

The Role of Morphological Structure in the Processing of Compounds: The Interface between Linguistics and Psycholinguistics

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This study presents a cross-linguistic investigation of lexical access and subjects' sensitivity to the internal morphological structure of compounds in two highly inflected languages, Greek and Polish. The following questions were addressed: Are individual constituents activated during on-line word recognition? To what extent does internal morphological structure play a role during lexical access? Is there an interaction between headedness and constituent-priming given that the inflection that the second constituent carries determines the gender, number, and case of the compound? Our results show activation of individual constituents of compounds during priming, a strong word effect, and a positional advantage for first constituents in spite of the presence of second constituent heads. © 1999 Academic Press

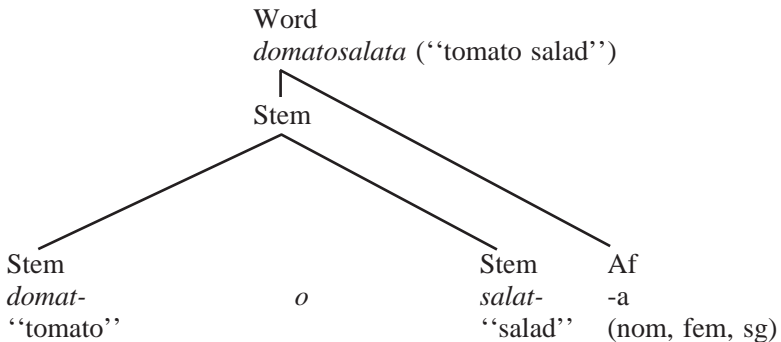
Psycholinguistic investigations of the mental lexicon have, thus far, largely focused on the access and representation of inflected and derived words. Compound words have been studied to a lesser extent and mainly under the scope of semantic compositionality and transparency (Libben, Gibson, Yoon, & Sandra, 1997; Sandra, 1990; Libben, 1996). Particularly with respect to the issue of constituent activation during the access of compounds, Libben et al. (1997) report the presence of significant priming effects for both initial and final constituents, thus suggesting that constituent activation

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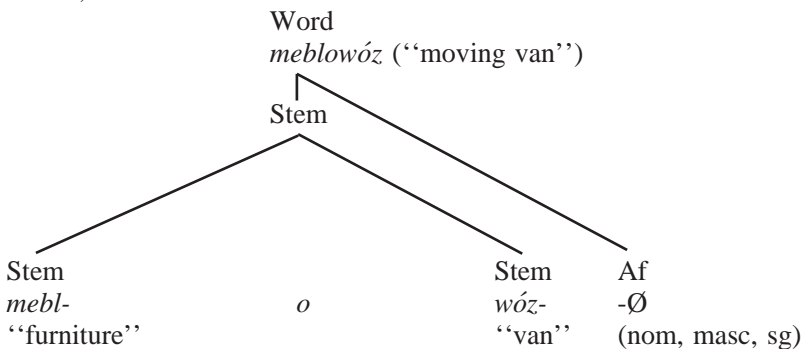
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occurs, at least at the level of form, for both transparent and opaque compounds. Constituent activation has also been reported for Dutch compounds in which first constituents containing the linking morpheme *-en* (in first-constituent–*en*–second-constituent structures) activated plural semantics as a result of the homography of the *-en* morpheme with the plural marker *-en* (Schreuder & Neijt, 1998).

