Canadian Journal of Linguistics/Revue canadienne de linguistique 60(1): 25–50, 2015

Stress properties of Greek compounds: Psycholinguistic considerations

ATHANASIOS TSIAMAS
GONIA JAREMA
Université de Montréal and
Research Center, Institut universitaire de gériatrie de Montréal (IUGM)
EVA KEHAYIA
McGill University and
Center for Interdisciplinary Research in Rehabiliation (CRIR)
GEVORG CHILINGARYAN
Center for Interdisciplinary Research in Rehabiliation (CRIR) and
Jewish Rehabilitation Hospital

1. Introduction

In this article, we investigate the role of stress and, in particular, of stress change in Greek compound processing. In a number of theoretical linguistic analyses (Malikouti-Drachman and Drachman 1989; Nespor and Ralli 1994, 1996; Revithiadou 1997; Tzakosta 2011), the stress properties of Greek compounds have been linked to their respective underlying morphological structure. Therefore, any account of compound stress processing should take into consideration the properties of the underlying morphological structure of these words, as they may interact with stress during compound activation.

Greek compounds are normally right-headed constructions[1] (i.e., the morphological head is on the right, as in other languages such as English, Russian, Turkish,

Preliminary results of this study were presented at the 2011 AMLaP (Architectures and Mechanisms for Language Processing) conference. We would like to express our gratitude to the Département de linguistique et de traduction of the Université de Montréal, the Centre de recherche de l'Institut universitaire de gériatrie de Montréal (CRIUGM), and the Centre for Interdisciplinary Research in Rehabilitation of Greater Montreal (CRIR), whose invaluable support made this study possible.

[1] The position of the head can be determined by its semantic and morphological properties, as in many instances there is a subordinate relation between the head and the non-head. Exocentric compounds, where the head is not part of the structure (Ralli 2007) and co-coordinative (*dvandva*) compounds, where, semantically, both constituents can act as a head, are also formed in the language but will not be considered in this study.

etc.) and in the majority of cases, a linking vowel (*-o-*) (CMPM, compound marker)[2] appears between the two constituents. With respect to stress, we focus on the two main types of Greek compounds: those that preserve the stress position of the head word (NSC, no stress change) as in (1) and those that invariably receive antepenultimate stress, regardless of the stress properties of the head (SC, stress change) as in (2).[3]

(1) ʝið- -o- voskós → ʝiðovoskós
'goat' -CMPM- 'herder' 'goat herder'

(2) gaz- -o- furn- → gazófurnos (cf. *fúrnos*)
'gas' -CMPM- 'oven' 'gas stove'

Nearly all the aforementioned theoretical accounts of compound stress refer to the categories of stems and words as building blocks for these structures. In particular, for Malikouti-Drachman and Drachman (1989), compound stress assignment is a subcase of the general principles governing stress assignment in the language (i.e., general extrametricality of the last syllable, trochaic feet, and right-to-left parsing). There are two particular factors that regulate compound stress, (a) their morphological structure (i.e., whether a compound constituent is a stem or a word) and (b) whether a compound consists of one or two distinct "stress fields". This is exemplified in (3).

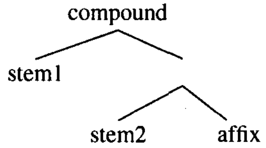
(3) a. Stem–word compounds b. Stem–stem compounds (single stress field)

[2]Abbreviations used in this article:

ANOVA	analysis of variance	NEUT	neuter
APU	antepenultimate	NN	noun–noun
CM	cross-modal	NSC	without stress change
CMPM	compound marker	NW	non-word
CONT	control	PU	penultimate
CV	consonant vowel	PrWd	phonological word
EXP	experimental	RF	relative frequency
FEM	feminine	RT	reaction time
L	lemma	SC	with stress change
L2	second language	STDEV	standard deviation
LD	lexical decision	U	ultimate
MASC	masculine	W	word

[3]The language also exhibits phrase-like compounds such as *zóni asfalías* 'safety belt'. Ralli (2007) interprets these formations as "loose multi-word compounds" that are formed in the morphological module of grammar and are accessed by certain syntactic mechanisms. For example, unlike our stimuli, *zoni asfalías* exhibits compound internal inflection. As phrase-like compounds are characterized by distinct morphological (compound internal inflection) and phonological (two main stress positions) properties, they fall beyond the scope of this study.

