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589

Type and number of violations and the grammatical congruency effect in lexical decision*

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Summary. An experiment was conducted in the Serbo-Croatian language in which native speakers/readers made lexical decisions on inflected nouns and legally inflected pseudonouns following inflected possessive pronouns. A possessive pronoun and the noun or pseudonoun that followed it could agree in case, gender, and number (0 violations), disagree in either case or gender or number (1 violation) or disagree simultaneously on two of the three (2 violations). A grammatical congruency effect was observed for both nouns and pseudonouns. Acceptance latencies were shorter and rejection latencies were longer for inflectional agreement than inflectional disagreement. However, for neither nouns nor pseudonouns was the magnitude of the effect influenced by the type or number of violations. The results are discussed in terms of (1) the automaticity of syntactic processes and (2) the properties of a decision making device (specially tailored to rapid lexical evaluations) relative to the properties of the language processor.

A growing body of evidence supports the notion that syntactical or grammatical relatedness colors the way in which one word affects the processing of another. Investigations with English language materials address this issue by violating the natural ordering of parts of speech. For example, lexical decision to a target is speeded when the context-target pair is ordered legally relative to when it is ordered illegally [e. g., *men-swear* vs *whose-swear* (Goodman, McClelland, & Gibb, 1981); "For now the happy family lives with *Batteries*" vs "For now the happy family lives with *Formulate*" (Wright & Garrett, 1984)]. In contrast, investigations with Serbo-Croatian materials have been able to preserve the ordinary adjacencies of parts of speech because grammatical violations can be introduced at the level of inflected morphemes. Grammatically acceptable pronoun-verb pairs must agree in person and number while adjective-noun pairs must agree in case, number, and gender. Violations of these relationships result in a grammatical congruency effect, that is, lexical decision to targets in a grammatically incongruent context are slow relative to those same targets in grammatically congruent contexts. As examples, lexical decisions to verb targets are faster when the preceding personal pronoun agrees in person than when it does not (Lukatela et al., 1982); decision times to nouns with a case inflection appropriate for a preceding preposition are speeded relative to those with an inappropriate inflection (Lukatela, Kostić, Feldman, & Turvey, 1983); slowed decision times are found for violations of case agreement between adjectives and nouns or legally inflected pseudoadjectives and nouns (Gurjanov, Lukatela, Moskovljević, Savić, & Turvey, 1985); nouns that agree with their possessive pronoun contexts in gender are lexically evaluated faster than those that do not agree (Gurjanov, G. Lukatela, K. Lukatela, Savić, & Turvey, 1986).

It has been argued that syntactic influences on lexical decision are postlexical (Gurjanov et al., 1986; Gurjanov et al., 1985; Seidenberg, Waters, Sanders, & Langer, 1984; West & Stanovich, 1982); that is to say, unlike the spreading activation among particular lexical items that is conjectured for associative priming (deGroot, 1983), the grammatical congruency effect is thought to be the result of a check on grammatical coherency of the given context-target pair (cf. deGroot, Thomassen, & Hudson, 1982; Gurjanov et al., 1986). The reason is quite simple: If the congruency effect were the result of spreading activation, then a prime would have to activate all words of a given type (e. g., all nouns of a particular case). It seems unlikely, therefore, that relations among lexical entries are responsible for syntactical influences on lexical decision.

Let us, then, provide a framework for this coherence checker. The central notion is that the language processor is composed of three relatively autonomous devices. One accesses lexical representations of each member of an arrangement of words, another assigns a syntactical structure to the arrangement of words, and the third assigns meaning to the arrangement of words (cf. Forster, 1979). In the course of normal language comprehension, all three devices are necessary. In the experimentally contrived situation of a lexical decision task, although it would seem that the lexical processor is all that is required, the other devices cannot be disengaged. With a grammatically congruent context-target pair, all devices provide positive output (i. e., each performs its usual function) so that the job of the decision-making mechanism is easy. With a grammatically incongruent pair, however, the syntactic processor balks because part of the information made available by the lexical processor is that, for example, the context is

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masculine and the target is feminine. The lexical decision mechanism must overcome the negative bias from the syntactical processor (cf. deGroot, 1985; West & Stanovich, 1982), resulting in slower decision times.

