

Grammatical information effects in auditory word recognition*

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Abstract

Three lexical decision experiments were concerned with the separability of syntactic and semantic processing in spoken word perception. An additional experiment examined the problem of measuring reaction times to a spoken stimulus. Words in the Serbo-Croatian language were used; each stimulus consisted of a noun stem (which was either a meaningful root or a pseudoword stem) plus an inflectional suffix which conveyed information about the noun's grammatical case. Speed of identifying the inflectionally related forms of a noun was a function of differences in their syntactic meanings rather than differences in their physical forms or their actual frequencies of occurrence. In addition, identification of a noun was facilitated when it was preceded by a stimulus carrying predictive inflectional information whether that stimulus was a real adjective or pseudo-adjective. The results echo previous findings for word perception in print and provide evidence of essential structural uniformity in the processing of inflection for both spoken and printed words. For both, there is evidence that inflectional processing is modular, at least to the extent that it is independent from semantic processing for the initial portion of its time course.

The principal language of Yugoslavia, Serbo-Croatian, has provided a useful vehicle for psycholinguistic study. Its structure contrasts sharply with that of

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English, the language that has been used most often in such studies, and, so, provides a perspective that would otherwise be lacking, an approach that helps to separate universal principles from language-specific ones. The present studies, which use the Serbo-Croatian language, elaborate that perspective but are, additionally, concerned with a generality of a different kind: the extension of previous findings on the perception of printed words to the perception of spoken words.

Our intention was to test the cognitive generality of two previous findings that have implications for theories of lexical organization and the processing of grammatical information (Gurjanov, Lukatela, Moskovljevic, Savic, & Turvey, 1985; Lukatela, Gligorijevic, Kostic, & Turvey, 1980). We were concerned with the processing relation between the semantic and syntactic parts of a word as represented by the root of the word and its syntactic inflectional suffix. The primary question is whether these two sources of information are processed independently or not, at least for some significant portion of their time course. In brief, we wanted to assess the modularity of inflectional processing.

The group of Slavic languages, which includes Serbo-Croatian, depends on inflection as the major means of communicating grammatical information. In contrast, English depends strongly on word order to convey such information. For purposes of this discussion, it will suffice to describe, briefly, the Serbo-Croatian system for the grammatical inflection of the noun word class. A grammatical inflection is added as a suffix to each noun stem to convey the information that the noun is, for example, the subject of the verb, or the object, the indirect object, an instrument, a location, etc. In addition, the inflection conveys information about number (is the noun singular or plural?). These different combinations of a fixed word stem plus an inflectional suffix are called the cases of the noun. For example, some cases for the word for 'woman' are *zena* ('woman' as subject of the verb: the nominative case), *zene* ('of the woman': genitive case), *zeni* ('to the woman': dative case), *zenu* ('woman' as object of the verb: accusative case), and *zenom* ('with the woman'; instrumental case). The nominative case form is the base form in the sense that it is the citation form (e.g., the form used in dictionaries); the other case forms, as a group, are referred to as the oblique cases.

For the experimental psychologist, there is a certain tactical advantage to be found in using an inflected language to study the processing of syntactic information. The close proximity of (1) the lexical semantic information conveyed by the stem and (2) the grammatical information conveyed by the inflectional suffix, both packaged into a single word, makes it possible to study the processing of the two kinds of information by means of standard

word recognition paradigms such as the lexical decision task. We take advantage of the proximity of the two kinds of information in order to address the central question of this paper: Is the morphological distinction between inflectional and semantic information mirrored by independence in their mental processing? Or, in contrast, is inflectional analysis informed by semantics?

Inflectional morphology in Serbo-Croatian nouns and adjectives appears in the form of a word suffix; it gives the meaning of the word's case role in the phrase. It can be distinguished from other kinds of syntactic information such as noun gender and from other kinds of morphology, for example, derivational morphology (by which diminutives are formed, nominalizations are formed, etc.). The experiments in this paper are addressed specifically to the question of the mental processing of inflection. Because derivational morphology has a different function and is much less pervasive than inflection, it may well be subserved by a different processing system.

A seminal experiment on this topic has been reported by Lukatela et al. (1980). It was concerned with the process of printed word identification for inflectionally related nouns, viz., the different case forms of a given noun, for example, *zena*, *zene*, *zeni*, etc. In that experiment, in spite of the fact that the various case forms have distinctly different frequencies of occurrence in the language (Dj. Kostic, 1965), reaction times for word identification in lexical decision experiments did not correlate with case frequency but, instead, fell into two groups. Reaction times were (1) identical among all the oblique case forms and (2) these were slower than the reaction time to the nominative case form. The equality of the oblique cases was surprising in light of the fact that one of these cases, the genitive, is used nearly as frequently as the nominative while another, the instrumental, occurs less than one-tenth as often. Thus, it was clear that the frequency of a noun's case form did not determine identification of that noun. Instead, it was the case form's syntactic identification (nominative or oblique) that affected the latency. Thus, Lukatela et al. found what appeared to be a processing difference that was a function of only syntactic structure; the mental machinery involved in word perception was apparently organized to process pure syntactic information. The term "satellite model" was applied to describe the pattern of reaction times because the nominative form was viewed as being central (the privileged form), surrounded by the slower, oblique, forms which were equal among themselves.

As suggested above, the only kind of explanation that can account for the superiority of the nominative case form is one that proposes an analysis of the word form in which one component is specifically *syntactic* in nature. The nominative form can not consistently be differentiated from the other forms on the basis of superficial stimulus properties. For example, the nominative

form *zena* can not be identified as a nominative form by reference to either the stem (*zen-*) or the inflection (*-a*); the former occurs for all of the other cases of *zena* and the latter occurs for all masculine and neuter genitive forms, all neuter accusatives and some masculine accusatives, in addition to the feminine nominative. Therefore, in order to identify the case of a noun, its inflection must be interpreted in the context of the "gender" (i.e., declension) of the noun, information that is more or less arbitrary and is available only as part of its lexical entry. Thus, no analysis of a stimulus into its phonological or graphemic properties provides, by itself, an identification of the stimulus as a nominative form and, therefore, no such analysis can provide the nominative form with privileged lexical access.

The critical assumption in this analysis is that stem and inflection are encoded by separate processes: the stimulus must be analyzed into distinct semantic and syntactic components. The syntactic information required for noun identification includes word class (e.g., that the word is a noun and not a verb, adjective, etc.), the noun gender and, finally, the noun's case role in the phrase. Analysis of the inflection must first be preceded by information about word class and gender. Although the present research does not pursue the question of the locus of the gender information, it seems plausible to consider it to be stored in the lexicon along with the semantic (nonsyntactic) meaning of the stem. Processing of the meaning of the suffix (i.e., the noun's case role) may then proceed without interacting with the semantic meaning of the stem. Therefore, this explanation supposes that there are, in fact, separate semantic and inflectional processors.

