in some studies, could be accounted for by weak semantic similarity between words.

Conspicuous diversity in results could be attributed to differences in experimental techniques (type of task, modality of stimuli presentation, exposure duration, proportion of stimuli, SOA, etc.). However, there is still no firm empirical evidence that would clarify how experimental procedure affects semantic/associative priming. On the other hand, lack of consensus on how to define *semantic* vs. *associative* relatedness deprives us from strict criteria of stimuli selection. Generally speaking, associative relatedness is an empirical issue. Measures of relatedness are usually provided through associative tests (discrete or continuous), construed ad hoc for the purpose of research or derived from standard associative norms (associative dictionaries). These provide us not only with a repertoire of associates, but also with a measure of the association strength. In contrast, semantic relatedness is based on overlap in meaning with no objective criterion for semantic relatedness, because the semantic structure of a word is sometimes impossible to analyze in detail. Therefore, exhaustive semantic description and precise specification of semantic relatedness is much more complex compared to associative relatedness. As a consequence, there is vast diversity in selection criteria which makes comparison of results over studies more difficult.

Having in mind equivocal and sometimes conflicting findings in studies that dealt with semantic and associative relatedness and their processing effects, discussed in previous paragraphs, we ask whether there is an effect of semantic relatedness over and above the effect of associative relatedness. If so, it could be argued that there is an effect of pure semantic relatedness, irrespective of the associative strength between two words.

The second issue addressed in this study is how difference in semantic and associative overlap affects priming. Variation in the amount of semantic and associative overlap is specified in terms of different types of semantic and associative relatedness within the framework of *Componential analysis*. The starting point of this theory is decomposition of word meaning into a limited set of universal semantic units (Lyons, 1977). It is assumed that by combining these units all meanings can be expressed. The most successful application of this theory is observed with concrete nouns (Dragićević, 2007). It should be

noted that Componential analysis faces problem of infinite number of semantic primitives. Also, it is not clear whether those primitives could be further partitioned into smaller units. Nevertheless, this theory can be applied to describe the differences in number of common semantic components of words in various lexical relations. If restricted to this purpose, the issue of infinite number of semantic components and their additional partitioning becomes irrelevant.

In order to test the validity of *Componential analysis* and its possible application in predicting variation in priming effects we introduce word relation types that differ in number of common semantic components. Three relation types (synonyms, antonyms and hyponyms) represent *semantic* relatedness with various amount of semantic overlap, while two relation types represent strong and weak associative relatedness, with negligible or no semantic relatedness. Note that pairs within each three types of semantic relatedness are also associatively related. Theoretically, synonymy pairs should have the highest overlap of semantic components. Differences in meaning (if any) between synonyms should derive from semantic components of minor relevance. Antonyms share the majority of semantic material, but the difference in meaning derives from the opposition of one critical semantic component.[3] In the case of hyponymy all the components of superordinate term are common to the subordinate one, but the subordinate term has some additional components.[4] Pairs characterized by stronger associative relatedness share even less common material, while pairs with weaker associative relatedness share no common material. The above specifications offer a straightforward order of semantic overlap. The question is whether the amount of semantic overlap, as specified above, will parallel the priming effects.

There is also a third issue addressed in this study which refers to relatedness symmetry and the direction of relatedness between two words. Will semantically or associatively related word pair elicit the same priming effect if prime and target swap their positions, i.e. if the prime becomes the target? In the forthcoming paragraphs we elaborate this question in more detail in the framework of the spreading activation theory and the distributed network theory.

The spreading activation approach assumes that semantic memory is made of interconnected nodes (words) along which the activation spreads (Collins & Loftus, 1975; Thompson-Schill et al., 1998). It should be noted that the direction of association is assumed to affect priming. There are two possible directions of (asymmetric) association. The *forward direction* refers to the situation where the target is an associate of the prime, while in *backward direction* prime is an

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3   For example, *day* and *night* share components such as *specific period of time in 24 hours cycle* etc., the difference being the component *from sunrise to sunset* vs. *from sunset to sunrise*.

4   For instance, *apple* shares with *fruit* components such as *tasty, sweet, eatable, grows on a tree, used as food* etc. but there are also some extra components such as *round, hard, thin peel, usually red, green or yellow* etc.

associate of the target.[5] Therefore, there are forward and backward associative priming. The spreading activation theory predicts that the amount of forward priming will be greater than the amount of backward priming (in the case of asymmetric associative relatedness). In contrast, the distributed network model assumes that a given concept is spread over semantic features that are also present in a number of different concepts (Plaut, 1995). This implies that activation spreads across word features and not across words. Therefore the amount of semantic/associative overlap between two words is the only relevant factor, with direction being irrelevant (Thompson-Schill et al., 1998).