It was mentioned earlier that grammatical congruency in the Serbo-Croatian language is defined over several dimensions. At issue in the present investigation is whether or not the congruency effect for possessive pronoun-noun pairs is influenced by: (1) which grammatical dimension – gender, number, or case – is violated, or (2) how many grammatical dimensions are violated. In other words, is the negative bias that is induced by the coherence check altered by the type or the extent of grammatical violation?

This question is directed primarily at the nature of the device that makes a decision about a word's lexical status on the basis of the information it receives from the largely independent lexical, syntactic, and message processors. These latter processes are presumed to be "hard molded, hard algorithmed". The decision-making device, on the other hand, is presumed to be "soft molded, soft algorithmed". It represents the fact that an ordinary speaker/reader of the language has temporarily made him or herself into a special purpose mechanism – one geared to reporting rapidly on the lexical status of printed letter strings. One could imagine that it is in the nature of this soft-molded decision-making device to weight the outcomes of the lexical, syntactic, and message processors. In a lexical decision experiment, for example, the lexical processor ought to be weighted most heavily. The value of the message processor would depend on how informative it is, given the constraints of the experimental situation. To anticipate our method, the present investigation simply uses some form of the possessive pronouns *MY* or *YOUR* on every trial. The message processor, therefore, is relatively noninformative and ought to be weighted accordingly. In contrast, numerous investigations of the effect of minimal grammatical contexts – for example, a single, closed class word with an inflection appropriate or inappropriate for the target – reveals that considerable weight is given to the syntactic processor in lexical decision.

Obviously, the more the outcomes of the three processors concur, the larger the probability that the lexical decision device will succeed in making a decision in a determined period of time. However, before a soft molded decision device can operate on, say, grammatical incongruency, it must receive information that incongruency of some type has been detected. This information must come from the hard-molded syntactic processor. It is reasonable, therefore, to expect the soft-molded decision maker to be sensitive to the speed of detection of an incongruity. One could hypothesize that the speed of detection might depend on the type and/or number of grammatical violations (case violation might be considered more egregious than – and be detected faster than – gender violation; two violations of any type might be detected faster than any single one, etc.). In experimental terms, these hypothesized properties of the decision-making device would be realized as lexical decision times on nouns in the context of possessive adjectives that (1) differ significantly as a function of the type of incongruency and (2) increase as a direct function of the number of incongruencies.

If the outcome of the experiment runs counter to the outlined hypotheses and shows no differential effect as a function of type or number of violations, then this lack of an effect can just as plausibly be ascribed to the real structural – i. e., hard molded – processor as to the decision maker. A little thought suggests that in order to do its real world job effectively, the hard-molded syntactic processor might only need to detect the fact that there is or is not a grammatical incongruency. Therefore, a self-terminating scan of grammatical features that is associated with binary coherence checks seems to be a plausible model of the syntactic processor. In experimental terms, this latter perspective on the decision-making device suggests that the lexical decision times for any type and any number of incongruencies will be the same and that they will be significantly slower than zero incongruencies.

The present experiment addresses these experimental predictions by observing the effects of different grammatical relations (1) between possessive pronouns (sometimes referred to as possessive adjectives) and nouns and (2) between possessive pronouns and pseudonouns. Pseudonouns are created from real nouns by substituting for one of the letters in the stem. Their inflected endings, therefore, are legal noun endings. In consequence, grammatical congruency can be defined between a possessive pronoun and a pseudonoun in the same way that it can be defined between a possessive pronoun and a noun. To the extent that grammatical relations are sustained purely by inflectional morphemes[1], equivalent effects should be observed for acceptance latencies (nouns) and rejection latencies (pseudonouns). In order to avoid a confound between grammatical and physical congruence of inflectional endings, targets were limited to feminine singular nouns in the dative case. The inflectional endings of such nouns *(–i)* and their congruent possessive adjectives (*Mojoj* and *Tvojoj*) are physically dissimilar.

