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Lexical Stress Effects In Italian Spoken Word Recognition

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Abstract

Two cross-modal priming experiments tested whether Italian listeners rely on lexical stress information in spoken word recognition. In both experiments participants performed a lexical decision task on visual targets; however in the trials where there was a relation between prime and target, the relation was one of identity in Experiment 1, whereas it was a semantic association in Experiment 2. In Experiment 1, the match condition (e.g., the prime ['go.mi] from *gomito*, elbow, for the target GOMITO), produced facilitation relative to the control condition, and the mismatch condition (e.g., the prime [go.'mi] from *gomitolo*, clew, for the target GOMITO) produced inhibition. In Experiment 2, responses were faster in the related (e.g., the prime ['go.mi] from *gomito*, elbow, for the target BRACCIO, arm) than in the control condition. This, however, did not differ from the unrelated condition (e.g., [go.'mi] from *gomitolo*, clew, for the target BRACCIO, arm). The methodological and theoretical implications of the results are discussed.

Introduction

In this study we investigated the role of lexical stress during spoken word recognition in Italian. The paradigm typically used in this line of work is the cross-modal priming paradigm, which is assumed to tap the early phases of lexical processing: participants have to perform a lexical decision or naming task on a visual target that is preceded by a spoken prime. Response times to the same target as a function of the tests or the unrelated control primes are measured (Swinney, Onifer, Prather, & Hirshkowitz, 1979). In the spoken language literature, this paradigm is normally associated with the lexical decision task that occurs in two versions, depending upon the nature of the relation between the test prime and the target: the identity and the associative priming (Van Donselaar, Koster & Cutler, 2005). In the former, the relation is one of identity (e.g., *elbow* and ELBOW)¹, whereas in the latter it is a semantic association (e.g., *elbow* and ARM).

Both techniques are employed in current research on the effects of lexical stress in spoken language processing. Identity priming studies showed that the paradigm is sensitive to lexical stress effects. Cooper, Cutler and Wales (2002) conducted a study in English. Participants were

presented with a visual target (e.g., MUSIC) after a one syllable long fragment. Responses were faster when the prime's stress matched the target word (e.g., *mu* from *music*) than when it did not (e.g., *mu* from *museum*). However, the mismatching prime produced faster responses than the control prime. Facilitation in the mismatching condition disappeared only when one-syllable long priming fragments were replaced by two-syllable long fragments. In Dutch, facilitation for a visual target (e.g., OKTOBER, October) after one syllable long fragment was observed only with a matching prime (e.g., *ok* from *ok'tober*, October), but not after a mismatching one (e.g., 'oc from 'octopus, octopus). Furthermore, after disyllabic fragments facilitation in the matching condition as well as inhibition in the mismatching condition have been recently reported (Van Donselaar et al., 2005). The only evidence in a Romance language replicates the Dutch results with disyllabic primes (Soto-Faraco, Sebastian-Galles & Cutler, 2001).

Somewhat less clear are results of associative priming studies. Cutler (1986) reported that in English minimal pairs such as *forebear* (N) and *forbear* (V) behave as homophones, both facilitating the recognition of targets associated to either meaning (e.g., ANCESTOR and TOLERATE). On the contrary, in Dutch Donselaar et al. (2005) obtained lexical stress effects using associative priming. In this study, responses to a visual target (e.g., HEMEL, heaven) were facilitated, respect to the control, when preceded by a fragment prime corresponding to the initial part of an associate word (*para* from *para'dijs*, paradise). Differently, responses were not facilitated when the fragment was the initial part of a word differently stressed (*pa'ra* from *pa'rade*, parade). However, facilitation was clearly observed only when priming fragments (e.g. *kas'ta*) uniquely identified a word (e.g., *kastanje*).

Altogether, these findings suggest that English and Dutch speakers are sensitive to lexical stress information from the early stages of word recognition and are consistent with the view that spoken word recognition involves competition between the phonological representations of multiple activated candidates. Phonological representations wholly or partially matching the input are initially activated and compete for recognition inhibiting each other. The inhibitory process depends on the level of activation of the phonological representation, which varies with the degree of correspondence between the input and the phonological representation and the number of the competing candidates.