c. Stem–stem compounds

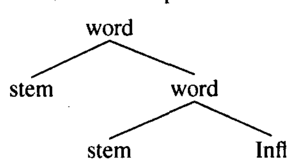


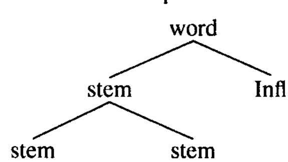
(Malikouti-Drachman and Drachman 1989:138)

The tree diagrams in (3) mostly reflect phonological and not morphological structure. The tree structure in (3a) corresponds to the compound in (1). For Malikouti-Drachman and Drachman (1989), compounding with a word as a second constituent results in the preservation of the already assigned word stress and the erasure of any secondary stress borne by the first constituent. The example in (2) is analyzed under the structure in (3b). The two morphological constituents [gaz] and [furn] form one stress field ([gazofurn]os).[4] As the last syllable is extrametrical, main stress will be assigned on the antepenultimate syllable of the word. Finally, the tree structure in (3c) corresponds to compounds that, although belonging to a stem–stem category, have a different stress pattern because they comprise two stress fields. This category mostly includes exocentric compounds or those ending in *-i* (e.g., *kondomális* 'red hair man', *monaxopéði* 'single child'). In these formations, the second stem (stem 2), bearing the inflectional affix, creates a distinct stress field [[*péð*]*i*] that determines the overall stress of the compound.

For Nespor and Ralli (1994, 1996) and Ralli (2007), the stress patterns of compounds and their underlying morphological structures are intrinsically related. They argue that both stems and words enter compound formations and they propose two major types of compound structures.

(4) a. Stem–word compound b. Stem–stem compound





Compounds like (1) belong to the stem–word category while ones like (2) belong to the stem–stem category. Stem–word compounds preserve the stress properties of the head word (as well as its inflectional category), as the word is considered to be a "complete stress unit and its stress cannot be erased according to [...] a structure preservation principle" (Ralli 2007:140). On the other hand, in a stem–stem

[4]It is unclear how the *-o-* is treated under this analysis. Ralli (2007) considers *-o-* as a compound marker. She argues that the presence of a CMPM is related to whether the language has "paradigmatic inflection" (p. 39) and that its form is determined by the history of the language. This *-o-* originated from a thematic vowel of ancient Greek but lost its inflectional properties and now functions only as a compound marker. It is usually not represented in word structure trees. For a detailed account why the *-o-* cannot be treated as an inflection, see Ralli (2007).

https://doi.org/10.1017/S0008413100000529 Published online by Cambridge University Press

compound configuration, stress has not been assigned yet, thus these formations are subject to a compound stress rule that assigns stress on the antepenultimate syllable.

The morphological distinction between stem–stem and stem–word compounds is crucial for this study, as it is intrinsically related to the distinction made between compounds in (1) and (2). In general, compounds like *jiðovoskós* in (1) are assigned the morphological structure of (4a) while *gazófurnos* in (2) is assigned that of (4b).[5] However, it may not be the case that all NSC compounds belong to the stem–word category. Such are the instances of compounds where the second constituent word is already stressed on the antepenultimate syllable, like in the case of *ksilopásalos* 'wooden peg'. Given that the head word *pásalos* 'peg' has antepenultimate stress, in theory there can be two structures associated with this word, one that is compatible with (4a) (i.e., [ksil-o-[pasal[os]]]) and one that is compatible with (4b) (i.e., [[ksil-o-pasal] os]). Ralli (2007) assumes that *ksilopásalos* has a stem–word structure, opting for an analysis with a greater generalization strength (p. 141)

For Ralli (2007), the different stress properties of compounds such as the ones in (1) and (2) are indicators of the underlying morphological structures proposed in (4). She points out that stem–stem compounds are prone to morphological change, especially when involving gender or inflectional class, and that these morphological features may also act as indicators of underlying structure.

