Does stress matter?
A study of stress related priming effects on Greek compounds

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Abstract

Single word compounds in Modern Greek (henceforth Greek) exhibit two main stress patterns; a) the compound preserves the stress of the second constituent and b) the compound receives stress on the antepenultimate syllable. Previous studies on compound processing have argued that compounds are represented in two ways, as whole units or decomposed. While other compound properties like headedness, constituency, and θ-role saturation have been examined both from a theoretical linguistic and a psycholinguistic standpoint, the phonological properties of compound words and in particular, stress assignment, have not yet been examined from a psycholinguistic perspective. This project focuses on the effect of stress on naming (timed reading) and word recognition of Greek compounds. Twenty native speakers participated in two experiments (cross-modal lexical decision and primed naming), specifically selected to investigate whether stress activates phonological cues speakers rely upon during processing. It is hypothesized that if compound processing involves the activation of its constituents, we would expect a differential performance for compounds with no stress change as compared to those with stress change, mainly due to the activation of the different compound features during lexical access. The experimental results confirm this hypothesis, especially for the naming task, where, due to its nature, phonological effects were expected to mediate processing.

1 Compounding in Greek. An overview

Greek compounds have been analyzed as complex word constructs[1] that consist of more than one root:

(1)	*domatosaláta*	<	*domat-*	-o-	*salata-*
	'tomato salad'		'tomato'	-CI-	'salad'

In most cases, there is a vowel, -o-, between the two constituents. Following Ralli (2007), we consider this vowel to be a linking element that acts as a

[1] This study focuses on instances of single -word compounds i.e., formations that exhibit a single main stress. The language also has "multi-word compounds" that resemble regular NPs like *psixrós pólemos* 'cold war', or *zóni asfalías* 'safety belt'. The properties of these formations fall beyond the scope of this paper and will not be addressed.

compounding index (CI), separating the two constituents. Ralli (2007) argues that this index should not be mistaken as an inflectional suffix (indicating for instance case or/and number,) since it remains unchanged throughout the paradigm.

Endocentric compounds in the language are right headed like in English[2] (cf. Williams' (1981) right-hand head rule.) The role of the head is revealed by the semantics of the word (i.e., there is often a subordinate relation between the head and the non-head; in (1) above, *domatosaláta* is a type of *saláta* 'salad') as well as by other features, like syntactic category. For example, in (2), the syntactic category of the head determines the category of the whole compound:

(2)	*kokinóxoma*	<	*kokin-*	-o-	*xoma-*
	'red clay'(N)		'red'(A)	-CI-	'ground'(N)

1.1 The phonological properties of Greek compounds

The most interesting phonological property of Greek compounds is that they are not characterized by uniform stress patterns. Like all words in Greek, compounds may be stressed only in one of the final three syllables of the word (ultimate, penultimate, or antepenultimate). Ralli (2007) argues that both stems and words can enter compound formations and as a result, four types of compounds are predicted; stem-stem, stem-word, word-stem and word-word.

In this paper, we will focus on the two major categories of compounds, namely, stem-stem and stem-word compounds. The first preserve the stress position of the original word (3), while the latter are usually stressed by rule on the antepenultimate syllable[3](4):

(3)	*ɟiðovoskós*	<	*ɟið-*	-o-	vosk-	(cf. voskós)
	'goat herder'		'goat'	-CI-	'herder'	
(4)	*tsimedóliθos*	<	*tsimed-*	-o-	*liθ-*	(cf. líθos)
	'concrete block'		'cement'	-CI-	'stone'	

Nespor and Ralli (1994, 1996) argue that these stress patterns are well predicted by the underlying morphological structure given in (5):

(5) a. $[[\text{stem}]\ [[\text{stem}]\ \text{infl}]_{\text{wd}}]_{\text{wd}}$
b. $[[\text{stem}]\ [[\text{stem}]_{\text{stem}}]\ \text{infl}]_{\text{wd}}$

Under a framework of Generative Morphology (Aronoff 1976, 1994), and for Greek (Ralli 1988, 2000, 2005) the lexical entry of every morpheme comprises specific phonological, syntactic and semantic information that enters into the

[2] The language also exhibits exocentric and coordinative (dvandva) compounds with different headedness properties (Ralli 2007).

[3] Stem-stem compounds with a bound stem as second constituent (i.e., *troxo-nómos* 'traffic policeman', *meliso-kómos* 'apiarist') do not receive antepenultimate stress due to the exceptional stress properties of the second constituent (Ralli 2007).

derivation. In a stem-word configuration, a word has already been formed and main stress has already been assigned. Adding a new stem to the word cannot trigger stress reassignment, because this would violate a stress preservation principle (Burzio 1994). On the other hand, stem-stem constructs enter the structure without any stress assigned. Since a stem-stem constituent has not received stress yet, stress can be assigned by rule on the antepenultimate syllable without violating any stress preservation principle.