¹ Spoken primes are in italics, whereas visual targets are in capital letters.

One syllable fragments initially activate compatible lexical candidates and stress information is used to advantage and disadvantage candidates; however, only when the competitor set is reduced candidates are activated enough to exert a detectable inhibitory effect. Afterwards, only strongly supported or winning candidates can activate and facilitate the corresponding and associate conceptual representations.

The available evidence also suggests that lexical stress effects are modulated by listeners' sensitivity to this information: English speakers showed weaker effects than Dutch and Spanish speakers. As Cutler, Dahan and Van Donselaar (1997) argued, the use of prosodic information in speech processing can depend on how relevant a type of information is in a given language. The presence of segmental correlates to lexical stress can influence the relevance of suprasegmental information for the listeners of a language, decreasing the number of cases in which listeners must rely on suprasegmental information to discriminate words. Thus in English, where the opposition between strong and weak syllables is reflected in the opposition between full and reduced vowels, lexical effects are weak. Dutch is prosodically similar to English, but differ from it as long as unstressed syllables quite often contain a full vowel; accordingly, in Dutch lexical stress effects are stronger than in English. Contrary to English and Dutch, Spanish does not show any interdependence between lexical stress and segmental variations: there are 5 full vowels that can occur both stressed and unstressed. Indeed, in Spanish suprasegmental and segmental information showed similar effects during spoken word recognition.

According to this interpretation, suprasegmental information should be maximally exploited by listeners of languages in which segmental information do not vary with lexical stress and lexical stress effects should be quickly reflected at the semantic level. So far, however, there is no evidence for lexical stress effects with associative priming in this kind of languages. We explored this hypothesis in Italian. This, like Spanish, is a free-stress language and does not show vowel reduction in unstressed syllables. Therefore, Italian listeners are likely to rely on lexical stress information to recognize words.

In Experiment 1 we used the cross-modal identity priming, aiming at replicating in Italian evidence available from Spanish. In Experiment 2 we tested whether stress effects can obtain in Italian using the associative priming paradigm.

Experiment 1

Listeners were asked to perform a lexical decision task on a visual target (e.g., GOMITO, elbow) immediately preceded by a bisyllabic spoken prime. In the match condition, the fragment prime was the first two syllable of the same word (e.g., ['go.mi] from *gomito*, elbow). In the mismatch condition, the prime was segmentally identical; however the two syllables were the initial part of a word differently

stressed (e.g., [go.'mi] from *gomitolo*, clew). Finally, in the control condition the bisyllabic prime was the initial part of a word with no relation with the target. If Italian listeners, like Spanish listeners, rely on lexical stress information, responses should be fastest in the match condition, next faster in the control condition, and slowest in the mismatch condition.

Method

Participants

Thirty native speakers of Italian either volunteered or received credit course for their participation. All had normal hearing and normal or correct-to-normal vision. None had known language disorders.

Materials

Eighteen pairs of test words were selected. Words of a pair were segmentally and structurally identical up to the first phoneme of the third syllable, but differed for the position of the lexical stress (e.g., *gomito*, ['go.mi.to] --elbow-- and *gomitolo* [go.'mi.to.lo] --clew). Three pairs had one member with the first syllable stressed and the other with the second syllable stressed (e.g., *gomito* and *gomitolo*), whereas the remaining 15 pairs had one member with the second syllable stressed and the other with the third syllable stressed (e.g., *reciproco* [re.'ci.pro.co] -- mutual -- and *recipiente* [re.ci.'pien.te] -- container). Members of a pair had neither morphological nor semantic relation. None of the test words either was a compound or have a prefix; moreover, their first two syllables never corresponded to an Italian word. Test words were three or four syllable long and their mean frequency was 20,83 (SD = 31,32; Istituto di Linguistica Computazionale, 1988). All the test words were employed both as primes and as targets. For example, for the visual target GOMITO the prime in the match condition was *gomi* ['go.mi] extracted from *gomito* and in the mismatching condition was [go.'mi] extracted from *gomitolo*, whereas for the target GOMITOLO primes in the match and mismatch condition were inverted.