There is additional experimental evidence to support this notion of separable semantic (lexical) and syntactic (inflectional) processors. Gurjanov et al. (1985) visually presented, on each trial, an adjective followed by a noun; a lexical decision was required on only the noun. Gurjanov et al. were looking for an effect of the syntactic relation between adjective and noun on the perception of the noun. In Serbo-Croatian, the inflections on a noun and the adjective modifying it must agree in gender, case, and number. However, such agreement does not entail phonological identity; these suffixes on the adjective and noun do not necessarily sound (or look) the same. For example, the adjective-noun pair *vitkoj guski* ('to the slim goose') has the congruent inflections *-oj* and *-i*. Thus, agreement (i.e., congruency) exists only at the level of syntax; not at the level of phonology. (This is a not uncommon situation in the languages of the world.) Table 4 presents some examples of Serbo-Croatian adjectives and nouns. Not surprisingly, when subjects in the Gurjanov et al. (1985) study were presented with adjective-noun pairs in which grammatical agreement occurred, subjects were faster in making a lexical decision than when the members of the pair were incongruent (differ-

ing in case). More interestingly, the relative facilitation produced by grammatical congruency occurred even when the stimulus preceding the noun was a pseudoadjective, that is, a meaningless nonword stem with a real, appropriate adjectival suffix. This apparent effect on the perception of a noun that followed a pseudoadjective could only have occurred by linking the inflections (the syntactic information code) of the pseudoadjective and noun. The congruency effect of pseudoadjective primes is a second piece of evidence (in addition to the satellite pattern reported by Lukatela et al., 1980) that suggests that words are analyzed into distinct semantic and syntactic codes and that the process of assigning meaning to an inflection is independent of the semantic status of the stem. Such grammatical congruency effects have been observed in Serbo-Croatian in other situations, for example, pronoun-verb combinations (Lukatela, Moraca, Stojnov, Savic, Katz, & Turvey, 1982), and preposition-noun combinations (Lukatela, Kostic, Feldman, & Turvey, 1983). Thus, there is consistent evidence of the kind that is needed to support the suggestion of the Lukatela et al. (1980) studies, that there is psychological reality to the notion of modular inflectional processing, at least for perception of the printed word.

A specific purpose of the present research was to determine if a syntactic congruency effect could also be found with auditory presentation. In fact, there was some reason to believe that the effect found with print might be due merely to an artifact of that particular presentation mode and would not be found when speech stimuli were used. As is common in the visual presentation paradigm, the entire stimulus, word or nonword, consisting of stem plus inflectional suffix had been displayed simultaneously in the Gurjanov et al. (1985) study. With simultaneous presentation, subjects could have easily attended to the inflection before the stem or in parallel with it. It could have been this peculiar strategy of focusing attention that was responsible for the apparently independent use of inflectional information. With speech, on the other hand, such an attentional strategy is much less feasible. Because the stimulus develops in time, the stem is completed before the onset of the inflection. Therefore, the subject must perceive the stem first, at least at some level of perception.

The present studies replicated two of the key experiments discussed above, using speech stimuli instead of print, in an attempt to assess the validity and generality of the previous results and, if possible, to advance their interpretation. The main experiments we present are (1) a simple lexical decision experiment designed to look for RT differences between nominative and oblique case nouns (the auditory analogue of the satellite pattern found by Lukatela et al., 1980) and (2) two adjective-noun priming experiments designed to look for auditory pseudoadjective syntactic congruency effects (an analogue

and an extension of the Gurjanov et al., 1985, study).

However, experiments on speech introduce methodological problems not present in print experiments, due to the temporally dynamic nature of speech. In the typical print lexical decision paradigm, in which all parts of the stimulus are presented simultaneously, it is reasonable to begin the reaction time clock at the point when the stimulus appears on the screen. Spoken words, on the other hand, are presented continuously over a period of time (250–1000 ms) that is long relative to the latencies of responses to those stimuli. During this time, the listener may be making successive judgments about what he or she has heard so far. Thus, it is reasonable to ask at what point during the temporal unfolding of the word the timing of subjects' responses should start.

There is evidence from mispronunciation detection and short-latency shadowing studies that listeners make use of information in the unfolding word during the course of its presentation (Marslen-Wilson, 1984; Marslen-Wilson & Welsh, 1978; Cole & Jakimik, 1980); often they are able to identify the word before hearing the full extent of the stimulus. Marslen-Wilson and his colleagues have argued further that word recognition in real time is a matter of selecting the correct word from among a field of possible choices; when the first few segments (roughly the first two phonemes) of the word have been scanned, a list of candidate words (called a "cohort") with the same initial phonemes is called up from the lexicon. As the succeeding segments are identified, they serve to narrow down the list of candidates until only one word remains as a possible match to the input. Word recognition is achieved at this point. Thus, in the absence of syntactic/semantic context (which Marslen-Wilson and his associates claim further narrows down the field of candidate words), recognition of any given word occurs at a stable point in the left-to-right sequence of phones, which point is determined by the intersection of the individual phonological properties of the stimulus word and the properties of other words in the lexicon.

However, even though lexical access may be achieved before the word ends, the lexical decision response itself may be delayed further. First, there may be uncertainty that the word has, in fact, ended; some accessed lexical items may be embedded within another item (e.g., *candid* in *candidate* and *iskren*, 'sincere' in *iskrenost*, 'sincerity'). Second, the response may be obligatorily delayed until after the inflectional suffix.

In the present experiments, we were not concerned with the factors that affect the identification points of different noun stems. Rather, we were interested in distinctions among the various case forms of a single noun stem, that is, syntactic inflectional effects. The technical problem facing us was to be able to unambiguously interpret reaction time differences among the various case forms as being due to syntactic factors and not to phonological

factors. For example, lexical decision time to the nominative form *zena* might be faster than reaction time to the instrumental form *zenom* either for a theoretically interesting reason (e.g., because nominatives have privileged lexical access) or for an artifactual reason (e.g., the instrumental form contains an additional phoneme that might lengthen the lexical decision process). Even when the oblique case forms do not contain more phonemes than the nominative, a similar argument could be made on the hypothesis that their different phonetic shapes may take longer to process.

Experiments 1 and 2 attempt to deal directly with this issue of the measurement point in the auditory modality by comparing the results obtained from presentations using different measurement points. These results are, in turn, compared to the print experiment data in Lukatela et al. (1980).

Experiment 1

Experiment 1 was designed to look for faster identification of spoken words in their nominative case form than in their oblique forms. As in the Lukatela et al. (1980) study, the nominative case was compared with two oblique cases, the genitive and instrumental. Additionally, the experiment went beyond the Lukatela et al. print study by including an explicit contrast between high and low frequency words. While the frequency effect is well established for lexical decision in the visual mode, it is not predicted per se by the Marslen-Wilson model (e.g., Marslen-Wilson & Welsh, 1980), and it seemed appropriate to test it in auditory mode. Experiment 1 was also designed to test the prediction that nonword stimuli that resemble words for a greater (left-to-right) temporal portion of their length will show longer RTs than stimuli which become nonwords early on.

Method

Stimuli

Words

Twenty-four high frequency and 24 low frequency nouns were selected from the word frequency dictionary prepared by Dj. Kostic (1965) from a corpus of approximately 14,000 words sampled from three years of the daily newspaper *Politika* (around 1953–1955). Of each high and low frequency group, half were masculine and half were feminine gender nouns. High frequency words were defined as occurring more than 32 times in the Kostic

corpus. Low frequency words occurred once in the same corpus.

Two native speakers independently checked the words selected for (1) current usage; (2) stress on the initial syllable and consistent accent pattern throughout the three cases; and (3) invariant meaning over grammatical cases. Each noun contained a regularly inflected 2-syllable stem.

The cases used were nominative, genitive, and instrumental singular. In all forms except masculine nominative there was an additional syllable corresponding to the case ending. Words were not always highly concrete in meaning, although words with obscure or literary denotations were avoided.