(5) mer- -o- nixta- → merónixt(o) (cf. *níxta*-(∅))
'day'$_{\text{-FEM}}$ -CMPM- 'night'$_{\text{-FEM}}$ 'day and night'$_{\text{-NEUT}}$

(6) karavi- -o- pani- → karavópan(o) (cf. *paní*-(∅))
'ship'$_{\text{-NEUT}}$ -CMPM- 'sail'$_{\text{-NEUT}}$ 'canvas'$_{\text{-NEUT}}$

In the examples in (5), *merónixto* is neuter while its morphological head (*nixta*-) is feminine.[6] The gender change is also accompanied by a change in inflectional class, as indicated by the different inflectional suffixes in the parentheses. Likewise, for *karavópano* in (6), there is a change in inflectional class; however, both the compound and its head have the same gender value (neuter).

It is worth pointing out that the majority of SC noun–noun compounds which do not undergo gender or inflectional class change have a second constituent that forms a disyllabic word (cf. *fúrnos* in (2), *níxta* in (5), *paní* in (6)). There are SC noun–noun compounds which include larger (in terms of syllable number) second constituents.

[5]By design, our experimental stimuli are of the two types presented in (1)–(2), with (1) corresponding to the structures in (3a) and (4a) and (2) to those in (3b) and (4b). The analyses of Malikouti-Drachman and Drachman (1989) and Nespor and Ralli (1994, 1996) differ in the classification of certain exocentric and endocentric compounds, which, however, are not part of our investigation.

[6]Following Ralli (2000), we assume that the Greek nominal inflectional system consists of eight inflectional classes, which are characterized by the allomorphic variation of the base and the presence of overt and null inflectional markers. In the examples in (5) and (6), the null symbol (∅) indicates a phonologically empty inflectional affix. As there are no inflectional markings for gender in the language, it has been argued that gender values are intrinsic morphological features that are part of the lexical entry of the stem (Ralli 2002:136).

However, these compounds usually incur gender and inflectional class change (7), while only a few do not follow this pattern (8).

(7) ðɟavol- -o- ɟineka- → ðɟavoloɟínek(o) (cf. *ɟinéka*-(∅))
'devil' -CMPM- 'woman'$_{\text{-FEM}}$ 'hellcat'$_{\text{-NEUT}}$

(8) nark- -o- peði- → narkopéði(o) (cf. *peðí*-(∅))
'mine' -CMPM- 'field'$_{\text{-NEUT}}$ 'mine field'$_{\text{-NEUT}}$

As morphological change does not always occur with stem–stem compounds, it is the stress pattern of the word that is considered the determining factor. That is why, especially in cases where there is variation, the stress properties of the construction are used to determine its classification as a stem–stem or stem–word compound. For example, *ðɟavoloɟíneko* in (7) has a variant *ðɟavoloɟinéka*, which does not exhibit gender or inflectional class change. However, as the stress falls on the penultimate syllable (as in the word *ɟinéka*), this compound is analyzed as stem–word. Therefore, for Ralli (2000), it is mainly the stress properties of these constructions that reveal their underlying morphological structure and, in a way, it seems that in her account, it is phonology that drives morphology.

We believe that compounding in Greek offers a unique opportunity to study the role of stress change not only because of compound stress features but also because of the properties of stress assignment in the language. More specifically, stress in Greek has the following characteristics (Malikouti-Drachman and Drachman 1989, Revithiadou 1999, Petrounias 2002). It is dynamic, thus stressed vowels are pronounced louder and are slightly lengthened. Furthermore, stress can often act as a contrastive feature (e.g., *mílo* 'apple' ~ *miló* 'I speak', *ɟérno* 'I lean' ~ *ɟernó* 'I grow old'). Finally, it can variably appear in any of the three last syllables of a word (antepenultimate, penultimate, and ultimate).

While researchers agree that stress is lexically marked in the language, there is no consensus in the literature as to the status of particular morphemes and the nature of that marking. For Malikouti-Drachman (1989) and Ralli (2007), specific morphological classes are associated with particular stress patterns while for Revithiadou (1999), within the phonological framework of Optimality Theory (Prince and Smolensky 2004), roots and affixes are associated with a lexical accent. In this view, word stress is the result of a complex interaction between the properties of that lexical accent and the fixed ranking of hierarchically ranked grammatical constraints. Under the assumption that many morphemes are marked with stress information in the lexicon, it is possible that speakers use stress cues during word recognition and production.

2. STRESS AND LANGUAGE PROCESSING

With respect to compounding, we believe that in order to explore how stress is processed in a language, we have to address the following three parameters: (a) whether stress properties are part of the mental representation of words, (b) whether speakers rely on stress cues during language processing, and (c) at what level of language processing stress is computed.