For each test pair a control word was also selected. Controls had no phonological overlap with the members of the corresponding pair; they were balanced for syllable length, lexical stress and frequency (on average 15.33, SD = 22.41).

For each of the resulting eighteen triplets a semantically and syntactically no constraining sentence was constructed (e.g., *la nipotina scrisse la parola...*, the little niece wrote the word...). Members of the triplets always appeared at the end of the sentence.

Further 60 words were selected to use as prime fillers. They were balanced to the experimental words for lexical stress position and syllabic structure and length. Twelve were coupled to target words that had no segmental overlap with them. For each of the other 48 prime fillers a phonotactically legal pseudo-word was constructed to appear as visual target; half of them had a phonological

overlap with the coupled prime, whereas the other 24 did not.

Finally 12 practice sentences were created with the same criteria of experimental materials.

Sentences were recorded directly onto the hard disk of a Macintosh Computer by a female native speaker of Italian. Recordings were digitized at 22.05 kHz and each sentence was saved in an individual audio file. Sentences were cut at the end of the second syllable of the prime using the SoundEdit 16 v2.0.7 software.

Three experimental lists were compiled; all contained all the test and the filler words. However, if a target occurred in the related condition in one list, it occurred in the unrelated condition in the second list and in the control condition in the third. Each list was divided into two blocks of 48 sentences each. Between blocks, number of fillers and experimental sentences in each condition were balanced. Trials were presented in a semi-randomized order with the constraint that there were at least 3 fillers at the beginning of each block and there were no more than 3 equal correct responses in a line.

Procedure and Design

Participants were tested individually in a quiet room. Pyscope 1.2 experiment control software performed stimulus presentation, timing and data collection. Sentences were presented with an inter-trial interval of 1.5 s. Visual targets were presented at the offset of the prime and last either for 1.5 s or till participants press a key of the button-box. The timer recording reaction times started at target onset and either stopped when participants pressed a key of the button box or reset automatically after 1.5 s.

Participants were instructed to listen to the sentences and to decide whether the target was an Italian word or not.

After receiving the practice trials, each participant was presented with one list. Overall, the experiment lasted about 20 minutes. An equal number of participants were randomly assigned to one of the lists. Block order was balanced across participants. There was one independent variable: the relation between priming fragment and target (match, mismatch and control).

Results and Discussion

Two items – *colombiano*, *columbian*, and *matriciana*, *amatriciana* -- had an error rate higher than 50% and were discarded from all the following analyses. Response times over or below two standard deviations from participants' mean response latencies were treated as errors and also excluded from analyses. The overall percentage of errors, including wrong responses, misses and outliers, was 4.32%.

Response times and errors were submitted to ANOVAs by participants (F_1) and items (F_2), where the main within factor was prime type. Latencies analysis showed a significant main effect of prime type ($F_1(2, 58) = 43.45, p < .001$; $F_2(2, 66) = 33.16, p < .001$). Planned contrast showed that participants responded faster in the match respect to the

control ($F_1(1, 29) = 65.86, p < .001$; $F_2(1, 33) = 45.99, p < .001$) condition. Responses in the mismatch condition were slower than in the match condition ($F_1(1, 29) = 71.46, p < .001$; $F_2(1, 33) = 71.86, p < .001$), but they did not statistically differed from those of the control condition ($p = .33$).

Responses were reliably faster in the match than in the mismatch condition, suggesting that Italian listeners employ lexical stress information during spoken word recognition. However, the data failed to replicate the inhibitory effect observed in Spanish in the mismatch condition (Soto-Faraco et al., 2001).