Koriat was the first to investigate the magnitude of priming with respect to the direction of association. His lexical decision experiments showed that regardless of the association direction, the overall amount of priming remains constant (Koriat, 1981; Hutchison, 2003). However, some authors claimed that only semantic relatedness is symmetric (Plaut, 1995; Thompson-Schill et al., 1998). Hence, associative priming is usually accounted for by means of spreading activation, and semantic priming by means of distributed network models of memory (Thompson-Schill et al., 1998). The fact that association may or may not include semantic relatedness makes understanding of the effects more complex. In an attempt to delimit the effects, some authors selected the exemplars of pure semantic and pure associative relatedness (Fischler, 1977; McRae & Boisvert, 1998; Perea & Rosa, 2002; Ferrand & New, 2003). However, because these two phenomena are to a great extent overlapped, the selected instances were often poor representatives of semantic and associative relatedness.

In two lexical decision experiments we address the three issues discussed earlier. In the first experiment we ask whether there is an effect of semantic relatedness per se and whether the amount of semantic overlap affects facilitation. In the second experiment we investigate whether the effects of semantic/associative relatedness are symmetrical.

EXPERIMENT 1

In the present experiment we asked whether there is an effect of semantic relatedness over and above the associative relatedness. If there is such an effect we would expect stronger facilitation for groups containing pairs that are both associatively and semantically related (synonyms, antonyms, and hyponyms), as compared to pairs that are only associatively related (stronger and weaker associative relatedness). Additionally, we addressed the nature of potential semantic boost by looking at relation between rank derived from predictions of Componential analysis and facilitation effect for five groups of word pairs.

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5 This meaning of forward and backward direction in priming experiment shouldn't be confused with a task where target is exposed before the prime, like in: Kiger & Glass (1983).

Method

Participants: Twenty-eight first-year undergraduates from the Department of Psychology, University of Belgrade, participated in the experiment as part of their academic requirements. Participants were randomly assigned to one of two experimental conditions (presented with one of two experimental lists).

Stimuli and design: We selected associatively related word pairs based on *The Associative Dictionary of the Serbian Language* (Piper, Dragićević, & Stefanović, 2005), which was compiled from the test of free associations in which 800 students took part. The selection was based on several criteria. Firstly, all of the selected stimuli were nouns in the nominative singular form, onomastic nouns being excluded. Secondly, only the most frequent associates were considered, the frequency of associate being operationalized as the number of participants that produced a given associate. Therefore, each pair consisted of noun entry (noun in the nominative singular form, onomastic nouns being excluded) and its most frequent associate from the dictionary (also noun in the nominative singular form, excluding onomastic nouns).

Additional selection criterion was the type of relation between nouns. There were five groups of associatively related noun pairs. Three of them contained word pairs that, in addition to associative relatedness, were also semantically related. The first group contained synonyms (e.g. *kuća – dom [house – home]*), the second contained antonyms (e.g. *noć – dan [night – day]*), and the third group contained hyponyms (*jabuka – voćka [apple – fruit]*). The two remaining groups contained pairs that were not semantically related: one group had strong associative relatedness (e.g. *majmun – banana [monkey – banana]*) while the other had weak associative relatedness (e.g. *svađa – tašta [quarrel – mother-in-law]*). The selection criterion for the synonyms and antonyms was based on the primary lexicographic definitions taken from *The Dictionary of Serbian Language* (Rečnik MS, 1967–1976). Primary lexicographic definition is the first definition listed for a given entry in a dictionary, which means that it is the most common meaning of a word. Usually it is also the most frequent meaning and most of the time it is the first to recall when heard or read in isolation.[6] Setting the primary definitions as a criterion was done for two reasons. Firstly, two words can represent more than one lexical relation (word polysemy). For example, concepts from the pair *man – woman* can be interpreted as concepts with the same superordinate term (homo sapiens), but also as superordinate and subordinate term (homo sapiens : female homo sapiens). This is due to polysemy of the word *man*. Pair *flower – stem* can be understood both as part-whole relation (flower meaning part of a plant consisting of stem and colored part) and co-hyponymous terms (flower meaning just colored part of the plant). Secondly, instead of arbitrary estimate we wanted to rely on more objective criterion of lexical relation. The only case where selection based on primary lexical definitions was not necessary was the case of hyponymy, because the criterion for hyponymy is unequivocal. The final two groups of word pairs consisted of associative pairs with no (or very low) semantic relatedness. Based on the associative frequency of the first associate, we formed a group of stronger associative relation (high associative frequency of the most frequent associate) and a group of weaker associative relation (low associative frequency of the most frequent associate).