Pseudowords

Forty-eight pseudowords were constructed to be phonotactically possible but non-occurring words in Serbo-Croatian, and to become pseudowords at one of four possible points from left to right in a 2-syllable stem. This was done by finding non-occurring initial sequences of varying lengths in a Serbo-Croatian dictionary (Grujic, 1969) and adding enough material to fill out a 2-syllable stem. For example, the pseudoword *bemaz* was made by first discovering that words beginning *bel-* and *ben-* existed but none beginning *bem-*, and then adding the final sequence *-az*. The four deviation points were defined as (1) at the first vowel; (2) at the middle consonant or consonant cluster; (3) at the second vowel; (4) at the final consonant or consonant cluster of the stem. The words were checked by two native speakers for acceptability and resemblance to real words—in particular, we tried to avoid pseudowords that differed from an actually occurring word by only one phonetic segment. The practice list contained pseudowords with each of the four possible deviation points. Thus, subjects were trained to avoid making an incorrect ‘word’ decision based on the early word-like portion of the pseudoword.

Stimulus tape

The list of words was read three times by a male native speaker of the Belgrade dialect in a sound-treated booth. To avoid the list-like intonation that might have occurred if all three cases had been read together, the words were read in blocks of all the nominatives, followed by all the genitives, and all the instrumental case words. The best and most intelligible recording for each word, as chosen by a second native speaker, was then digitized at a sampling rate of 20 kHz using the Haskins Laboratories’ Pulse Code Modulation system. The beginning of each word was located automatically by the amplitude of its onset. In a few cases where the amplitude was too low, the onset was adjusted manually. The digitized speech file of stimuli was then randomized and recorded onto tape. A 20-ms marker pulse, timed to coincide

with the beginning of the word, was recorded onto a second channel; this was used to start the RT clock.

The tape consisted of a practice list of 35 words and pseudowords followed by the main test list of 102 words divided into 6 lead-in (dummy) words and 96 test words. The stimuli were recorded with an interstimulus interval of 5 s.

Design

Each subject heard a total of 96 words in the main test, of which 48 were words and 48 were pseudowords. No subject heard any given noun more than once in the course of the test. This was achieved by dividing the 96 words into three groups (A, B, C) and the 45 subjects into three groups (I, II, III). Each group of 16 real words contained 8 high frequency and 8 low frequency nouns, of which half again were masculine and half feminine gender. Subjects in Group I saw words from Group A in the nominative case, from Group B in the genitive case, and from Group C in the instrumental case. For subjects in Group II the categories were B, C, A respectively, and for subjects in Group III the categories were C, A, B. Nonwords were partitioned similarly into categories and subject groups, with the exception that instead of a two-level division into high and low frequency items, they were divided into four categories based on constructed deviation point. Thus, each group of 16 consisted of four groups of 4, each with a different deviation point. Of each group, half again were controls for the masculine gender suffixes and half were controls for the feminine gender. Note that the suffix inflections on pseudowords are quite ambiguous with regard to specification of case because interpretation of a suffix must, in part, depend on the lexically specified knowledge about the noun's gender. For example, the suffix *-a* on a pseudoword could be interpreted as either the nominative singular case (if the stem is taken to be a feminine gender word) or the genitive singular (if the stem is taken to be a masculine gender word). The reason for manipulating suffixes on pseudowords was in order to balance the number of presentations of each real suffix.

Procedure

The stimulus tape was played to the subjects from an Uher tape recorder over headphones. The headphones had a cutoff frequency of 8000 Hz. On each trial, the subject's task was to decide as rapidly as possible whether the auditory stimulus was a word or not. Both hands were employed in responding to the stimulus. Both thumbs were placed on a telegraph key close to the subject, and both forefingers were placed on another telegraph key 4.5 cm

farther away. The closer button was depressed for a “no” response (the auditory stimulus did not correspond to a word) and the farther button was depressed for a “yes” response (the auditory stimulus corresponded to a word).

During the interstimulus interval, the subject was required to write down ‘sigurna’ (sure) or ‘non sigurna’ (not sure) as an indication of confidence about the accuracy of each response. There was ample time for the subject to be ready for the next response. The entire session lasted approximately 30 minutes with a short break after the practice session and after 51 items in the main test.

Subjects

Subjects were 45 undergraduate students at the University of Belgrade who participated as part of their course requirements. All had had recent experience with reaction time experiments in the visual mode but little or no experience with auditory experiments. All were speakers of the Belgrade dialect.

Results and discussion

Words

Errors of classification (word-pseudoword) and all latencies less than 300 and greater than 2000 ms were excluded from the data set. Error rates were 1.5% for words, 2.5% for pseudowords, and were unsystematic. Separate analyses of variance were performed using, respectively, subject and stimulus item variability as the error term. Data from the three subject groups were pooled after a simple one-way analysis of variance failed to show any significant difference between them. For the subjects analysis, means were calculated over the four items which appeared in each combination of Frequency, Gender and Case; for the items analysis, means were calculated over the 15 subjects who saw that item in a particular case. A priori, we had expected a main effect of frequency and a main effect of case. It was further predicted that the case effect would break down into a pattern in which the oblique cases would show longer RTs than the nominative but would not differ from each other.

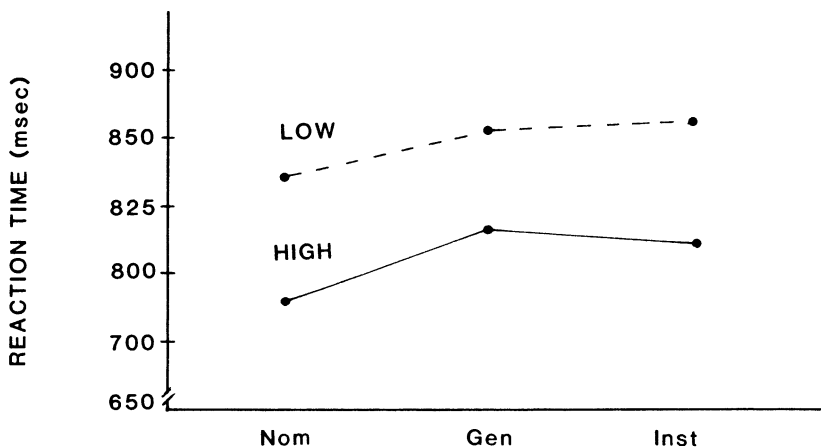
Table 1 presents mean RT for each combination of Frequency (High/Low), Gender (Masculine/Feminine) and Case (Nominative/Genitive/Instrumental).

Both of the predicted main effects were significant. For Frequency: subjects $F(1,44) = 204.26$, $MS_e = 4873$, $p < .001$, and items $F(1,44) = 22.61$, $MS_e = 13632$, $p < .001$. For Case: subjects $F(2,88) = 16.58$, $MS_e = 6605$, $p < .001$, and items $F(2,88) = 5.31$, $MS_e = 4725$, $p < .01$. There were no other significant effects. The essential results of Table 1 are presented in Figure 1.

Table 1. *Mean reaction times followed by standard deviations for real words in Experiment 1 as a function of case, frequency, and gender*

Freq.	Gender	Case					
		Nominative		Genitive		Instrumental	
High	Masculine	742	47	779	53	780	60
	Feminine	714	66	786	101	757	69
Low	Masculine	854	105	882	144	843	116
	Feminine	809	75	840	70	885	92
Mean		780	92	822	104	816	98

Figure 1. *Lexical decision reaction time to real nouns preceded by real or pseudoadjectives with congruent or incongruent case matches.*



Orthogonal contrasts indicated that the two oblique cases did not differ between themselves and that a large proportion of the significant case effect was due to the difference between nominative and oblique cases. The contrast Nominative vs. Genitive-Instrumental gave, for the subjects analysis, $F(1,44) = 32.9$, $p < .001$, and for the items analysis, $F(1,44) = 14.48$, $p < .001$. The contrast Genitive vs. Instrumental was, for subjects, $F(1,44) = .55$, n.s., and for items, $F(1,44) = .12$, n.s.