The aforementioned equivalence between effects obtained with acceptance and rejection latencies has been noted in two previous grammatical congruency experiments (Lukatela et al., 1982, 1983). The data from a study using possessive pronoun-noun pairs, (Gurjanov et al., 1986) as the present experiment does, were ambiguous about the equivalence.

Methods

Subjects. Seventy-two students from the Department of Psychology in the Faculty of Philosophy at the University of Belgrade participated in the experiment in partial fulfillment of a course requirement. All subjects had previously participated in reaction time experiments.

Materials. Targets were selected from a basic set of 80 nouns, primarily of the CCVCV type (e. g., *Ptica, bird*) drawn from the midfrequency range (Dj. Kostić, 1965). Corresponding pseudonouns were formed using an entirely different set of 80 comparable nouns and changing 1 letter in the stem of each (leaving the inflectional morpheme intact). Of the 160 context-target pairs (see Appendix), 100 were test trials and 60 were filler trials included to equate

[1] Although it is assumed that pseudowords have no lexical entry, there is evidence that some pseudowords derived from real words may access the lexical entry of the source words [e. g., Martin (1982), but see Chambers (1979)]. Of course, this would affect syntactically congruent and incongruent situations to the same extent

the number of congruent and incongruent pairs seen by a given subject. The fillers were not analyzed.

All targets in the test trials were singular feminine nouns of Class A (after Bidewell, 1970) in the dative case (where the ending is *i*). Fifty of these were paired with possessive pronouns [half first person *(MY)* and half second person *(YOUR)*] to generate 5 types of situations containing 10 tokens of each type: 1 set with no violations, 3 sets with one violation (where case was accusative, gender was masculine, or number was plural) and 1 set with 2 violations (where gender was masculine and, simultaneously, number was plural). Fifty corresponding context-pseudonoun pairs were similarly constructed. In addition to precluding the physical similarity of inflectional endings for contexts and targets, the selection restrictions ensured that only unique violation types were produced (test trials included only Class A feminine singular nouns in the dative case, case violations were introduced solely with accusative contexts, and the two violation condition was limited to gender plus number). (For example, Type A feminine nominative singular and Type 0 masculine genitive singular both end in *a* so that had such targets been used, the extent of the violation would be ambiguous.)

For the filler trials, ten feminine singular accusative, ten masculine singular dative, and ten feminine plural dative nouns were paired with appropriate pronouns, as were a corresponding set of pseudonouns.

Design. Each subject saw 80 pronoun-noun and 80 pronoun-pseudonoun pairs, half of which were grammatically congruent and half of which contained at least 1 violation. Of the incongruent pairs, there were equal numbers of case, gender, number, and gender-plus-number violations. A given subject never encountered a given target more than once.

Procedure. A subject was seated before the cathode ray tube (CRT) display of an Apple IIe computer in a dimly lit room. A fixation point was centered on the screen. On each trial, the subject heard a brief warning signal, after which a possessive pronoun appeared for 300 ms centered above the fixation point. After a 300-ms interstimulus interval, a noun or pseudonoun appeared below the fixation point for 1400 ms. All letter strings appeared in uppercase Roman letters. Subjects were instructed to decide as rapidly as possible whether or not the second letter string was a word. To ensure that subjects were reading the contexts, they were occasionally asked to report both stimuli after the lexical decision had been made. Decisions were indicated by depressing a telegraph key with both thumbs for a *No* response or by depressing a slightly further key with both forefingers for a *Yes* response. Latencies were measured from the onset of the target. If the response latency was longer than 1400 ms, a message appeared on the screen requesting that the subject respond more quickly. The experimental sequence was preceded by a practice sequence of 20 different context-target pairs.