In this study, we address the issue of constituent activation in compounds and present a cross-linguistic investigation of subjects' sensitivity to the internal morphological structure of compounds during lexical access in two highly inflected languages, Greek and Polish. Compounds in these languages are right headed and are typically formed by inserting a linking vowel (LV) between the first and second constituents. We examine simple Noun–Noun (Greek–Polish) and Adjective–Noun (Polish) transparent compounds that are fully compositional in meaning and feature the linking vowel ‘o’ as in the Greek *domatosalata* (‘tomato salad’) and the Polish, *mebłówóz* (‘moving van’). As both languages are highly inflected, nominal and adjectival compounds, like all simple and derived nouns and adjectives, are marked for gender, number, and case and exhibit the following structures. In Greek,



In Polish,



While, structurally, compounds seem to be similar across the two languages, surface differences emerge when we look at each of the constituents. Thus, in Greek, stems of major lexical categories such as nouns and adjectives are bound and do not project to the level of the word unless they are affixed with an inflectional suffix, e.g., [salat]_{N-1} + a_{fem.sg.nom}]_N. In Polish, nominal and adjectival stems also require the presence of an inflectional suffix. However, due to the existence of -Ø inflectional suffixes, such as the nominative masculine singular or the genitive plural marker, nominal and adjectival stems may be homographic to nouns and adjectives when these are affixed with a -Ø inflectional suffix. For example, in the compound *gwiazdozbiór* ('constellation') the first constituent *gwiazd-* ('star') is a stem that is homographic to *gwiazd-Ø*, a word in the genitive plural, as is the second constituent stem *zbiór-* ('collection') which is homographic to the word *zbiór-Ø* in the nominative masculine singular. This is never the case in Greek, where Ø-affixes do not exist. Thus, while the underlying compound-internal and constituent structures are similar in Greek and Polish, the two languages appear to be different at the surface level. With respect to the Stem+LV combination the following two pictures emerge. In Greek, a Stem+LV can be homographic to a real word (this combination is henceforth referred to as HW) if the stem requires the neuter inflectional marker -o, as in *hortopita* ('vegetable pie'), where the Stem+LV *horto* is homographic to the word for 'vegetable.' Alternatively, Stem+LV combinations can have the formal characteristics of a real word, but nevertheless not exist in the language (this combination is henceforth referred to as NW), as in *domatosalata*, where the stem + LV *domato* is an NW and *domata* is the actual word for 'tomato.' In Polish, one of the following occurs: (1) the first constituent is an NW stem and together with the linking vowel it becomes an HW, e.g., *drobn-o-ustrój* ('microbe'); (2) the first constituent is an NW stem and together with the linking vowel it remains an NW, e.g., *mebl-o-wóz* ('moving van'); (3) the first constituent is an HW stem and together with the linking vowel it remains an HW, e.g., *gwiazd-o-zbiór* ('constellation'); and (4) the first constituent is an HW stem and together with the linking vowel it becomes an NW, e.g., *kosci-o-trup* ('skeleton').

Given the underlying structural similarities and the seeming surface differences between Greek and Polish, a comparison of subjects' sensitivity to the morphological structure of compounds in the two languages is of particular interest. The following questions were addressed: Are individual constituents of compounds activated during on-line word recognition? To what extent does internal morphological structure play a role during lexical access, i.e., is recognition speed influenced by the lexical status of the constituent (HW, NW)? Finally, is there a positional effect in the priming of compounds, given the role of the second constituent as the head of the compound and given that the inflection it carries determines the gender, number, and case of the whole compound?

HYPOTHESES

We hypothesize that individual constituents of transparent compounds that are compositional in meaning are activated during lexical access and predict constituent priming effects. We further hypothesize that the grammatical information specifying lexical items facilitates lexical access during priming. We thus anticipate a ‘‘word effect’’ in both languages. Finally, we hypothesize that the information carried by the second constituent, the head of the compound, has a facilitatory effect during lexical access.

METHOD

Procedure and design

To address the above questions and to test our hypotheses, a primed lexical decision task was administered. Greek-speaking and Polish-speaking subjects were tested on a Macintosh computer using the PsyScope 1.1 program. The instructions were followed by a training block of 20 items. The stimuli were presented in the center of the screen. The prime appeared for a period of 100 ms, followed by a pause of 100 ms, in turn followed by a series of pound symbols (#####) for 150 ms and finally the target (unlimited time). The independent variables were prime type and language and the dependent variables were reaction time (RT) and accuracy of response.