These results correspond reassuringly with those of Lukatela et al. (1980). Overall, however, latencies to our auditory stimuli were longer than latencies to the visually presented stimuli of Lukatela et al.

Pseudowords

This experiment was also designed to test the 'left-to-right' processing model (or cohort model) of auditory word recognition by using pseudowords which resembled existing words up to various divergence points in their temporal left-to-right sequence. The prediction of the cohort model was that pseudowords with earlier points of divergence would be rejected faster.

As was the case for real words, separate analyses of variance using subject and item variability were carried out for nonwords. Factors here were Position of Divergence (Points 1 to 4), Gender Control (Masculine/Feminine), and Case Control (Nominative/Genitive/Instrumental). (Recall that the Case and Gender factors for pseudowords are only methodological controls designed to balance the number of occurrences of the suffixes that occurred with real words.) Table 2 presents the mean reaction time for each combination of factors. In the subjects analysis, all main effects and interactions except the three-way interaction were significant.

On the other hand, in the items analysis only Case was significant, and that marginally, $F(2,80) = 3.34$, $MS_e = 4448$, $p < .05$.

This weak outcome for the effect of position of the divergence point offers no useful evaluation of the notion that the process of word recognition involves a reductive winnowing of candidate words within a cohort. However, the relatively greater strength of the case effect suggests that if a reductive process exists, the time scale of the process may be substantially shorter than the time consumed by inflectional processing.

RT measurement considerations

One might conclude from these results that lexical decision making is the same for both the auditory and visual modes. However, there are aspects of response timing for the respective modes that must be considered before such

Table 2. *Mean reaction times followed by standard deviations for pseudowords in Experiment 1 as a function of case, gender, and position of the divergence point*

Position	Gender	Case					
		Nominative		Genitive		Instrumental	
One	Masculine	851	110	943	164	938	180
	Feminine	776	114	804	154	812	148
Two	Masculine	831	172	866	142	868	136
	Feminine	885	162	884	166	854	162
Three	Masculine	876	136	907	186	921	189
	Feminine	834	161	879	159	860	153
Four	Masculine	915	130	889	156	963	161
	Feminine	900	176	899	170	926	166
Mean		858	151	884	165	893	168

an interpretation is warranted for real words. The results of these analyses were based on the raw RT as measured from the beginning of the word. As mentioned above, a serious consideration, when comparing different spoken words, is whether to make the starting point for a lexical decision latency an arbitrary and uniform point for every word (e.g., starting each measure from the beginning of the word) or to make it a different point for every word, based on the properties of the individual word. However, for Experiment 1, the important comparisons are not the typical ones made between different nouns (i.e., between different stems); rather, the relevant comparisons are between different case forms of the same noun stem. Therefore, in order to interpret appropriately the reaction times to these different inflected forms, we must know the point in a speech stimulus where that form can be discriminated from the other cases. The following experiment was designed to discover the perceptual identification point for each inflection in each noun in the present experiment. Having found this point, we can then reanalyze the raw reaction time data but with RT scores adjusted individually for each stimulus item. For example, we wished to make accurate comparisons of lexical decision identification latencies to the nominative *zena*, the genitive *zene*, and the instrumental *zenom* based on the individual identification points of each.

Experiment 2

This experiment used a variation of Grosjean's (1980) 'gating' procedure. In the original experiment, subjects were presented auditorily with successively longer sections of the stimulus word and asked to guess what the word might be. They were also asked to indicate on a rating scale how confident they were about their choice. This procedure made it possible for Grosjean to monitor which words were being entertained as candidates by the subjects at any point during the word, as well as the point at which they began to identify the word consistently.

Method

Our concerns were slightly different than Grosjean's (1980). We wished to determine the point in a given suffix-inflected word at which the item diverges from other inflected forms with the same stem; that is, the point where the different case forms of the same lexical item are perceptually discriminated. Armed with these discrimination points, we could then calculate (for the data in Experiment 1) an adjusted lexical decision RT to each of the different case forms for each stem, clocking each RT from the discrimination point for its stimulus.

Subjects were presented with successively longer left-to-right sections of the stimulus item, but for each stimulus trial the subject was presented with a list of the responses he or she was allowed to choose from. The gating interval was set at 20 ms. Thus, on each successive trial the section of the stimulus word presented was 20 ms longer, measured from the beginning of the word, than in the previous trial. The subject was given four alternatives to choose from for each trial. Three of the possible responses were the nominative, genitive, and instrumental case forms of the lexical item in question. Data from these were designed to identify the point at which a response to the case form might be initiated. Additionally, there was a fourth possible response which corresponded to the 2-syllable stem form of the word plus an extra syllable beginning with a stop consonant. This condition was inserted to provide a pseudoword control for the nominative case of masculine nouns, which has zero marking. On a phoneme-by-phoneme basis, the three cases for nouns in Serbo-Croatian diverge at similar points; thus *sadnica* (seedling), a feminine noun in the nominative, differs from its genitive form *sadnice* and its instrumental form *sadnicom* in the vowel following /c/. (On an acoustic/perceptual basis, this is less clear, of course; differing amounts of the vowels /a/, /e/ and /o/ may be required for identification in any given phonetic envi-

ronment, and anticipatory nasalization from the /m/ may be present.) The situation is similar for masculine nouns; *prozor* (window) in the nominative differs from *prozora* and *prozorom* in what follows /r/; however, in the masculine nominative, what follows is silence. We felt we needed some way of determining for these stimuli at what point subjects would feel confident that there was no phonological material following the stem. Stop consonants were chosen to begin the extra syllable so that we could test subjects' ability to distinguish the condition of a null inflection on a masculine nominative noun from the onset of a syllable that begins with silence. Four consonants, /t/, /d/, /k/, and /g/, were used in conjunction with the vowel /a/. These were concatenated to the 2-syllable word stem in accordance with a Serbo-Croatian constraint against dissimilar voicing in clusters. Geminates were avoided. Thus, for example, the stem *fabrik* received the pseudoword control *fabrikta*, *nastup* received *nastupta*, and *prinud* received *prinudga*.

The 48 masculine and feminine real word nouns used in Experiment 1 were divided into four sets of 12, of which half were feminine and half were masculine nouns. There were 32 subjects divided into four groups of 8. Each group heard gating trials for one set of nouns in the nominative case, one set of different nouns in the genitive case, one set of different nouns in the instrumental case, and a fourth set of different nouns with an extra syllable at the end. Some of the subjects had previously participated in Experiment 1 but to minimize familiarity effects several days elapsed between experiments.

Because of the large number of gating intervals involved when starting from the beginning of the word (some longer words had as many as twenty 20 ms gating trials) and the fact that the choice point between possible responses came late rather than early in the stimulus, we did not begin presentations with only the first 20 ms segment. Instead, we first submitted the gated stimuli for judgment to a panel of four native speakers, with instructions to indicate the first trial at which they detected any hint of the identity of the correct inflection. (The judges were told which word stem to expect on each trial.) Gating trials for the 32 subjects in the experiment proper were then set to begin two gates (40 ms) before the earliest point indicated by any judge. The gating tapes were played over headphones, with 1 s between trials and approximately 5 s between trials for different stimuli.