These criteria reduced the number of possible candidates which was already restricted by limiting the selection to paradigmatic relations[7] between stimulus and its most frequent

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6   More about possible differences between primary and dominant meaning of a word in Filipović Đurđević (2007).

7   Paradigmatic relation refers to relation between two words belonging to same part of speech and being concurrent for the same syntactic constituent, as opposed to syntagmatic

associate. Consequently, from a total of 600 entries listed in *The Associative Dictionary of Serbian Language*, it was not possible to select enough word pairs for each category of stimuli (at least ten per group). Only eight noun pairs satisfied the respective criteria for antonyms, seven for hyponyms and nine for synonyms. Therefore, additional word pairs (two antonymy pairs, three hyponymy and one synonymy pair) were included based on a separately conducted study (Jakić, 2009).[8]

Fifty selected noun pairs were arranged in two lists of prime-target pairs with noun entries as targets and its first associates as primes. In each list, across the five groups, half of the targets were coupled by its first associate, while the remaining half was coupled by a neutral context (*****). The set of target nouns was the same across two lists, while the set of prime nouns was split in halves in order to achieve counterbalancing of the lists (half of the prime nouns was presented in the first list and the remaining half was presented in the second list). This way, each target noun was coupled both with its prime noun and a neutral context, while appearing only once per list.

In addition to target nouns, each list contained 50 target pseudonouns, half of which was coupled with another noun (not being associated with any of target words), and half of which was coupled with a neutral context (*****).

Overall, the experiment was based on 2x2x2 design. The first factor, lexicality of the target (word, pseudoword), was not included in the analyses. The second factor was prime condition (neutral context, associatively/semantically related context). Finally, the third factor was relation type, with two levels that were formed by merging appropriate groups of word pairs: word pairs that were both semantically and associatively related (synonyms, antonyms, and hyponyms) and word pairs that were associatively related (strong associative relation and weak associative relation).

The two groups of noun pairs (associatively related and both associatively and semantically related) were matched for *lemma frequency of prime*, *lemma frequency of target* (both taken from Kostić, 1999), *associative frequency of prime* (taken from Piper et al., 2005), *rated associative relatedness* (separate research using 0 to 7 rating scale with filler pairs), *prime and target length* (number of graphemes in Cyrillic alphabet), and the *Levenshtein*

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relation, which is relation between two words in a linear string of language (Sosir, 1989). According to some authors paradigmatic associations represent more advanced level of language development and language acquisition, and assume knowledge of word meanings (Kurcz, 1966). By implication, such associations are more stable than syntagmatic ones, with greater probability of replicating the results in repeated associative tests (Gašić-Pavišić, 1981).

8 Selection of additional noun pairs was based on average rated associative relatedness, since associative frequency and rated associative relatedness are highly correlated: $r=0.97$, $F(1,2)=37.88$, $p<0.05$ (Jakić, 2009). Thirty word pairs that accommodate design were created. These word pairs were presented together with all the stimuli selected from *The Associative Dictionary of Serbian Language,* and 400 filler pairs. Thirty-five participants were asked to rate the associative relatedness of given stimuli pairs on an eight-point scale (0-7). Average rating value for each pair was calculated, as well as for each category of word relation. Pairs whose average rating was closest to its group average were chosen. Finally, missing associative frequency for additional pairs was estimated from word frequency of the prime, based on the fact that associative frequency and word frequency are highly correlated: $r=0.985$ $F(1,2)=67.12$, $p=0.01$ (Jakić, 2009). Each associative frequency value was derived from the regression equation (obtained in Jakić, 2009) and word frequency of the prime (taken from Kostić, 1999).

distance between prime and target. The Levenshtein distance between two strings is given by the minimum number of edit operations (insertions, deletions and substitutions of a single character) needed to transform one string into the other, thus reflecting the level of orthographic similarity between two words (Левенштейн, 1965).

Due to the fact that targets were not repeated across five groups of lexical relations, we were not able to perform all the relevant analyses on the raw reaction times. Therefore, we derived additional dependent variable by calculating residual reaction time for the target preceded by related prime from the reaction time for the same target preceded by the neutral context. This was done in a separate regression analysis, with reaction time from the neutral context as predictor variable, and reaction time from the related context as the criterion variable. By doing so, we extracted the variance that can not be attributed to processing of the target per se, but is attributable to the effect of the related context. We named this variable *facilitation effect*.