With respect to the first parameter, stress properties have been generally argued to be a part of the mental representation of words, as stress position is generally unaffected by slips of the tongue (Fromkin 1971) and stressed syllables are more salient than unstressed ones (Cutler and Foss 1977, Browman 1978). For Fromkin (1971), speech errors and slips of the tongue are not random and unconstrained but reflect phonological underlying representations. Since speakers seem to respect the stress properties of words, Fromkin suggests that word stress is "stored as part of the articulatory specifications" of the word (1971:43), further noting that "words (or perhaps formatives) are stored in a more abstract form than by their actual articulatory specifications" (p. 43). Brown and McNeil (1966) and Browman (1978) focus on tip of the tongue phenomena, where stress is one of the cues used by speakers to help recall words. Likewise, Nakatami and Schaffer (1978) suggest that speech stress patterns act as cues in word perception. Thus, one would expect that the stress properties of Greek compounds are also part of their mental representations.

However, stress manifests itself in a non-uniform pattern across languages, both in its physical manifestations (i.e., dynamic vs. pitch accent) and in its grammatical realization (i.e., languages with fixed stress vs. languages with variable stress assignment within words). We therefore hypothesize that stress effects are displayed differentially in word processing. This hypothesis appears to be confirmed in a number of studies. For example, while speakers of English (Cutler 1986) and Japanese (Sekiguchi 2006) do not seem to rely on stress cues during word processing, in Dutch (Cutler and van Donselaar 2001) and Spanish (Soto-Faraco et al. 2001), language users make use of suprasegmental cues. In fact, Lukyanchenko et al. (2012), from a second language acquisition perspective, also point out that speakers often use the stress processing strategies of their own language in an L2 environment, where strategies are not available to non-native speakers. However, in a study of Cooper et al. (2002), a more complex picture is revealed, as it was found that English speakers are not totally insensitive to stress cues: they make some use of these cues but rely mostly on other prosodic cues that are more readily available to them. We expect that in a language like Greek, where stress is lexically specified, unpredictable in many instances, and even contrastive, speakers do rely on and make use of stress cues during processing. This should be especially true for the two main categories of compounds under investigation that exhibit distinct stress patterns.

With the respect to the last parameter, the literature provides little consensus on the very locus of stress processing. While it is generally accepted that, at the post-lexical level, all phonological features must be specified and linked with specific phonetic representations (i.e., articulatory information) and prosodic specification (e.g., syllable structure, stress, etc.), it is not clear whether these features are present at earlier levels. For example, Béland et al. (1990), in a study of phonemic paraphasias in French, argue that syllable structure and other prosodic information (including stress) are not a part of the underlying representation of words, but are realized at the post-lexical level by a "syllabification algorithm". On the other hand, Kohn and Smith (1994) assume that both syllabic and prosodic information, and the link that connects them, are specified in the lexical representation of words.

Between these two opposite views, there are some researchers who have argued that while some aspects of syllable structure and prosody (i.e., CV syllables, position of stress) are specified at the lexical level, they are not linked to specific segments or features. For example, Butterworth (1992:263) proposes that the phonological lexical representation of a word contains all the "sufficient" information (e.g., syllable and stress patterns, segmental content of the syllables) to uniquely specify that word, which, crucially, is indexed separately at the lexical level. Successful articulation of the word requires prior combination of these properties and a "translation" to the actual phonetic representation appropriate for the speech context occurring at a later level. Thus, it is possible that tasks that tap into different levels of representation may reveal different types of information and performance with respect to stress.

3. THE ROLE OF STRESS CHANGE IN GREEK COMPOUND PROCESSING

In an attempt to investigate possible effects of stress and stress change in word processing, Tsiamas et al. (submitted) studied the effects of stress change on the recognition and production of Greek compounds. Under a hybrid model of mental representation according to which compounds may be listed in the mental lexicon as whole units and as decomposed forms (Libben 2006:9) together with all their properties, including stress, Tsiamas et al. suggest that the structures in (4) allow one to make predictions about the manner in which the two major categories of compounds are processed. They propose that stem–word compounds that do not undergo stress change (NSC) have a stress processing advantage over stem–stem compounds that are invariably stressed on the antepenultimate syllable. In the mental lexicon, the representations of compounds and their constituents are connected. For SC compounds there is a stress mismatch between the compound and its head, which could result in an extra processing cost, as speakers will have to override the conflicting stress properties of the head.[7]