Results and discussion

Subject answer sheets contained, for each trial, the list of four possible responses, on which subjects were instructed to mark their choice for identifi-

cation of the stimulus, and a continuous scale from 0 to 100, on which subjects were instructed to indicate how confident they felt about that choice. The first trial on which a subject indicated he or she was 80% or more confident of identification for the stimulus was recorded as the recognition trial for that subject. However, if the subject later changed his or her identification or indicated a drop in confidence level, the next 80% point was chosen. The eight recognition trials so obtained for each stimulus were averaged, and converted to units in milliseconds from the beginning of the word. For example, if the various subjects' choices for 80% identification of the stimulus *nacinom* (masculine, instrumental case) were trials 7, 7, 8, 6, 7, 8, and 10, and the first trial began 200 ms into the stimulus, the recognition (i.e., identification) point was defined as 200 plus 20 times the mean of the eight trial choices, or $200 + (20 \times 7.63) = 352.6$ ms from the beginning of the word.

These steps produced a matrix of recognition point values corresponding to the set of different nouns, with each noun in three cases, used in Experiment 1. These values were then used in an analysis of covariance as covariate control scores (the dependent variable being the same as before, i.e. raw lexical decision latency). Thus, the analysis of covariance was used to test the satellite pattern on the adjusted means. Because subjects for the two experiments differed, only an items analysis of covariance was possible. Strikingly, the pattern of results was nearly identical to that obtained for the analysis of variance using raw reaction time scores only. Frequency was significant, $F(1,43) = 27.48$, $MS_e = 9839$, $p < .001$, as was Case, $F(2,87) = 5.01$, $MS_e = 4778$, $p < .01$; there were no significant interactions. The covariate itself was significant between-items, $F(1,43) = 17.97$, $MS_e = 9839$, $p < .001$, correlation coefficient = .51, but not within Case. Orthogonal contrasts on the Case effect again revealed a pattern in which the nominative was faster than the other two cases, but the oblique cases did not differ between themselves (Nominative vs. Genitive-Instrumental: $F(1,43) = 14.06$, $p < .001$; Genitive vs. Instrumental: $F(1,43) = .54$, n.s.).

We also performed an analysis of variance on just the recognition point data for the three cases. Cell means for these data are reported in Table 3. The analysis revealed no effect for Frequency or Gender but a significant effect did occur for Case, $F(2,28) = 9.82$, $MS_e = 1631$, $p < .001$, and for the Case \times Gender interaction, $F(2,88) = 3.21$, $MS_e = 1631$, $p < .05$. This outcome appeared to stem from systematic differences in length among the cases; instrumentals are longer for both genders and nominatives are shorter than genitives for the masculine nouns. Thus, the perceptual recognition point was apparently sensitive to length of the suffix itself. However, when this length difference among different cases was statistically corrected (in the analysis of covariance reported above), reaction times still followed a satellite pattern.

Table 3. Mean gated recognition points and standard deviations for real words in Experiment 2

Freq.	Gender	Case					
		Nominative		Genitive		Instrumental	
High	Masculine	515	92	525	63	554	60
	Feminine	503	76	471	69	522	55
Low	Masculine	494	107	514	64	507	68
	Feminine	527	88	530	77	583	106
Mean		510	89	510	70	542	78

We also examined the recognition point results for those stimuli with an extra syllable that turned them into pseudowords (e.g., the pseudoword *fab-rikta* from the real word *fabrik*). Although on a phoneme-by-phoneme count these stimuli were no longer than nouns in the instrumental case, recognition points to these stimuli were typically from 20 to 60 ms later, averaging 50 ms later than the instrumental case, and later than the recognition points for the nominative case by 80 ms. It is clear, therefore, that the recognition of normal masculine nominative case words (which lack any inflectional suffix) is not delayed by a presumed uncertainty about when the word ends; those normal nouns, in fact, had *earlier* recognition points than longer items. Note, however, that because these extra-syllable words become phonemically identifiable as nonwords at exactly the same point as the nominative, genitive and instrumental case real words, their longer response times must indicate some effect of their anomalous syntactic status. Nor can length alone be a sufficient explanation, because the extra-syllable is equivalent in length to the real words' instrumental case suffix.

All our analyses point to the same pattern; namely, that there is a stable reaction time advantage for the nominative case. We conclude therefore that the so-called satellite pattern is a robust aspect of the lexical decision process. Further, it seems that the choice of a measurement point is not crucial to tests of auditory lexical decision time for inflected words, as long as that measure is consistent over the different items.

Experiment 3

In Experiment 3, we studied the processing of noun inflections in adjective-noun pairs. Both the purpose and design of Experiment 3 were similar to

those of the print experiment by Gurjanov et al. (1985) with the single exception that the modality of presentation in the present experiment was auditory. The Gurjanov et al. results had demonstrated that there was independent processing of inflectional information in the course of recognizing a word. As we discussed in the introduction to this paper, there was some reason to suspect that this apparent influence had been merely an artifact of the visual presentation mode. In visual presentation, it is possible for subjects to attend to the inflectional suffix before attending to the stem of the noun. In contrast this strategy is much less likely to occur when the stimulus is spoken because the stem precedes the suffix temporally. Thus, the purpose of Experiment 3 was to determine whether or not grammatical congruency between an adjective and a noun—and particularly between a pseudoadjective and a noun—would affect the time to decide on the lexicality of the noun when the stimuli were auditorily presented.

Method

Design

An auditory lexical decision task was used in a priming paradigm. On each trial, the noun target was preceded by an adjective. However, the adjective was never associatively related to the noun. Noun and adjective combinations were selected on the basis of results of an earlier study (see Gurjanov et al., 1985) which asked subjects for associations to the adjectives used in the present study. The adjective–noun combinations used in the present study were those that had never been produced by subjects. Thus, the so-called adjective prime was unlikely to be an effective semantic prime.

Although the adjective was not semantically predictive, it did contain information enabling prediction of the inflection on the subsequent noun for half of the trials. The inflection on the adjective member of each pair either agreed, in case and number, with the inflection on the following noun or it disagreed in case (but not in number). Two cases were used: the nominative (agent case) and the dative (indirect object case). For the dative case, the masculine-neuter adjectival inflection was unique (for adjective inflections although not unique if noun inflections are included) and the feminine adjectival inflection was universally unique, so that the case of the dative case adjectives could be identified easily. In contrast, the nominative case suffixes were ambiguously either nominative, accusative, or vocative case for singular adjectives and could also be read as certain plural forms (except for the singular neuter form). The variable of case agreement between adjective and

noun (grammatical congruency) was the major variable of the experiment. In addition, half of the adjectives were real adjectives known to the subject (that is, they had meaningful stems with real inflections) while half of the adjectives were pseudo-adjectives, composed of pseudostems, but with real inflections. Finally, in accordance with the lexical decision paradigm, half of the noun targets were real words, while half were pseudowords, composed of a pseudostem, but with a real inflection. Pseudoword adjectives and nouns were phonologically legal. They were constructed by changing a consonant and vowel at random positions in a real adjective or noun. Pseudowords were the same items used in the Gurjanov et al. (1985) print experiment. Thus, all words and pseudowords in the experiment had real inflections. The variables were combined factorially to produce a $2 \times 2 \times 2 \times 2$ design, that is, Adjective Lexicality (Word/Pseudoword) \times Noun Lexicality (Word/Pseudoword) \times Noun Case (Nominative/Dative) \times Grammatical Congruency (Agreement/No Agreement).