Results and discussion

Latencies in excess of 1400 ms and less than 400 ms were excluded from the analysis. The means of the subjects' latencies and errors for the three types of violations with noun and pseudonoun targets are presented in Table 1. Inspection of Table 1 suggests that for single violations, decision latencies were not distinguished by type of violation. For the noun latencies and errors the *F* ratios were less than unity by both the subjects and stimuli analyses. The *F* by the subjects' analysis for the pseudoword latencies exceeded unity but was not significant, $F(2,142) = 1.63$, $MS_e = 1288$, $P > 0.10$. The three other *F* tests on the pseudoword data (latencies by stimuli and errors by subjects and stimuli) yielded values less than unity. In short, type of violation did not differentially affect word and pseudoword latencies and errors.

Given this fact, the latency and error data were collapsed over the type variable to yield three sets of means corresponding to 0, 1, and 2 grammatical violations and these are presented in Table 2. The effect of number of violations was evaluated on these means. Noun latencies were significantly affected by number according to both the subjects and the stimuli analyses, $F(2,142) = 5.36$, $MS_e = 1402$, $P < 0.01$ and $F(2,118) = 5.95$, $MS_e = 1311$, $P < 0.01$, respectively. The same statistical outcomes were obtained for the pseudonoun latencies: $F(2,142) = 4.65$, $MS_e = 1147$, $P < 0.01$ by the subjects analysis and $F(2,118) = 4.86$, $P < 0.01$ by the stimuli analysis. Errors in noun decision making were significantly affected by number of violations according to both the subjects and stimuli analyses: $F(2,142) = 4.97$; $MS_e = 34$; $P < 0.01$ and $F(2,118) = 7.37$; $MS_e = 31$; $P < 0.001$. In contrast, number did not affect pseudonoun errors. The ANOVA on subjects and stimuli means both yielded *F* ratios less than unity.

Protected *t*-tests (where the error term from the ANOVA is used as the estimate of the variance; see Cohen and Cohen, 1975) were conducted on the means for the 1 versus 2 violations. No significant differences were obtained.

The results of the experiment are fairly straightforward. First, there was a grammatical congruency effect,

Table 1. Lexical decision as a function of type of grammatical violation

Target	Type of violation		
	Case	Gender	Number
Noun	671[a]	675	671
	4.4[b]	6.0	6.0
Pseudonoun	718	708	717
	2.6	3.5	2.1

[a] Latency (ms)
[b] Error (percent)

Table 2. Lexical decision as a function of number of violations

Target	Number of violations		
	0	1	2
Noun	656[a]	672	675
	3.2[b]	5.5	6.1
Pseudonoun	730	714	715
	3.3	2.7	3.6

[a] Latency (ms)
[b] Error (percent)

and it was observed for both nouns and pseudonouns. Second, the magnitude of the effect for both nouns and pseudonouns was indifferent to the type and the number of grammatical violations.