Procedure: Backward direction stimuli were presented in a visual lexical decision task, on the computer screen, using SuperLab software (Cedrus, 2001). At the beginning of each trial a fixation point was presented for 1000 ms, followed by prime with exposure duration of 500 ms, ISI 250 ms, and the target stimulus with maximum duration of 1500 ms. Participants had to decide whether the second stimulus was a word of the Serbian language (by pressing YES/ NO key). The dependent variable was the reaction time, measured from the second stimulus onset. The order of presentation was randomized. Participants received instruction about the procedure, followed by twelve practice trials. In order to ensure that participants were paying attention to primes they were sporadically asked to repeat presented pair of stimuli. The whole procedure lasted about five minutes per participant.

Results

Prior to analysis, two item pairs that elicited above 20% error were excluded from analyses (*prisila – prinuda [force – coercion]* and *karfiol – povrće [cauliflower – vegetable]*). Additionally, for each participant, we excluded reaction times that were outside of range of –/+ 2.5 units of standard deviation of distribution of his/her own reaction times. This way, additional 3% of data points were excluded.

In the first step, we tested for the overall priming effect, that is for the overall effect of related context, by comparing reaction times elicited by targets presented in neutral context and reaction times elicited by targets presented in related context. This analysis demonstrated a clear facilitation by related context: $F(1, 49)=56.154$, $p<0.01$ (Figure 1).

In the next step, we residualized reaction times elicited by targets presented in related context, as explained in method section. We conducted two analyses with residualized reaction time as dependent variable.

In order to test for the effect of semantically related context over and above the effect of pure association, we compared words that are only associatively related and words that are both associatively and semantically related. Here, we observed a statistically significant advantage of both semantically and associatively related word pairs: $F(1, 46)=8.216$, $p<0.01$ (Figure 2).
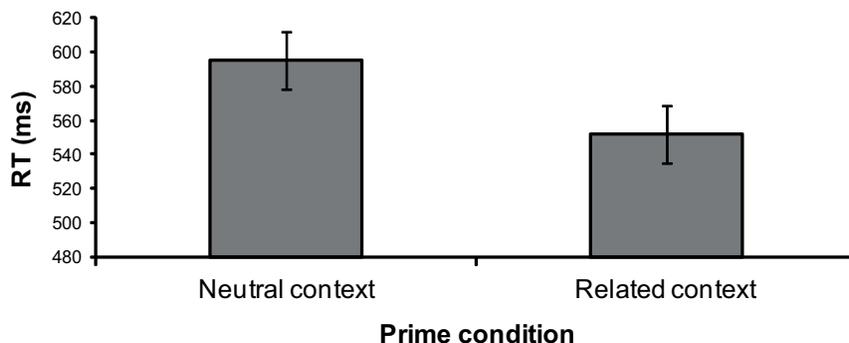
Figure 1: Average values of reaction times for two levels of prime condition in Experiment 1. Vertical bars denote standard error of the mean.
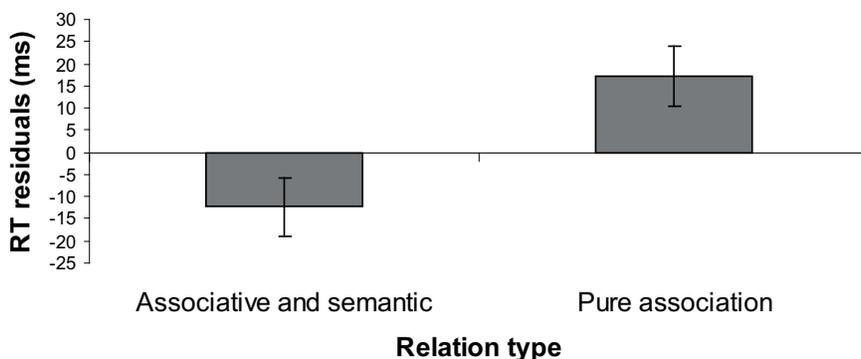

Figure 2: Average values of reaction time residuals for two levels of relation type in Experiment 1. Vertical bars denote standard error of the mean.

In addition to overall facilitation, our results indicated that there was an effect of semantic variables over and above associative relatedness. In other words, our results suggested that in addition to *associative boost* documented in many studies (Moss et al., 1994; Lucas, 2000; Ferrand & New, 2003) there also could be a *semantic boost*.