On the other hand, given the morphological (gender or inflectional class change) and semantic (semantic drift) properties generally observed for SC compounds, Tsiamas et al. (submitted) suggest that these formations are structurally "tighter" than stem–word ones. In other words, Tsiamas et al. suggest that stress change (SC) compounds have a structural (lexical) advantage over NSC compounds because, as concatenation happens earlier in the structure, their semantic and morphological features, sometimes distinct from those of their constituents, are indicative of a new, separate word. In fact, we have already seen that stem–stem compounds are more prone to instances of morphological change in gender and inflectional class (5) and often show a greater degree of semantic drift (6) than stem–word ones.

Tsiamas et al. (submitted) hypothesize that the interaction between the lexical and stress properties of NSC and SC compounds is reflected in the speed and

[7]Following Tsiamas et al. (submitted) and under the analysis of Ralli (2007), we consider that all SC compounds belong to the stem–stem morphological category while all NSC compounds belong to the stem–word category. Consequently, these terms are used interchangeably in the present study.

efficiency of online performance, yielding faster reaction times for NSC compounds, when there is full activation of their stress properties. On the other hand, they hypothesize that the same formations are activated more slowly when their lexical features need to be accessed, as a direct result of their underlying structure.

These hypotheses are tested in two on-line psycholinguistic tasks, a cross-modal (audio-visual) lexical decision (LD) task focusing on recognition and a naming (reading) task focusing on production. The two tasks reveal a seemingly puzzling picture. In the LD task, there is no statistically significant difference between the recognition latencies of NSC and SC compounds. However, in the naming task, NSC compounds exhibit greater facilitation than SC compounds. This trend is attributed to the lack of stress change for NSC and the extra processing cost that stress change may trigger for SC compounds.

One of the main questions that arose in that study was whether the different results obtained for LD and naming were task-related (i.e., visual vs. auditory presentation of the stimuli), modality related (i.e., recognition vs. production), or whether the effects were ultimately related to the underlying structure of SC and NSC compounds and the lexical and stress properties they involve. With respect to the first possibility, the lack of any role of orthography in compound recognition demonstrated by Protopapas et al. (2007) casts doubt on such an interpretation. After all, if speakers did rely on visual cues such as orthography for stress processing (Greek polysyllables are marked orthographically for stress), their effects should be present in both tasks, as the target was always presented visually, but this was not the case.

With respect to the possibility that such effects were indicative of a "recognition vs. production" effect, Tsiamas et al. (submitted) explicitly point out the different activation patterns involved and the different demands that these tasks make on the computational system. In particular, following Lorch et al. (1986), Tsiamas et al. acknowledge the operation of these patterns at different levels of representation (i.e., post-lexical for LD/recognition vs. prelexical for naming/production). They suggest that what drives the difference in performance across tasks may be the underlying structural properties of these constructions and the way they interact with the tasks involved. In particular, it is proposed that the lexical advantage of SC compounds is enhanced by the mechanisms of activation involved in LD, where the task is to recognize a word item. SC compounds trigger less competition during activation, because, in principle, they have fewer matched competitors compared to the NSC ones, where we also have stress matching between second constituent and compound word. On the other hand, in naming, where the task is to read a word aloud, the stress patterns of the compound take precedence over activation, resulting in facilitation for NSC compounds, because they do not involve the extra computational cost of stress change incurred online during reading.

In the present study, we use an auditory LD task within a priming paradigm to (a) further evaluate the role of stress change in compound processing, and (b) address the question of whether the results reported in the Tsiamas et al. study could be interpreted as a task effect. In particular, we hypothesize that NSC compounds will be processed differently compared to SC compounds because of their distinct phonological and morphological properties. Furthermore, given the model of compound processing adopted (Libben 2006) that proposes "maximization of opportunity", we expect that an auditory presentation of the target compound should fully activate its stress features, yielding similar results to those obtained for the naming task in the previous study. Thus, we predict facilitation for NSC compounds due to stress preservation, while the implementation of the compound stress rule may come at a computational cost in the processing of SC compounds, as stress has to be recomputed.