Participants

Twenty-four native Greek-speaking individuals, 20–30 years old, all right handed, with 14–18 years of education and 25 native Polish-speakers, 29–40 years old, all right handed, with 12–16 years of education participated in the experiment.

Materials

In Greek the stimuli comprised 39 experimental items and 90 fillers. In Polish, there were 36 experimental stimuli and 76 fillers. The stimulus sets in both languages also comprised a set of nonwords that were created by changing the first phoneme of the first and second constituent of the compounds and the first phoneme of the control and filler words. In the Greek experiment, the total set of stimuli included 600 prime–target pairs and in Polish the total set included 852 prime–target pairs. In both languages, targets were primed by the stem of the first constituent (S1); the first constituent plus the linking vowel (S1+LV HW, S1+LV NW); the word derived from the first constituent (W1); the stem of the second constituent (S2); the word derived from the second constituent (W2); and a neutral unrelated control item (N).

Stimuli were divided into blocks of 100 pairs and arranged so that neither the target nor the prime were presented more than twice.

RESULTS AND DISCUSSION

In both languages, erroneous responses (3–5%) and outliers (RTs above or below 2 standard deviations within each category) were removed prior to

TABLE 1
Neutral versus Constituent Priming Effects in Compound Word Recognition^a

Prime type	Greek		Polish	
	Prime	Target <i>hortosalata</i> "vegetable salad"	Prime	Target <i>gwiazdozbiór</i> "constellation"
N	<i>vouno</i> "mountain"	744	<i>kłopot</i> "problem"	726
W1	<i>horto</i> "vegetable"	656	<i>gwiazda</i> "star"	645
S1+LV (HW)	<i>horto</i> "vegetable"	654	<i>gwiazdo</i> "star"	650
W2	<i>salata</i> "salad"	689	<i>zbiór</i> "collection"	695

^a Reaction times are given in milliseconds.

statistical analysis. Table 1 presents mean reaction times (RTs) in milliseconds on the experimental stimuli when primed by (N), (W1), (W2), and (S1+LV HW).

Repeated-measures ANOVAs with prime type as the within-factor and language as the between-factor revealed significant main effects of constituent-priming when compared with the neutral control prime [N/W1, $F(1, 47) = 100.5, p < .0001$; N/S1+LV HW, $F(1, 47) = 105.8, p < .0001$; N/W2, $F(1, 47) = 38.9, p < .0001$]. In all of these comparisons no main effect of language was found [N/W1, $F(1, 47) = 1.8, p = \text{ns}$; N/S1+LV HW, $F(1, 47) = .7, p = \text{ns}$; N/W2, $F(1, 47) = .32, p = \text{ns}$].

When we compared word and HW primes to NW primes, we found strong word and HW effects (see Table 2). Repeated-measures ANOVAs revealed a significant main word effect in both languages [W1/S1+LV(NW), $F(1, 47) = 15.4, p < .0005$; W1/S1(NW), $F(1, 47) = 15.5, p < .0005$].

As mentioned above, in both languages all stems are bound and surface to the level of the word only after the affixation of an inflectional suffix. Furthermore, although the [S1+LV (NW)] sequences might have the formal characteristics of a word, comprising a stem and the compounding vowel "o," they lack the full grammatical specification that the homographic inflectional suffix *-o* would provide. When comparing W1 and S1+LV HW, no significant difference was found [W1/S1+LV HW, $F(1, 47) = .04, p = \text{ns}$]. It thus appears that, in cases of homography with an actual word, the semantics and grammatical specification of the word carry over to the S1+LV HW and create the "word effect" observed. This effect is similar to that observed in the Schreuder and Neijt (1998) study where the homography of the *-en* linking morpheme to the *-en* plural marker induces the activation of plural semantics during compound recognition. When comparing RTs on first-position priming conditions (S1 NW, W1, S1+LV HW, S1+LV NW, and N), we obtained a statistically significant main effect of priming condition [$F(4, 47) = 34.4, p < .0001$]. No main effect of language [$F(1, 47) = .08, p = \text{ns}$] and no interaction was found [$F(4, 47) = 1.4, p = \text{ns}$]. Scheffe post hoc tests revealed significant differences between