In order to test whether the advantage of additional semantic relatedness could be attributed to the amount of semantic overlap between words, we looked at correlation between level of semantic overlap and facilitation effect (primed RT residuals). The level of semantic overlap was a rank variable, formed in accordance with *Componential analysis* (Lyons, 1977; Gortan-Premk, 2004). Based on this theory, we assigned synonymy pairs the highest rank of level of semantic overlap, followed by antonyms, hyponyms, stronger associative relatedness, and finally weaker associative relatedness as the lowest rank of

semantic overlap (explained in details in introduction section). We observed significant Gamma coefficient of rank correlation (Goodman and Kruskal, 1954; 1959; 1963): G=0.28, z=2.547, p<0.05. Gamma coefficient was applied as the most suitable correlation measure for dataset with large number of tied measures, as was the case in our study. This indicated that it is *the amount of semantic overlap* that influenced the amount of facilitation in Experiment 1.

EXPERIMENT 2

In Experiment 1 the direction of the association was backward, that is prime was the associate of a target. Componential analysis and Distributed models of memory predict that facilitation effect would be the same, irrespective of the association direction (forward or backward). In contrast, localistic theories, such as Spreading activation theory, take into account the direction of association, predicting that forward direction would elicit stronger facilitation effect. In Experiment 2 we tested these predictions. Firstly, we repeated the analysis conducted in the first experiment. Next, we tested for the symmetry in a more direct manner, by analyzing the data from the two experiments together.

Method

Participants. Twenty-seven first-year undergraduates from the Department of Psychology, University of Belgrade participated in the experiment as part of their academic requirements.

Stimuli, design and procedure. Stimuli, procedure and design were the same as in Experiment 1. The only difference concerned the order of presentation of prime and target. In this experiment prime and target from Experiment 1 were reversed. Applying this manipulation we provided forward relatedness between prime and target because primes were stimuli from associative norms and targets were their most frequent associates.

Results

In order to test for potential symmetry in effects, the data from the second experiment were analyzed in three ways. The analyses applied to data from experiment 1 was applied, and after that, the data from two experiments were analyzed together, with experiment as additional independent variable. Finally, we looked at by-item correlation for pairs presented in two experiments.

Firstly, the data from this experiment were analyzed by applying the identical analysis as in the previous experiment. Prior to analysis, the same two item pairs that elicited above 20% error were excluded from analyses (*prisila – prinuda [force – coercion]* and *karfiol – povrće [cauliflower – vegetable]*). As in the first experiment, for each participant, we excluded reaction times that were outside of range of –/+ 2.5 units of standard deviation of distribution of his/her own reaction times. This way, additional 2.8% of data points were excluded.

As in the first experiment, we firstly tested for the overall priming effect, and we observed significant effect of related context compared to neutral context: $F(1, 49)=35.812$, $p<0.01$ (Figure 3).
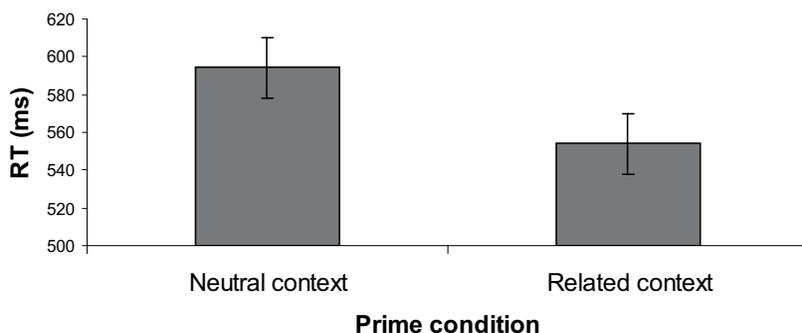

Figure 3: Average values of reaction times for two levels of prime condition in Experiment 2. Vertical bars denote standard error of the mean.

In the next step, we residualized reaction times elicited by related context in the same way as we did in Experiment 1. In order to test for the effect of relation type, we compared two groups of word pairs with respect to reaction time residuals, and again observed the advantage of word pairs that were both semantically and associatively related compared to purely associatively related pairs: $F(1, 46)=4.623$, $p<0.05$ (Figure 4). This way, the semantic boost that was observed in the first experiment, was observed here, as well. Along the same line, significant Gamma coefficient of rank correlation (Goodman & Kruskal, 1954; 1959; 1963) between reaction time residuals and ranked level of semantic overlap was observed: $G=0.21$, $z=1.973$, $p<0.05$.
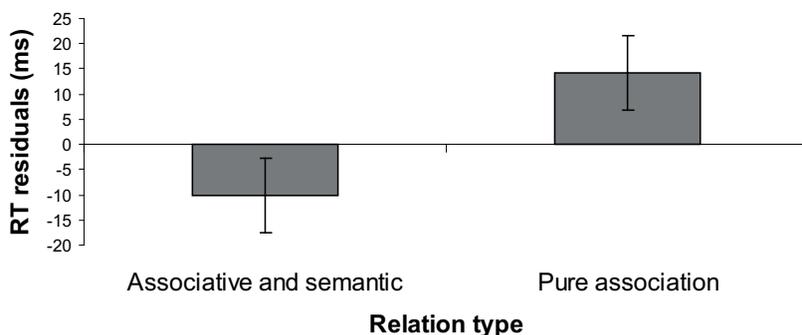