1.2. Expectations for processing

If stress properties are part of the lexical entry, then there is a conceptual difference between stem-stem and stem-word compounds, particularly in the way these stress properties interact with the stress rule. Stem-word compounds will preserve the stress properties of the head, stem-stem compounds will not and will receive stress on the antepenultimate syllable. Thus, the internal representation of stem-stem compounds seems to be more complex than that of stem-word compounds because it involves the application of a stress rule which overrides any relevant information of the lexical entry. On the other hand, stem-word compounds do not undergo the same process. Therefore, we could expect that computation of stem-word compounds should be faster than that of stem-stem ones, because the stress rule is absent and thus, the derivation is simpler as it involves fewer processes.

If we assume that the computation of linguistic features is instantiated in on-line psycholinguistic performance, then we would expect that speakers will perform differently with respect to these categories.

2 The psychological reality of compounds

Current psycholinguistic approaches to compounding favour a model of compound representation that involves the storage and computation of a compound as a whole lexical unit and/or in a decomposed form (Libben 2006). This view is in accordance with studies on language impairment on alexia (Caramazza et al. 1985) and aphasia (Ullman et al. 2005), where experimental results call for a storage and processing mechanism that has access to a word both as a whole unit and as decomposed. This dual system would favour the maximization of both computational and storage efficiency and although it can be viewed as redundant and inefficient, Libben (2006) argues that in fact, it is the preferred way for speakers to process compound words. This is shown in a number of studies on opaque and transparent compounds (Libben et al. 1997), on novel and ambiguous compounds (Libben et al. 1999), studies on constituent activation and headedness (Kehayia et al. 1999), for Greek and Polish compounds), as well as a in a study on the interaction of position-in-the-string, headedness and transparency effects (Jarema et al. 1999).

Tsapkini et al. (1999), in a study of phonological change during derivation, showed that forms subject to phonological change during derivation (level 1 affixes, cf. Kiparsky 1982) were always recognized significantly slower than

those without phonological alteration (level 2), when modality was taken into consideration (i.e., a differential priming effect was revealed in the task where the prime was auditorily presented). Nevertheless, thus far the role of stress in compound processing in Greek has not been thoroughly addressed. The present study aims to investigate this issue, by focusing on the role of stress change in compound processing.

2.1 The experimental question

Theoretical analyses of single-word compounds group them into two major categories, stem-stem ones and stem-word. The first category is assigned stress at the end of the derivation, while the latter (stem-word), at an intermediate stage.

Under a hybrid model of psycholinguistic analysis where words can be stored either as whole units or decomposed, is there facilitation in the recognition and production of a compound, if the position of the stress of the second constituent is similar to that of the whole compound?

3 The experiment

In what follows the details of the experimental settings used to address the question posed above are presented.

3.1 Methodology

3.1.1 Participants

Twenty native speakers (12 women, 8 men) of Greek participated in two tasks (cross-modal lexical decision and naming, run on a Macintosh computer using Psyscope. All participants were native speakers of standard Greek, aged 20–61 years old with an average of 18 years of education.

3.1.2 Experimental stimuli

For both tasks, experimental stimuli comprised two sets of noun-noun (NN compounds one with stress change (SC), n=24 compounds with stress change (12x2 for masculine and feminine[4]) and one without (NSC), n=36 (12x3 for each gender, masculine, feminine and neuter.

We opted for NN compounds because they are the most referentially neutral ones, as adjectives and verbs carry thematic information that may alter priming effects, (cf. Manouilidou 2004). Finally, our stimuli comprised only of morphologically simple roots because derivational affixes exhibit both morphological and phonological prominence in a construction (they are category changing and their stress properties override those of the roots).

The same set of stimuli was used for both tasks. There were sixty experimental pairs each task with the second constituent of the compound being

[4] Due to limitations of available linguistic data, neuter NN stem-stem compounds could not be tested.

the prime and the compound the target. In addition, there were sixty control pairs where the compound was primed by a control noun matched with experimental prime for length (number of syllables), frequency, gender (Masc, Fem and Neut), phonetic onset and stress position[5]. Experimental stimuli and controls were selected from the dictionaries of Triantafillidis and Anastasiadi-Simeonidou and frequencies were obtained from the ILSP **(**Institute for Language and Speech Processing) corpus of Greek texts. Some examples are provided below for a feminine NSC compound (6) and a masculine SC one (7):

(6)	*domatosaláta*	↔	*saláta*	prime
	'tomato salad'		'salad'	
	domatosaláta	↔	*sarðéla*	control
	'tomato salad'		'sardine'$_{fem}$	
(7)	*laxanókipos*	↔	*kʲípos*	prime
	'vegetable garden'		'garden'$_{masc}$	
	laxanókipos	↔	*kʲívos*	control
	'vegetable garden'		'cube'	

To reduce the density of the experimental items, 120 pairs of filler items consisting of a singleton word (used as "prime") and a derivative of it (as the "target") were added. Finally, only for the lexical decision task a set of pseudowords were used. Pseudowords were constructed from existing words by changing their initial phoneme(s) (i.e., *pasaθeristís*) of the first or second syllable or b) by creating non licit derivatives (i.e., **adipaθitís*). All pseudowords were phonotactically legal.