Perhaps inhibitory effects can be observed only when the lexical candidates compatible with the fragment prime are few, and hence activated enough to exert a detectable effect. To test this hypothesis we re-analyzed the data taking into account the presence of a competitor set in the mismatching condition. Competitor set was added as a within factor in the participants' analysis, and a between factor in the item analysis. The mean latencies of correct responses in the experimental conditions are shown in Figure 1.

In the latencies analyses both the main effect of prime type ($F_1(2, 58) = 31.59, p < .001$; $F_2(2, 64) = 29.23, p < .001$) and the interaction ($F_1(2, 58) = 3.21, p < .05$; $F_2(2, 64) = 3.09, p = .05$) were significant. The main effect of competitor set was significant only in the analysis by participant ($F_1(1, 29) = 5.36, p < .03$). Planned comparisons revealed that in the absence of a set of competitor responses were faster in the match than in the control condition ($F_1(1, 29) = 25.72, p < .001$; $F_2(1, 32) = 25.42, p < .001$), which in turn were faster than in the mismatching condition ($F_1(1, 29) = 6.06, p < .02$; $F_2(1, 32) = 4.53, p < .05$). In contrast, in the presence of a set of competitor, responses were faster in the match than in both the control ($F_1(1, 29) = 20.65, p < .001$; $F_2(1, 32) = 21.20, p < .001$) and the mismatch ($F_1(1, 29) = 21.92, p < .001$; $F_2(1, 32) = 12.47, p < .001$) conditions, which did not differ from each other.

We detected an inhibitory effect when the mismatching prime uniquely identified a word.

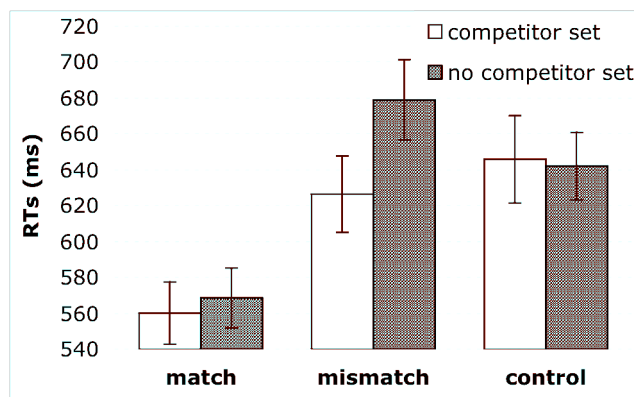


Figure 1: Experiment 1 participants' mean latencies (ms) and Standard Errors in different experimental conditions.

Italian listeners showed to rely on lexical stress information during spoken word recognition. Results from the identity priming replicated those obtained in Spanish and Dutch. Experiment 2 was devised to investigate whether in Italian lexical stress effects can be detected with the associative priming.

Experiment 2

Listeners were asked to perform a lexical decision task on a visual target (e.g., BRACCIO, arm) immediately preceded by a bisyllabic spoken prime. In the related condition, the fragment prime was the first two syllable of a word associatively related to the target (e.g., [go.mi] from *gomito*, elbow). In the unrelated condition, the prime was segmentally identical, however the two syllables were the initial part of a word differently stressed (e.g., [go.'mi] from *gomitolo*, clew). Finally, in the control condition the bisyllabic prime was the initial part of words with no relation to the target. If Italian listeners rely on lexical stress information we expect faster responses in the related condition than in the unrelated or the control condition. As neither the unrelated nor the control primes have any semantic relation with the target, we expect no difference between them, and no inhibitory effect is predicted.

Method

Participants

Twenty-seven Italian native speakers, from the University of Trieste either volunteered or received credit course for their participation. They all had normal hearing and normal or corrected-to-normal vision; none had known language disorders. Finally, none had participated in the previous experiment.

Materials

We employed the same pairs of test and control words as in the previous experiment.

For each test word an associate was selected to appear as visual target. Targets' frequency was 229 (SD = 862) on average (Istituto di Linguistica Computazionale, 1988). The appropriateness of targets was tested in an intra-visual priming experiment ($t_1(11) = -4.02, p < .01$; $t_2(35) = -3.22, p < .01$).