Figure 4: Average values of reaction time residuals for two levels of relation type in Experiment 2. Vertical bars denote standard error of the mean.

Although the results of the second experiment mirror the results of the first experiment, in order to explicitly test for the symmetry of the effects observed in the two experiments, we jointly analyzed the data. Firstly, we conducted 2x2 by-item analysis of variance on reaction times, with experiment and prime condition as independent variables. We observed only the main effect of prime condition: $F(1, 98)=88.788$, $p<0.01$. There was no main effect of experiment, and no experiment by prime condition interaction. Secondly, we conducted 2x2 analysis of variance on residualized reaction time (previously described), with experiment and relation type as independent variables. Here, again, we observed the same pattern of results. Only the main effect of relation type was signifficant: $F(1, 92)=12.370$, $p<0.01$. There was no main effect of experiment, nor interaction between experiment and relation type. Finally, the symmetry between the two experiments was tested by looking at by-item correlation for pairs presented in two experiments. Here, a significant Pearson coefficient of correlation was observed: $r=0.30$, $t(46)=2.182$, $p<0.05$. However, the level of the observed correlation was low, suggesting systematic but not substantial relation between two priming directions. Additionaly, statistical significance of the observed coefficient was dependent on exclusion of outliers. Unlike previous analyses, this coefficient was not statistically significant if outliers were not excluded.

GENERAL DISCUSSION

In this study we asked whether the semantic relatedness between two words could cause the facilitation effect over and above the effect of words that are only associatively related. Additionally, we wanted to investigate the nature of the possible advantage, by testing the predictions derived from Componential analysis. Finally, we wanted to test for the symmetry in facilitation by comparing the effects in backward and forward priming procedure, thus contrasting predictions of spreading activation models and distributed models of memory. In order to answer these questions, we designed two experiments in which we varied the type of relatedness between word pair constituents. Five groups of word pairs were presented. In addition to associative relatedness (of a word and its most frequent associate), the first three groups contained pairs that were also semantically related (synonyms, antonyms and hyponyms). The fourth group contained pairs with stronger associative relatedness, while the fifth group encompassed pairs with weaker associative relatedness. The index of the effects of associative and associative and semantic relatedness was the residual variation in reaction time elicited by a target in the related context, that could not be attributed to the cost of processing target per se (i.e. target presented in the neutral context). In the first experiment we tested for the effect of backward association (i.e. targets were entries from *The Associative Dictionary of Serbian*

Language and primes were their most frequent associates), while in the second experiment the order of prime and target was reversed, in order to test for the effect of forward association.

For items presented in the two experiments it was shown that facilitation effect was significantly stronger when, in addition to associative relatedness, word pairs were also semantically related. This way, we documented the existence of some sort of the *semantic boost*. In order to better understand the nature of this advantage, we looked at semantic differences among five groups of word pairs. *Componential Analysis* was the theoretical framework for discussing the differences among groups because it is sensitive to the amount of semantic overlap between two words. With this we loose strict distinction between the two types of relation (pure associative vs. associative and semantic). Instead, we now operate with single parameter that is the amount of semantic overlap, asking whether the amount of facilitation ordinally parallels the amount of overlap. By correlating the two experiments, Gamma coefficient of rank correlation confirmed this relation, the implication being that it is *the amount of semantic overlap* that plays the role in target facilitation. However, the level of the correlation coefficient was moderate, which could indicate two possibilities. On the one hand, it could indicate the existence of additional factors that influence processing of targets presented in related context. On the other hand, the ranking procedure that we applied was very rough, and perhaps the greater value of correlation coefficient could be obtained if the word pairs were ranked in a more precise manner. One way to achieve this would be to rank them on a pair-by-pair basis, instead of the group ranking that we applied. However, even though such a procedure might provide us with finer grain distinction of semantic overlap it would be very demanding to take into account all semantic units that constitute meaning of a given word, and measure the weight of the semantic components, since not all of them are of the same importance (archisems, grammems and semes of lower rank; Алефиренко, 2005).