Let us consider the first result. Possessive pronoun-noun pairings that were in full grammatical agreement were associated with faster lexical decisions than possessive pronoun-noun pairings that disagreed on one or two grammatical dimensions. Similarly, possessive pronoun-pseudonoun pairings that were in full grammatical agreement (the pseudonoun's inflection agreed in case, gender, and number with the possessive pronoun's inflection) were associated with slower rejection latencies than pairings in which the agreement was incomplete by one or two dimensions. The magnitude of the grammatical congruency effect in the noun latency data was16 ms for zero versus 1 violation and 19 ms for zero versus 2 violations. Gurjanov et al. (1986) obtained a congruency effect for 0 versus 1 violation of the order of 51 ms (calculated from the data on feminine nouns preceded by possessive pronouns reported in their Table 2). In the course of the latter experiment, only one type of disagreement ever occurred, namely, in gender. It contrasts, therefore, with the present experiment in which all three types of possible disagreement occurred and in which the number of disagreements was frequently 2. The large difference in the magnitudes of the congruency effect defined over possessive pronoun-noun pairs in the two experiments is probably attributable to these differences in the homogeneity of grammatical manipulations. The situation may be analogous to that in associative priming experiments. Tweedy, Lapinski, and Schvaneveldt (1977) showed that the facilitation due to an associative context was greater with a larger proportion of associative trials. They interpreted this result within Posner and Synder's (1975) two-factor theory of attention. Focusing on the conscious attentional component, Tweedy et al. (1977) argued that the subjects' expectation concerning the relatedness of the items allows for a specialized postlexical control strategy (cf. Shiffrin & Schneider, 1977) to be brought into effect. In principle, the decision-making device in the experiments by Gurjanov et al. (1986) concentrated on just the gender dimension. The concentration in the present experiment could not have been as focused, because the subjects' expectancies were that any one of the dimensions of grammatical agreement could be violated with near equal probability.

The magnitude of the grammatical congruency effect on word (noun) latencies in the present experiment compares favorably with the magnitudes of syntactical congruency effects reported for English language two-word sequences by Goodman et al. (1981) and Seidenberg et al. (1984). In the two experiments of Goodman et al., the magnitudes were 19 ms and 15 ms. In the single experiment of Seidenberg et al., the magnitude was 13 ms. A further favorable comparison is to be found between the respective error productions. In the present experiment the percent error for the congruent condition was 3.19. For the single and double incongruency conditions the percent errors were 5.42 and 6.11, respectively, to yield congruent-incongruent differences of −2.24% and −2.92%. Significant differences in error production between congruent and incongruent conditions on the order of −4.0% and −1.3% were reported, respectively, for the first experiment of Goodman et al. and for the experiment by Seidenberg et al. In the study by Gurjanov et al. (1986), the congruency-incongruency error production difference (averaged over masculine and feminine nouns of typical and atypical declension) amounted to −2.7%.

The grammatical congruency effect in the pseudonoun latency data was −16 ms for the 0 versus 1 comparison and −15 ms for the 0 versus 2 comparison. These rejection latency differences complement the acceptance latency differences and concur in this respect with the results of several previous experiments that used pseudoverbs and pseudoadjectives as well as pseudonouns. We will summarize these findings briefly before elaborating the significance of grammatical effects with pseudowords.

The preposition-noun experiment of Lukatela et al. (1982) included pseudonouns that were mostly but not exclusively generated by the substitution of the first letter of a noun keeping the inflected ending legal. An interaction between preposition and pseudonoun type (nominativelike, dative/locativelike, instrumentallike) was obtained with subject variability as the error term, but not with stimulus variability as the error term. The data suggested that where the inflection of a pseudonoun agreed with the preceding preposition, the rejection latencies were slowed (by approximately 18 ms) relative to when they were in disagreement. For the noun targets, grammatical agreement with the preceding preposition hastened (by approximately 28 ms) positive decisions relative to grammatical disagreement. In the pronoun-verb experiments of Lukatela et al. (1983), all pseudoverb stimuli were inflected with verb endings. They were created by single-letter substitution in the stems of the verbs. These experiments also provided evidence for complementary effects between the positive and negative latencies. Taking the first experiment of Lukatela et al. (1982) as an example, grammatical congruency resulted in faster (by 128 ms) positive decisions and slower (by 27 ms) negative decisions. Finally, the experiments by Gurjanov et al. (1985) should be mentioned, in which adjective-noun pairings were examined. These experiments found no evidence of a grammatical congruency effect with pseudonoun targets. They did demonstrate, however, a grammatical congruency effect with *pseudoadjective*-noun pairs (that is, on positive decision latencies) that was as large as the effect for adjective-noun pairs.