Filler materials and practice were modified in agreement with the experimental materials. The same recordings of Experiment 1 were used.

Three lists were created, divided in two blocks and semi-randomized as in the previous experiment.

Procedure and Design

Procedure was the same as in experiment 1. There was one independent variable: prime type (related, unrelated and control).

Results and Discussion

Mean latencies of correct responses in the experimental conditions are displayed in Figure 2.

Three items – *cappuccio*, hood, *cappuccino*, cappuccino, *matriciana*, amatriciana - and RTs above and below two standard deviations from participants' means were excluded from analyses. The overall percentage of errors (including false alarms, misses, and outliers) was 2.11%.

Response times and errors were submitted to ANOVAs by participants (F_1) and items (F_2), where the main within factor was prime type. The main effect of prime type was reliable ($F_1(2, 52) = 4.09, p < .03$; $F_2(2, 64) = 3.16, p < .05$). Planned comparisons showed faster responses in the related than in the unrelated ($F_1(1, 52) = 4.08, p < .05$; $F_2(1, 64) = 3.61, p = .06$) and the control ($F_1(1, 52) = 7.66, p < .01$; $F_2(1, 64) = 5.64, p < .03$) condition. These did not differ from each other.

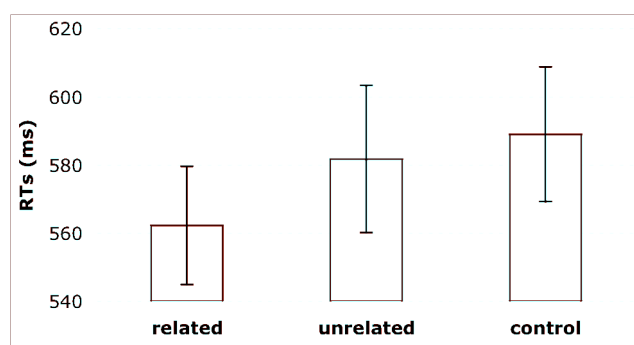


Figure 2: Experiment 2 participants' mean latencies (ms) and Standard Errors in different experimental conditions.

As predicted, Italian listeners rely on lexical stress to constrain lexical hypotheses during spoken word recognition, and associative priming is as sensitive to this effects as identity priming.

General Discussion

Two cross-modal priming experiments tested whether Italian listeners rely on lexical stress during spoken word recognition. Experiment 1 showed both the facilitatory effects of matching information and the inhibitory effects of mismatching information. In Experiment 2, prime fragments facilitated responses only insofar as they matched both segmentally and supra-segmentally the beginnings of the words associated to the targets.

Theoretically, the findings are compatible with competition-based models of spoken word recognition. Initially many compatible candidates are activated and compete with each other for recognition. Among many competitors none can effectively inhibit the others. When the fragment drastically restricts the set of candidates, these can produce detectable inhibitory effects (Van Donselaar et al., 2005). Lexical candidates feed activation to the

corresponding (and then facilitate the associated) representations at the conceptual level.

Altogether, the findings indicate that Italian listeners profitably rely on lexical stress during spoken word recognition and both identity and associative priming show these effects. Associative priming captures selective activation at the conceptual level regardless to whether the information that constraint the process of lexical activation is contextual, lexical, segmental or prosodic in nature (Tabossi, 1996). As in the present study, the fragment version of this technique (Zwitserslood, 1898) showed to be sensitive to segmental as well as prosodic information (Tabossi, Collina, Mazzetti & Zoppello, 2000; Zwitserslood & Schriefers, 1995). Evidently, the failure to observe stress effects with the associative priming in English and Dutch does not reflect so much the lack of sensitivity of the paradigm to stress effects as the relatively little use of stress information made by listeners of those languages compared to speakers of Italian, and presumably other similar languages.

In conclusion, lexical stress is a useful source of information in spoken word recognition. However, listeners of different languages take advantage of this information to different degrees. Italian listeners exploit it quickly to discern both the form and the meaning of the incoming speech.

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