Our last goal concerned the symmetry between backward and forward priming. In the second experiment we reversed the positions of prime and target presented in the first experiment in order to investigate whether we would get the same effect if we used forward, instead of backward prime-target association. By doing so, we aimed at comparing two theories – spreading activation theory (Collins & Loftus, 1975; Thompson-Schill et al., 1998) and distributed models of memory (Plaut, 1995). As noted in the introductory section, spreading activation predicts that effect of forward association would be greater than that of backward association, while distributed models predict no difference in the amount of facilitation, since constituent pairs share common semantic material. Our results are not in concord with predictions of spreading activation theory, and seem to comply with distributed models of memory. Predictions of spreading activation theory were rejected because no facilitation difference was observed between the

two experiments. Conversely, several points from our study are in accordance with predictions of distributed models of memory. Firstly, in two experiments we observed identical pattern of results concerning the advantage of word pairs that are both associatively and semantically related and concerning the effect of semantic overlap. Next, we found no evidence of experiment by relation type interaction. Finally, we observed significant correlation coefficient between by-item reaction time residuals from two experiments. All of these findings speak in favor of the claim that semantic overlap influences facilitation regardless of priming direction. However, we must keep in mind that correlation coefficient between by-item reaction time residuals was low, and dependent on exclusion of outliers. It suggested systematic, but not substantial relation between reaction time residuals observed in two priming directions. Having in mind that this correlation represents the ultimate test of symmetry between two experiments, further studies are necessary to build a stronger case for distributed models of memory.

Acknowledgement

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APPENDIX

Stimuli presented in Experiment 1 and Experiment 2

relation type in direction of backw assoc	stimuli (Serbian)	stimuli (translation)	Average by-item RT (ms), Experiment 1, neutral context	Average by-item RT (ms), Experiment 1, related context	Average by-item RT (ms), Experiment 2, neutral context	Average by-item RT (ms), Experiment 2, related context	assoc freq	freq 1 (prime exp 1, target exp 2)	freq 2 (target exp 1, prime exp 2)	rating scale	length 1 (prime exp 1, target exp 2)	length 2 (target exp 1, prime exp 2)	levensht dist
synonymy	dete : čedo	child : kid	626	543	531	561	301	1662	57	5.967	4	4	3
synonymy	kuća : dom	house : home	559	528	590	552	257	1690	836	6.543	4	3	4
synonymy	prkos : inat	defiance : spite	652	569	683	605	144	60	6	6.046	5	4	5
synonymy	vest : informacija	news : information	628	642	564	552	104	685	62	5.857	4	11	11
synonymy	abortus : pobačaj	abortion : miscarriage	669	610	694	570	128	0	6	5.500	7	7	7
synonymy	sujeverje : praznoverje	superstition : bigotry	762	643	684	612	92	0	3	4.486	9	11	6
synonymy	prinuda : prisila	force : coercion	800	620	695	563	72	0	0	5.800	7	7	3
synonymy	patriota : rodoljub	patriot : nationalist/ flag-waver	734	635	727	587	109	4	21	5.686	8	8	8
synonymy	providnost : transparentnost	translucence : transparency	789	731	716	620	47	0	0	2.571	10	15	10
synonymy	čežnja : žudnja	yearning/ craving : longing	680	565	611	589	130*[1]	414	229	5.343	6	7	4
antonymy	noć : dan	night : day	528	496	604	462	261	4334	5758	4.457	3	3	3
antonymy	laž : istina	lie : truth	564	506	560	530	291	192	375	4.371	3	6	6
antonymy	sever : jug	north : south	592	563	576	568	259	62	105	4.333	5	3	5
antonymy	ljubav : mržnja	love : hate	585	599	614	519	90	2365	320	4.086	6	6	6
antonymy	sreća : tuga	happiness : sadness	563	582	543	549	153*	1011	1326	4.314	5	4	4
antonymy	poraz : pobeda	defeat : victory	574	515	659	570	91	126	551	3.870	5	6	4
antonymy	brat : sestra	brother : sister	583	514	614	501	188	696	347	5.944	4	6	5
antonymy	istok : zapad	east : west	603	504	574	491	289	84	105	5.100	5	5	5
antonymy	smrt : život	death : life	598	523	541	531	135	2024	3423	5.067	4	6	5
antonymy	mir : rat	peace : war	592	490	587	512	160*	1199	857	5.143	3	3	3
hyponymy	nana : čaj	mint : tea	552	526	653	640	61	26	52	5.943	4	3	3
hyponymy	auto : kola	automobile : car	595	521	542	519	43	42	0	6.429	4	4	4
hyponymy	pomfrit : krompir	french fries : potato	627	535	702	622	117	0	62	6.181	7	7	5