Each subject heard seven different examples in each of the 16 combinations of the four factors, for a total of 112 trials. No subject heard the stem of any adjective, noun, or pseudoword more than once. There were four groups of 16 subjects each. Among the four groups, each adjective–noun combination was given inflected suffixes that produced adjective–noun agreement once when the noun was in the nominative case and once when it was in the dative case. Likewise, there was adjective–noun incongruency once when the noun was in the nominative case and once when it was in the dative case (see Table 4). A practice list of 28 trials preceded the experimental list.

Stimuli

A female speaker of the Belgrade dialect produced a token for each word and pseudoword in each case. When the words were produced, the adjectives were spoken one after the other, as in a list. Likewise, the nouns were spoken in a listwise manner. The tokens were digitized at 20 kHz and prime-target combinations were constructed from the digitized tokens. For example, the exact same digitized noun token (e.g., *slonu*) was used following the nominative case adjective *mladi* and the dative case form *mladom*. That is, the same utterance was the target stimulus for both adjective–noun agreement and disagreement. Thus, no information relating to the prosodic contour of a normal adjective–noun utterance existed in the synthesized pairing. The silent interval between each adjective and noun was approximately 630 ms. Following the results of Experiment 2, a subject's reaction time to a noun target was measured from a marker pulse signaling the onset of the target. The interval between trials was 2 s.

Table 4. *Design summary: Grammatical congruence for adjective-noun*

Noun Stem	Adjective Stem	Noun Case Inflection	Adjective Case Congruence	Example Adjective-Noun		
Real	Real	Nominative	Agree w/Noun	mladi	slon	
			Not Agree	mladom	slon	
		Dative	Agree	mladom	slonu	
	Not Agree		mladi	slonu		
	Pseudo	Nominative	Agree	bleti	covek	
			Not Agree	bletom	covek	
Dative		Agree	bletom	coveku		
Pseudo	Real	Nominative	Agree	dragi	nod	
			Not Agree	dragom	nod	
		Dative	Agree	dragom	nodu	
	Pseudo	Nominative	Agree	dragi	nodu	
			Not Agree	mafi	pavnot	
		Dative	Agree	mafom	pavnot	
			Not Agree	mafom	pavnotu	
				Agree	mafi	pavnotu
				Not Agree		

mladi slon: young elephant; bleti covek: ---- man; dragi nod: dear ----; mafi pavnot: ----

Subjects

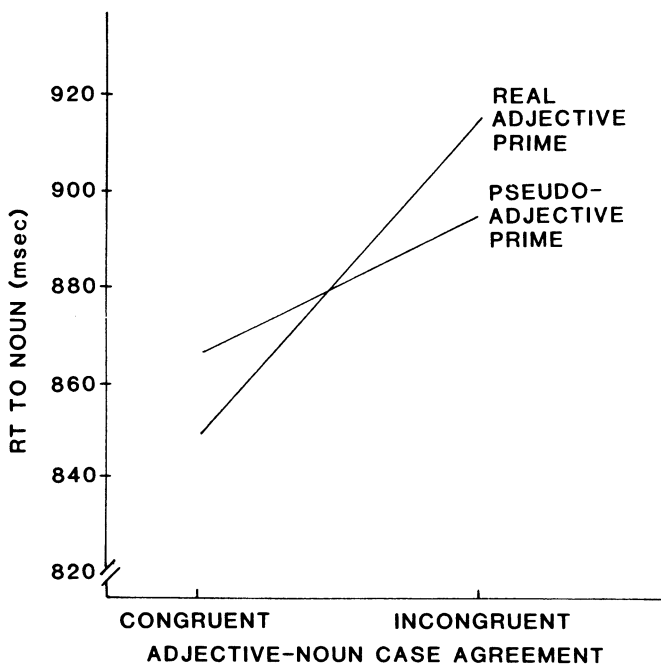
Subjects were 64 psychology students at the University of Belgrade who were required to participate as part of a course requirement.

Results and discussion

The question under study was: Would spoken grammatical information, in the form of inflectional congruence between an adjective and a subsequent noun, affect identification of the noun? Further, if recognition of a congruent target noun is facilitated relative to an incongruent noun, is this facilitation effect just as large when the preceding stimulus is a pseudoadjective as when it is a real adjective? That is, will appropriate inflectional information be as effective in a stimulus that has no lexical/semantic meaning as in a stimulus that does have such meaning? Or, on the other hand, is the processing of inflectional information inextricably bound to the processing of the stem; is there no processing of the inflection that is distinct from semantic processing?

Figure 2 presents the average reaction times for recognition of real noun targets. Error rates were low (1%–3%) and were unsystematic.

Figure 2. *Lexical decision reaction time to real nouns preceded by real or pseudoadjectives with congruent or incongruent case matches. Interstimulus interval was approximately 630 ms.*



Reaction time is plotted as a function of the grammatical congruence of the adjective-noun combination (i.e., agreement or no agreement in their case inflections). It also shows the lexical status of the stem of the priming stimulus (i.e., whether or not it was a real or pseudoadjective stem). The data have been averaged over the nominative and dative cases. The results show a large effect of congruence; when both members of the pair agree in case, reaction time is faster. Moreover, this facilitation appears even when the priming stimulus is a pseudoadjective and not only when it is a real adjective. Nevertheless, the facilitation effect appears to be stronger when the priming stimulus is a real adjective.

All of these effects were confirmed by analyses of variance. For the main effect of Grammatical Congruency, the subjects analysis of variance produced $F(1,60) = 67.44$, $MS_e = 4691$, $p < .001$, and the items analysis of variance produced $F(1,54) = 42.75$, $MS_e = 3254$, $p < .001$. In the items analysis,

Grammatical Congruency accounted for 50.3% of the total variance. For the interaction between Grammatical Congruency \times Adjective Lexicality, the subjects analysis produced $F(1,60) = 12.7$, $MS_e = 4691$, $p < .001$, and the items analysis produced $F(1,54) = 6.89$, $MS_e = 3254$, $p < .02$. In the latter analysis, the interaction accounted for 8% of the total variance. Thus, although there was an interaction, the main effect of Grammatical Congruency was stronger, accounting for over four times as much of the variance in RT. The only remaining significant result, not shown in Figure 1, is that of Noun Case. Nouns in the nominative case were recognized faster than nouns in the dative case (a result that appears consistently in all of our experiments). This main effect was significant both in the subjects analysis of variance, $F(1,60) = 57.61$, $MS_e = 4033$, $p < .001$, and in the items analysis of variance, $F(1,54) = 10.08$, $MS_e = 10168$, $p < .003$.

The pseudonoun data were inspected and no consistencies appeared except that pseudonoun reaction times ("Nonword" responses) were slower than responses to real nouns. The lack of consistency was not surprising because most of the pseudonoun suffixes we used were uninterpretable given the absence of a lexical entry for the pseudonoun and, therefore, the absence of information about the target's gender (i.e., declension). The suffixes that were used were mainly those that take on different case meanings depending on the gender of the stem. For example, the suffix *-u* would be interpreted as having dative case meaning for a real masculine or neuter noun but would be interpreted as accusative case for a real feminine gender noun. Note that there is no comparable problem with pseudoadjective stimuli. Suffixes are often ambiguous for real adjectives (disambiguation must await the appearance of its noun complement). Moreover, for the real and pseudoadjective suffixes used in the present experiment, only one, *-i*, was ambiguous.