3.1.3 Experimental Tasks and Procedure

The two on-line psycholinguistic tasks (primed lexical decision and naming) were specifically selected because they allow the verification of linguistic performance in real time and with the participant not being conscious of the questions at hand. Furthermore, while the first task targeted word recognition, the second required word production through primed reading. Given the nature of our experimental question, the second task, in particular, was anticipated to be more revealing of whether stress activates specific phonological cues that speakers rely upon during compound processing and reading. Dependent variables for both tasks were Latency (Reaction Time in msc) and Error. Independent variables were the categories of compounds tested (compounds with and without stress-change).

[5] Dumay et al. (2001) show that for monosyllabic words, segmental matching at the end of the world facilitates recognition. It is plausible to assume that perhaps similar effects can arise on the onset of words, crucially for the naming task, where the time reading of a word often depends on the particular onset phoneme.

Participants were tested in two separate sessions, the first one comprising the auditory-visual (cross-modal) lexical decision task and the second the primed naming task.

For the lexical decision task, the participants were auditorily presented the prime consisting of the second constituent of a compound (NSC, or SC), or a control word. This was immediately followed by the target, the whole compound, which was presented visually. Participants were then asked to decide whether the target is a word of Greek or not by pressing the NAI ('yes') or OXI ('no') button on a button box. The target remained on the screen until the participant responded.

For the naming task, speakers first heard the prime, the second constituent of a compound and afterwards they were asked to read the target, i.e., the whole compound. The target stayed on the screen for 1500msec. This task differed from the cross-modal one in that it required not only the recognition of the target, but also production/reading. Thus, it was anticipated it would add important information to the lexical decision task by providing further possibilities for the realization of the stress properties of compound.

3.1.4 Data Analysis

At a first step experimental items were separated from the pseudowords and the fillers. Prior to any data analysis, erroneous responses and outliers were removed from the data set. At a second step, the mean and standard deviation was calculated for the group of words and data points above and below 2xSTDEV from the AVER ± were removed as per standard procedure in such psycholinguistic experiments. The different subgroups within the set of words were then separated, i.e. NSC and SC compounds. An item analysis and descriptive statistics (necessary t-tests) were run to compare performance across categories within each task and across tasks.

3.2 Experimental Results—Lexical Decision

For this task, we report results from 17 out of 20 participants, as three participants had to be excluded due to a high number of errors > 10%.

At a first step, analyses aimed at identifying the presence of priming. To achieve this, the Mean Difference (MD) was calculated by subtracting the mean RTs for the experimental pairs from the mean To determine the presence of priming, planned comparisons across all conditions were conducted and revealed significant priming ($p<.0001$) for all experimental pairs.

At a second step, we addressed our main research question, namely, whether stress change matters in compound recognition. The main prediction was that if compound processing involves the activation of both constituents and if this implies the processing of features such as stress, then compounds that undergo stress change would show differential performance from those without stress shift. The results are summarized in table 1 below:

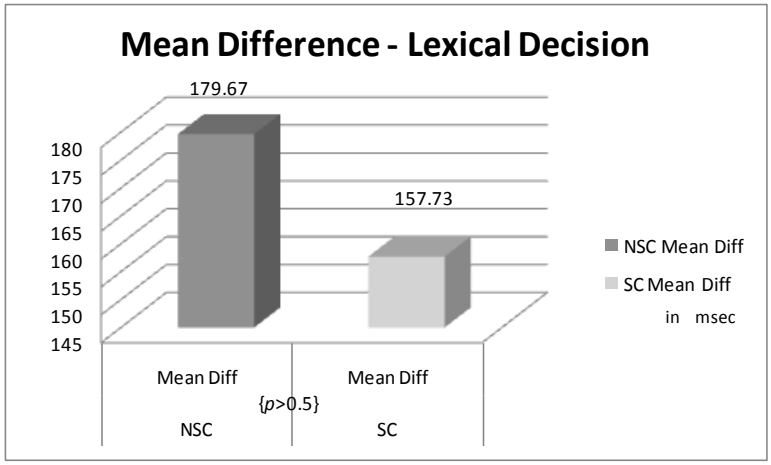

Table 1: MD Lexical Decision

We had predicted that SC compounds should incur longer RTs and thus smaller mean differences than NSC ones, which is also corroborated by the data (NSC: 179.67 > SC: 157.73). However, statistical analysis revealed that this difference (*21.*94msc) was not statistically significant (*p>0.5*). Whether the absence of statistical significance is due to the small power both in terms of sample size of participants and tokens remains to be further verified in subsequent experiments.