The significance of demonstrating grammatical congruency effects with legally inflected pseudowords as either contexts or targets is that it points to the main carriers of grammatical information, the inflectional morphemes, as largely responsible for the effect. In more theoretical terms, it lends support to the hypothesis that the syntactic level of processing operates relatively independently from the semantic-interpretative processes (Forster's message processor). When pseudowords are used as either contexts or targets, the *word* sequence is meaningless. Consequently, one cannot appeal to a process of sentence comprehension to effect, in top-down fashion, the syntactic analysis. Further, when pseudowords are used as either contexts or targets the lexical processor must deliver definitional information, to use Fodor's (1983) term, pertaining to the grammatical function of the pseudoword's inflection. The implication is that lexical processes work with a morphemic inventory and can effectively distinguish morphemic constituents in the absence of activating full (that is, word) lexical entries. That the grammatical congruency effect is demonstrable with pseudowords means that the lexical processes provide acceptable inputs to the syntactic processes. We must, nevertheless, be careful of carrying this line of argument too far. The grammatical congruency effect is less reliable for pseudowords than words, and this difference is probably telling us (not surprisingly) that the stem as well as the suffix is a source of grammatical information. The lexical processor working with words rather than the constituents of words can furnish definitional information about the parts of speech more reliably. Serbo-Croatian nouns share many of their inflections with other word types (most notably with adjectives but also with the cardinal numerals). To the extent that stem information is not accessed, the identity of a letter string as a noun is less clear and the lexical processor is less able to provide acceptable resources for the syntactic operations.

Another reason that the grammatical congruency effect is more difficult to reveal with pseudoword targets is that the process of isolating affixal information in pseudowords may be slower than in words. In consequence, the lexical search determining the absence of a pseudoword's entry may often be completed before affixal information about the pseudoword has been discerned (Wright and Garrett, 1984). Under these conditions no contribution of the syntactic processor would be expected.

The second result of the present experiment was that the magnitude of the grammatical congruency effect, for both nouns and pseudonouns, was indifferent to the type of violation and to the number of violations (one or two). In terms of the arguments raised in the introduction, this result suggests that the information of relevance to the decision-making process is merely that the two words do not agree grammatically. Type of disagreement and the number of disagreements do not affect the magnitude of the negative bias (that hinders positive decisions and aids negative decisions). Each type of grammatical disagreement (case, gender, and number) contrasted with complete agreement. This fact of a grammatical congruency effect, defined with respect to each violation, suggests that in the experiment syntactic processors were evaluating all three grammatical relations between the possessive pronoun context and the noun or pseudonoun target. From the perspective of the job that these processors ordinarily perform in everyday sentence comprehension, namely, assigning grammatical structure to word sequences, it may well be that the assignment relies differentially on case, gender, and number information. This possibility cannot be ruled out by the fact that in the present experiment each type of grammatical disagreement contrasted with full agreement to the same degree and by the related fact that two disagreements were no worse than one.

Inferences from lexical decision data to underlying linguistic mechanisms have to contend with the soft algorithmical capabilities assembled specifically for the task. As suggested in the introduction, it is useful to construe a subject in a lexical decision task as assembling him or herself into a device specially tailored to the goal of passing rapid judgment on the lexical status of a letter string. The subject, of course, is a language processor – a complex device that ordinarily analyzes multiple embeddings of linguistic structures of different grains, and does so on line. Fashioning a device tailored to lexical decision can be regarded as the fashioning of an *alternative description* of the language processor [see Pattee (1972) for a general argument of this kind with regard to biological functions]. This alternative (simpler) description makes explicit some of the detailed processing that is implicit in ordinary sentence comprehension. The important point to be underscored is that the special purpose lexical decision device as an alternative (simpler) description of the language processor is selective. It does not make explicit all of the processing detail. Thus, it suffices for lexical decision to make explicit grammatical conformity. The nature and time course of the processing details that determine grammatical conformity remain, however, largely implicit.

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