The overall results of Experiment 3 are similar to those found in the print experiment of Gurjanov et al. (1985), with one exception. In print, no congruency effect was found for nominative case nouns; only the dative case nouns (and, in a second experiment, genitive case forms) were affected by grammatical agreement or disagreement with a preceding adjective.

Experiment 3 was informative in two ways. First, note that processing the inflection appears to be an obligatory process; congruency effects were found even though the stem was heard before the inflection and even though it was not necessary for the subject to attend at all to the inflection—which was always a real inflection and was, therefore, irrelevant to the subject's decision about the lexical status of the stimulus item (i.e., whether it was a word or pseudoword). Second, the answer to our question about the independence of syntactic processing from lexical/semantic processing is less than straightforward, but it is informative, nevertheless. It is clear that in auditory

presentation as well as in print there is a substantial facilitating effect of congruence between grammatical markers. This facilitation is strong even when the priming stimulus is not a real word. The latter point is particularly important because it suggests that there is a means by which syntactic processing can proceed without semantic support. However, it is also the case that the facilitating effect of congruence is even greater when the priming stimulus is, in fact, a real word and has a lexical representation. This interaction leaves us with an ambiguous outcome with regard to the hypothesis that inflectional information is processed without any reference at all to semantic information.

Experiment 4

The fourth experiment was designed to address the question of the naturalness of the congruency facilitation effect found in Experiment 3. In Experiment 3, the interstimulus interval (the time between the end of the adjective and the onset of the noun) was approximately 630 ms. This is much larger than the interval in natural connected speech. In fact, in rapid normal speech, the interval is effectively zero. Thus, our concern was whether the facilitation effect would generalize to the shorter, more natural, interval.

A secondary question involved the interaction in Experiment 3. This suggested that the facilitation effect of a congruent adjective–noun pairing was somewhat stronger when the adjective was a real adjective than when it was a pseudoadjective. This outcome speaks against the modularity of inflectional processing and semantic (i.e., stem) processing because it suggests the possibility that semantic characteristics of the adjective influence the speed of processing the noun's inflection. A second purpose of Experiment 4 was to determine if the interaction found in the previous experiment would still be found in the more natural interstimulus interval. If not, it could be claimed that the apparent nonindependence observed in Experiment 3 had just been an artifact of the abnormally long length of time between stimuli.

Method

The digitized stimuli created for Experiment 3 were used. The silent interval between the adjective and noun was reduced to zero for one set of stimuli and was increased to 800 ms for an otherwise identical set of stimuli. Two sets of 36 subjects each were run; 9 subjects in each set were given one of the four permutations of adjective–noun combinations described in Experi-

ment 3. One set of 36 subjects received the zero ms interstimulus interval stimuli (short ISI) and a second set of 36 received the 800 ms interstimulus interval stimuli (long ISI). None of the subjects had participated in Experiment 3. All procedures, including practice trials, were identical to Experiment 3.

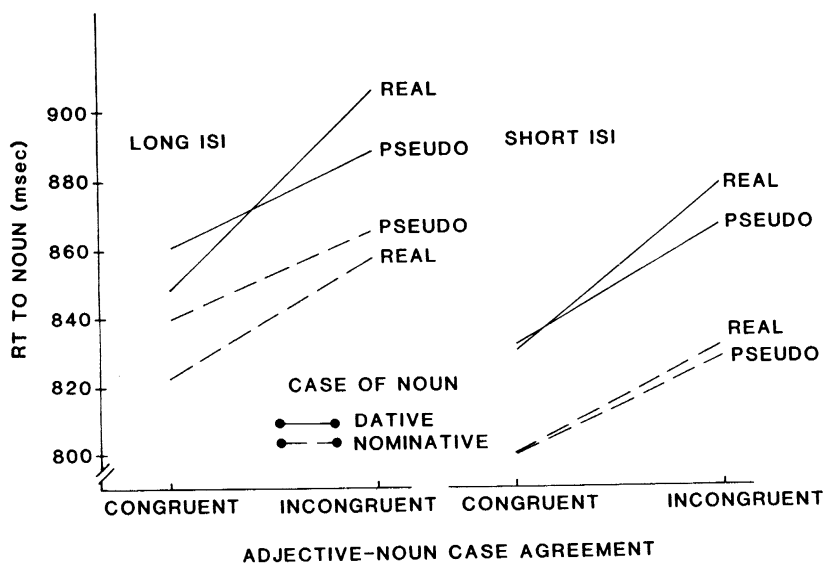
Subjectively, a short ISI pair sounded like fast but normal speech; in contrast, a long ISI pair was perceived with a brief but distinct pause between adjective and noun, as if the speaker were enunciating carefully.

Results and discussion

Figure 3 presents lexical decision RT means for real word noun targets only. Responses are presented as a function of ISI, the case of the noun (nominative or dative), and the grammatical congruency of the adjective-noun pairing.

Inspection of Figure 3 suggests three clear effects. Apparently, RTs were faster for short than for long ISIs. Also, responses to nouns inflected with

Figure 3. *Lexical decision reaction time to real nouns preceded by real or pseudo adjectives with congruent or incongruent case matches and long (800 ms) or short (zero) interstimulus intervals between adjective and noun.*



the nominative case suffix appear to be faster than responses to dative case nouns. Finally, nouns in grammatically incongruent adjective–noun pairings are consistently responded to more slowly than in congruent pairings. Analyses of variance supported these suggestions, to greater or lesser degrees. Least powerful was the effect of ISI; for the subjects analysis, $F(1,70) = 3.43$, $MS_e = 486$, $p < .06$ and for the items analysis, $F(1,54) = 86.91$, $MS_e = 19$, $p < .001$. For the Case of the noun, the subjects analysis gave $F(1,70) = 118.19$, $MS_e = 19$, $p < .001$ and the items analysis gave $F(1,54) = 9.56$, $MS_e = 61$, $p < .004$. Finally, for the main effect of Congruency, the subjects analysis gave $F(1,70) = 169.62$, $MS_e = 16$, $p < .001$ and the stimulus analysis, $F(1,54) = 44.40$, $MS_e = 61$, $p < .001$. In marked contrast to Experiment 3, there were no significant interactions for either ISI. Most importantly, there were no significant effects involving the lexicality of the adjective; there is no evidence to suggest that the different effects of grammatically congruent and incongruent suffixes depended on whether the priming adjective was a real adjective or not. Only the congruency of the inflections made a difference, not the stem to which it was attached.

Despite the absence of any significant interaction between lexicality of the adjective and congruency, there is the hint of such a pattern for the long ISI condition and, more convincingly, a significant interaction in Experiment 3, in which the SOA was similar to the long ISI of the present experiment. We have no compelling explanation of these results except to suggest that, with long SOA, there is time for subjects to apply an experiment-specific strategy: because pseudoadjectives have only grammatical meaning, subjects may tend to drop them from short-term memory more readily and, for the long SOA, these pseudoadjectives (including, of course, their inflectional suffix) will often have disappeared from memory before the appearance of the following noun target. Therefore, the observed congruency effect will be attenuated for nouns that follow pseudoadjectives, but only at SOAs that are long enough to allow substantial forgetting to occur.