3.3 Experimental Results—Naming Task

While the same participants were invited to participate in the two experiments, of the 20 initial ones only 15 accepted to continue with the naming task. As with the lexical decision task, the first analysis sought to identify the presence of priming which was found to be significant (p<.0001) across all categories.

Proceeding with further analyses, we addressed the hypothesis according to which the second constituent of the compound would facilitate the naming of the target word in the absence of any additional operations, e.g. stress change. This facilitation would be translated into shorter RTs and greater priming; In contrast, as anticipated, longer RTs and smaller priming was found for compounds that undergo stress change. This is exemplified in table (2):

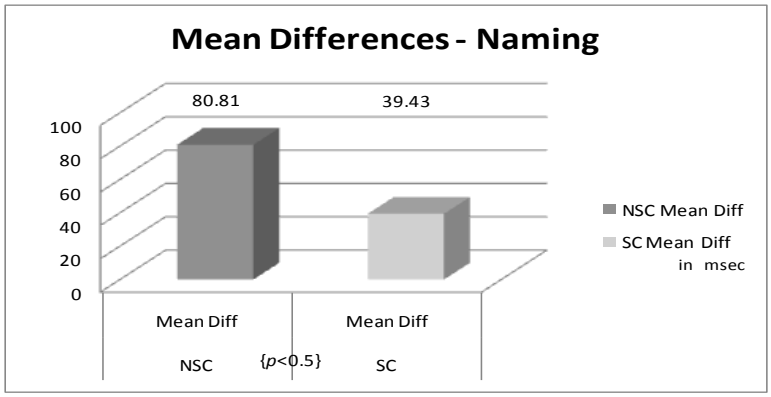

Table 2: MD Primed naming

Similarly to the previous task, participants performed faster in the experimental stimuli than the control ones. However, this time, the mean difference of SC compounds was found to be significantly lower than the NSC ones ($p<0.5$). Considering that the main variable manipulated in this task was stress change, we can assume that the longer RTs observed in the naming/reading of the compounds with stress change is indeed due to this variable and the time cost it incurs.

Finally, given that gender was controlled for across the two tasks, separate analyses were run to investigate whether there was a differential performance. Planned comparisons did not reveal any effects and existing mean differences were not found to be significant.

3.4 General discussion

In this paper, we addressed the issue whether stress change effects in Greek compounds are reflected in the on-line psycholinguistic performance of native speakers of the language during two tasks, a cross-modal primed lexical decision and a naming task. The prediction was made that compounds that do not undergo stress change will trigger faster RTs in second constituent activation and thus, stronger priming effects than those with stress change. Furthermore, it was hypothesised that because of the nature of linguistic change involved (i.e., stress change) priming effects should be enhanced in the second task, where because of on-line production, phonological changes are predicted to be more prominent.

For both tasks, we report facilitation of the recognition and production of the compound words when in the experimental condition. However, it was only in the naming task where stress change appeared to significantly affect the processing (i.e., on-line production) of compounds. Nevertheless, even for the lexical decision task, we do report higher mean differences for NSC compounds compared to SC compounds and only a *tendency* is reported.

Finally, these results are compatible with the generative morphological approach to stress assignment in compounding argued by Nespor and Ralli (1994,

1996). We believe a relation can be established between the stress rule overriding the inherent stress properties of the stem on one hand and the extra computational cost incurred because of stress change, (evident by the longer RTs) on the other.

3.5 Contributions-Issues for further research

We believe that this study has provided a first and unique insight into the role of stress, and in particular stress change, in compound processing and in doing so allowed a better understanding of how this linguistic feature is realized in language performance.

Furthermore, the experimental results reported in this study are in accordance with a psycholinguistic analysis of the role of stress change in English derivatives as reported by Tsapkini et al. (1999). They are also consistent with the aforementioned theoretical analyses of Greek compounds that attribute the different stress patterns (preservation of stress, or stress on the antepenultimate syllable) to distinct morphological structures (stem-word, stem-stem compounds) Finally, the reported priming effects of stress change in the naming task in contrast to the absence of priming in the lexical decision task invite further investigation of this phenomenon in populations that exhibit differential performance across different language tasks. Areas like language acquisition and language impairment easily come to mind, where for example, an extension of this study to individuals with phonological deficits may not only benefit from the knowledge acquired from the present study, but also allow for further research initiatives.

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