TABLE 2
W and HW versus NW Priming Effects in Compound Word Recognition^a

Prime type	Greek		Polish	
	Prime	Target	Prime	Target
N	<i>karekla</i> 'chair'	<i>domatosalata</i> 'tomato salad'	<i>numer</i> 'number'; <i>kłopot</i> 'problem'	<i>meblowóz</i> 'moving van'
W1	<i>vouno</i> 'mountain'	<i>hortosalata</i> 'vegetable salad'	<i>mebel</i> 'furniture'	645
S1+LV (HW)	<i>domata</i> 'tomato'	656	<i>gwiazdo</i> 'star'	650
S1+LV (NW)	<i>horto</i> 'vegetable'	654	<i>meblo</i>	693
S1 (NW)	<i>domato</i>	688	<i>mebl-</i>	675
	<i>hort-/domat-</i>	692		

^a Reaction times are given in milliseconds.

TABLE 3
 Word 1 (W1) versus Word 2 (W2) Priming Effects in Compound Word Recognition

Prime type	Greek		Polish	
	Prime	Target <i>domatosalata</i> "tomato salad"	Prime	Target <i>gwiazdozbiór</i> "constellation"
N	<i>karekla</i> "chair"	744	<i>kłopot</i> "problem"	726
W1	<i>domata</i> "tomato"	656	<i>gwiazda</i> "star"	645
W2	<i>salata</i> "salad"	689	<i>zbiór</i> "collection"	695

S1+LV HW and N and between W1 and N (N/S1+LV HW, $p < .05$; N/W1, $p < .05$), but not between S1 NW and N and between S1+LV NW and N (N/S1, $p = ns$; N/S1+LV NW, $p = ns$).

Turning to the effect of position, when we compared the priming effects among the different priming conditions (see Table 3), we found a main effect of priming condition [$F(4, 47) = 12.48, p < .0001$], but no main effect of language [$F(4, 47) = .73, p = ns$]. Scheffe's post hoc test of significance revealed a stronger priming effect for W1 as compared to W2 ($p < .005$).

It thus appears that while both W1 and W2 primes facilitate compound word recognition when compared to neutral primes, W1 primes were stronger despite the fact that W2, the second constituent, is the head of the compound.

CONCLUDING REMARKS

In this article we have addressed the issue of word recognition of transparent N-N and A-N compounds in Greek and Polish. This comparative study was motivated by the underlying similarities, but also by the surface differences between the two languages. Our goal has been to investigate to what extent individual constituents of compounds are activated during word recognition and to identify the factors that may facilitate their activation in an attempt to obtain a better understanding of the process of lexical access of compounds.

As previously reported in the literature (Libben et al., 1997; Schreuder & Neijt, 1998), our results show the activation of the individual constituents of compounds during priming. Furthermore, first constituents are found to have a positional advantage in visual recognition, despite the presence of second-constituent heads. This finding confirms previous results (Libben et al., 1998; Jarema et al., 1999, this issue) from experiments where the first constituent was found to play an important role in compound recognition. In our study, this effect interacts with the word 1 (first constituent stem+inflectional suffix) or word-homographic first constituent (S1+LV) effect. Furthermore, as shown by Schreuder and Neijt (1998) for Dutch, the linking morpheme *-o* appears to create a "word effect" when its combination with the first constituent is homographic to an actual word in both Greek and

Polish. Thus, during compound recognition, subjects are not simply establishing a cohort, but rather are using the information provided by the fully specified prime or its homograph.

In conclusion, our study reveals that in the recognition of compounds in Greek and Polish, fully specified lexical representations of the first constituent are activated and play an important role in the process of lexical access.

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