relation type in direction of backw assoc	stimuli (Serbian)	stimuli (translation)	Average by-item RT (ms), Experiment 1, neutral context	Average by-item RT (ms), Experiment 1, related context	Average by-item RT (ms), Experiment 2, neutral context	Average by-item RT (ms), Experiment 2, related context	assoc freq	freq 1 (prime exp 1, target exp 2)	freq 2 (target exp 1, prime exp 2)	rating scale	length 1 (prime exp 1, target exp 2)	length 2 (target exp 1, prime exp 2)	levensht dist
hyponymy	alkohol : piće	alcohol : drink	560	531	607	525	92	45	104	5.943	7	4	7
hyponymy	prsten : nakit	ring : jewelry	645	586	639	595	116*	62	26	5.743	6	5	6
hyponymy	kupus : salata	cabbage : salad	600	559	613	601	138	29	22	5.571	5	6	6
hyponymy	umetnost : stvaralaštvo	art : creativity	716	686	573	534	156	146	8	5.286	8	12	11
hyponymy	jabuka : voćka	apple : fruit	661	529	576	579	163	212	79	5.771	6	5	4
hyponymy	krofna : kolač	doughnut : cake	602	554	597	635	114*	0	36	4.771	6	5	4
hyponymy	karfiol : povrće	cauliflower : vegetable	587	566	785	694	114*	3	83	5.771	7	6	7
stronger assoc relat	majmun : banana	monkey : banana	587	602	618	616	176	25	12	5.886	6	6	5
stronger assoc relat	more : brod	sea : ship	546	557	550	579	253	1784	505	6.133	4	4	4
stronger assoc relat	država : zastava	country : flag	603	561	591	564	77	447	446	6.122	6	7	4
stronger assoc relat	smeh : humor	laugh : humor	604	569	545	566	370	736	24	6.381	4	5	4
stronger assoc relat	vatra : logor	fire : camp	663	623	559	547	79	719	159	5.140	5	5	5
stronger assoc relat	reka : most	river : bridge	589	537	608	527	105	1465	526	6.240	4	4	4
stronger assoc relat	pamet : mozak	cleverness : brain	551	536	635	586	147	40	132	5.819	5	5	5
stronger assoc relat	fabrika : radnik	factory : worker	607	504	641	585	71	424	941	6.229	7	6	4
stronger assoc relat	njiva : seljak	field: farmer/ peasant	586	557	711	610	99	556	335	5.919	5	6	5
stronger assoc relat	učenje : škola	learning : school	564	539	626	534	75	25	885	6.075	6	5	6
weaker assoc relat	jakna : koža	jacket : skin/ leather	542	541	591	556	61	0	273	4.721	5	4	4
weaker assoc relat	krava : tolerancija	cow : tolerance	690	729	643	686	45	88	0	2.657	5	11	8
weaker assoc relat	prevara : zavera	deceit : conspiracy	584	586	633	605	83	38	38	4.949	7	6	4
weaker assoc relat	neizvesnot : budućnost	uncertainty : future	579	583	669	656	59	24	214	4.286	11	9	7

relation type in direction of backw assoc	stimuli (Serbian)	stimuli (translation)	Average by-item RT (ms), Experiment 1, neutral context	Average by-item RT (ms), Experiment 1, related context	Average by-item RT (ms), Experiment 2, neutral context	Average by-item RT (ms), Experiment 2, related context	assoc freq	freq 1 (prime exp 1, target exp 2)	freq 2 (target exp 2, prime exp 2)	rating scale	length 1 (prime exp 1, target exp 2)	length 2 (target exp 1, prime exp 2)	levensht dist
weaker assoc relat	osuda : krivica	condemnation: guilt/blame	590	599	611	622	70	21	47	4.943	5	7	6
weaker assoc relat	svađa : tašta	quarrel : mother-in-law	669	642	574	574	53	19	6	4.498	5	5	4
weaker assoc relat	strah : nesigurnost	fear : insecurity	711	655	628	515	145	612	10	4.771	5	11	9
weaker assoc relat	bolnica : institut	hospital : institute	709	660	583	542	68	120	72	4.429	7	8	7
weaker assoc relat	vreteno : telo	spindle : body	592	514	714	686	98	68	1215	3.321	7	4	4
weaker assoc relat	lepota : lice	beauty : face	572	534	605	603	106	509	1797	5.125	6	4	5