General discussion

The present study offers evidence of essentially similar lexical decision processing for printed and spoken words. Further, and more importantly, it suggests that syntactic (inflectional) information and semantic information are initially processed by different, separable, mechanisms.

In Experiment 1, the recognition latencies for spoken nouns replicated the pattern obtained earlier by Lukatela et al. (1980) for printed nouns: fast reaction times to nominative case forms and slower, but equal, reaction times

among the oblique case forms. Lukatela et al. had demonstrated that this pattern (the 'satellite' pattern) could not be accounted for by the individual case frequencies in Serbo-Croatian. Experiments 1 and 2 demonstrated further that the satellite pattern is not caused by differences in phonological structure among the different case forms of the same noun: The satellite pattern was unaffected by adjusting reaction times to the point within a word where the inflection becomes uniquely identifiable. Thus, inflectional (syntactic) differences alone appear to account for the satellite pattern. Confirmation that this syntactic effect is independent of word frequency was indicated by a finding of identical satellite patterns for high and low frequency nouns, even though high frequency nouns were faster overall.

In current linguistic theory, inflectional morphemes are described as having a distinct function and representation in the grammar. The results of the first two experiments suggest that this intuition has some counterpart in the cognitive mechanisms underlying word perception: that a separate device for processing inflection exists. One characteristic of the device is suggested by the fact that the case-dependent satellite pattern occurred even though, logically, a subject could have made a lexical decision after listening to the stem without waiting for or attending to the inflection (because the inflection was always correct and, therefore, redundant with regard to the lexical decision). The fact that subjects, instead, were affected by the inflection suggests that the operation of the inflectional processor is mandatory during word recognition.

The suggestion of an autonomous inflection processor must be tempered, however, by the knowledge that the inflectional message (syntactic information about the case of the noun) can not be interpreted *solely* on the basis of the inflectional suffix. As was discussed earlier, the phonological form of the suffix (e.g., *-a*, *-e*, or *-u*, etc.) can not be assigned a case role unless the gender of the stem is known. This gender assignment is generally arbitrary and, therefore, must be represented lexically for each stem. Inflectional processing, then, must follow lexical access, an access that is based on the stem. This scenario of sequential events, in which lexical access for the stem precedes the activation of a separable inflectional processor, is, not surprisingly, in accord with the facts of Serbo-Croatian word formation, in which the stem always precedes the inflectional morpheme.

It is reasonable to ask whether this scenario is peculiar to the Serbo-Croatian language or, instead, represents a universal tendency of languages for word recognition. One piece of evidence in favor of the latter hypothesis is the tendency for languages to use suffixes instead of prefixes for inflection (Greenberg, 1966). Some languages also make use of infixes or word-internal changes but only rarely does inflection precede the base. The temporal prior-

ity given to lexical access over inflectional processing may also be reflected in the developmental pattern of language acquisition; children produce violations of syntax even when they make no semantic violations. Moreover, the temporal precedence of lexical access over inflectional processing would follow as a plausible consequence of the evolution of the perception and production of syntax from an earlier, nonsyntactic, mind in the development of *Homo sapiens*. Evolutionary changes that are extensions of earlier functions tend to build onto the previous system in a way that preserves the modular character of that earlier structure; the alternative would be to reform the entire preexisting system in order to accommodate the new function.

This view of the processing of inflectional information as being postlexical is consistent with the view of Seidenberg and his associates (e.g., Seidenberg, 1985; Seidenberg, Waters, Sanders, & Langer, 1984; Seidenberg, Tanenhaus, Leiman, & Bienkowski, 1982). They find that syntactic priming, as well as semantic (associative) priming facilitates lexical decision but only the latter kind of priming, semantic priming, has a facilitating effect for naming. They interpret this to mean that (a) lexical decision latency reflects both lexical and postlexical processing but naming latency reflects only lexical processing and (b) syntactic processing is postlexical. Seidenberg et al. have compared lexical decision and naming only for the English language and only for printed material. Nevertheless, the similarity of interpretations for both English and Serbo-Croatian, two languages that implement grammatical meaning in different ways, inclines us to conjecture as a general principle that lexical processing occurs before inflectional processing. One cautionary note: Katz and Feldman (1983) compared printed word recognition in English and Serbo-Croatian and found there were some differences between the two languages for the naming task although they appeared similar for lexical decision. For example, English naming was facilitated by semantic priming but Serbo-Croatian naming was not, a result attributed to the highly regular spelling-to-sound correspondence in the Serbo-Croatian orthography (Katz & Feldman, 1981). Thus, it is quite possible that naming in Serbo-Croatian may be accomplished differently than naming in English (although lexical decision may be similar) and, therefore, the techniques of Seidenberg et al. may not be appropriate for distinguishing pre- and postlexical processing in that language.

The third and fourth experiments further strengthened the evidence from the first two experiments that the inflectional processor (a) is unaffected by semantic information, (b) functions obligatorily in natural, rapid speech and (c) operates postlexically. It was found that a noun was identified more easily when it was preceded by an inflectional suffix that was syntactically predicative. It did not matter whether the semantic content that accompanied the

adjective was full (i.e., a real adjective stem) or was null (i.e., a pseudo-adjective stem). Experiment 4 demonstrated that equal amounts of relative facilitation were produced by pseudo- and real adjectives. In addition, the relative facilitation effect was strong even when the interval between the adjective and the noun was as short as it is in normal rapid speech. The important finding of Experiment 4 was that the relative facilitation effect was not weaker when the adjective-noun interval was shorter. The effect did not disappear when there was little or no time for conscious strategies to operate. This suggests that the inflection processor is normally activated when listening to natural rapid speech and that its operation is not informed by the listener's expectations or biases.

Our results are consistent with a model of an inflectional processor whose major characteristics are (1) its inputs are limited to syntactic information (e.g., word class, gender, and inflectional suffix), (2) the process is not influenced by semantic information, (3) its operation, once initiated, is self-contained (non-interactive and, in particular, not informed by higher order cognitive processes), and (4) its output is specifically syntactic in nature (e.g., the meaning of a noun's case role and number). In Fodor's (1983) terminology, the model describes a system that is domain specific and informationally encapsulated. Our experimental evidence suggests that, in addition to these characteristics, inflectional processing is mandatory as well.

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Résumé

Trois expériences de décision lexicale cherchent à étudier la séparabilité du traitement syntaxique et sémantique au cours de la reconnaissance auditive des mots. Une quatrième expérience étudie le problème de la mesure des temps de réponse à un stimulus auditif. Les mots utilisés sont du Serbo-croate, chaque stimulus consistant en une racine nominale (qui correspond à un mot attesté ou bien à un pseudo-mot) et d'une flexion casuelle qui véhicule de l'information sur le cas grammatical du nom. La vitesse d'identification des formes fléchies d'un mot dépend de leur sens syntaxique plutôt que de leur forme physique ou de leur fréquence d'apparition. En plus, l'identification d'un nom est facilitée lorsque celui-ci est précédé par un stimulus véhiculant de l'information permettant de prédire le cas du nom, qu'il s'agisse d'un véritable adjectif ou d'un pseudoadjectif. Ces résultats sont analogues à ceux obtenus préalablement pour la perception des mots en présentation visuelle; ils suggèrent qu'il existe une grande uniformité dans le traitement des suffixes flexionnels pour le langage écrit et parlé. Dans les deux cas, les résultats suggèrent que le traitement des suffixes flexionnels est modulaire, du moins dans la mesure où il est indépendant du traitement sémantique pendant la partie initiale de son déroulement.