3.1 Methodology

3.1.1 Participants

We tested 29 speakers of standard Modern Greek (17 men, 12 women), with an age range of 24–73 years and with an average of 15 years of education. None of the participants reported any hearing problems.

3.1.2 Stimuli

The stimuli were selected from the same pool as the one used in the Tsiamas et al. study. Greek nouns, although they do not exhibit an overt gender marker, obligatorily carry one of the three gender values available in the language (masculine, feminine, or neuter). Neuter SC compounds were excluded from our stimuli because the vast majority of neuter SC compounds exhibit changes in gender and/or morphological class, making them unsuitable candidates for a study that focuses solely on the effects of stress change. As no significant gender effect was reported in the study of Tsiamas et al., we decided not to pursue the role of gender in the present study in order to achieve greater uniformity across compound categories.

We selected sets of noun–noun compounds because they are referentially more neutral as compared to other types of compounds. Contrary to verbs, only a subset of nominals, those that express complex events, have argument structure (Grimshaw 1990) and, unlike verbs, nouns cannot assign structural case (Chomsky 1986). Moreover, Manouilidou (2004) found that thematic information and argument structure can alter priming. Since adjectives and verbs carry both, using either of these grammatical categories as compound constituents could obscure any effects of stress. All compounds used were endocentric and transparent with a subordinate relation between constituents. Because derivational affixes have been found to interact with priming effects (Tsapkini et al. 1999) our experimental stimuli did not contain any.

The experimental stimuli consisted of 20 compounds with stress change and 20 without (10 $\times$ 2 for each gender value, masculine and feminine), with their second constituent as prime (40 pairs) and with an unrelated noun as control (40 pairs). The full set of stimuli is presented in Appendix A. The task also comprised a set of filler (distractor) item pairs ($n = 45$) and a set of non-word pairs ($n = 10$), for a total of 225 pairs. The set of fillers is presented in Appendix B.

(9) *Compounds with stress change*:

a. pónos → stomaxóponos (*stomaxi-* 'stomach', *pon-* 'pain/ache')
'pain'$_{\text{-MASC}}$ 'belly ache'

https://doi.org/10.1017/S0008413100000529 Published online by Cambridge University Press

Control: pólos → stomaxóponos
'pole'$_{\text{-MASC}}$

b. súpa → kremiðósupa (*kremiði-* 'onion', *supa-* 'soup')
'soup'$_{\text{-FEM}}$ 'onion soup'
Control: súvla → kremiðósupa
'spit'$_{\text{-FEM}}$

(10) *Compounds without stress change*:

a. voskós → ɣiðovoskós (*ɣiða-* 'goat', *voskós* 'shepherd')
'shepherd'$_{\text{-MASC}}$ 'goat herder'
Control: vomós → ɣ iðovoskós
'altar'$_{\text{-MASC}}$

b. saláta → domatosaláta (*domata-* 'tomato', *saláta* 'salad')
'salad'$_{\text{-FEM}}$ 'tomato salad'
Control: sarðéla → domatosaláta
'sardine'$_{\text{-FEM}}$

Experimental primes and their controls were matched for length (number of syllables), phonemic onset, stress position, lemma and word frequency, and gender (masculine or feminine). As discussed earlier in the introduction, the majority of SC noun–noun compounds, the second constituent of which does not undergo gender or inflectional class change, has a morphological head that forms a disyllabic word. As a result, it was not possible to match word length across categories, that is, SC compounds are slightly shorter with respect to syllable number (4.7 vs. 5.1) than the NSC ones. However, they are virtually equal in phonemic length (11 vs. 11.45).

Our stimuli for the NSC compounds also include four masculine tokens, where the second constituent word is stressed on the antepenultimate syllable. As all of these stimuli are semantically transparent and do not undergo any change in morphological category or gender, we consider them as NSC compounds. In fact, none of the compound stimuli used exhibit variation in stress and thus they can only be interpreted as either NSC or SC compounds.

Word (actual word form in the nominative case) and lemma (the whole inflectional paradigm of the word in all cases and numbers) frequencies were obtained from the Institute of Language and Speech processing corpus (Protopapas et al. 2012) containing over 47,000,000 words, from written samples only. The filler items used to reduce the density of the experimental items comprised a singleton word (used as "prime") and an adjectival or nominal derivative (used as "target"). For the purposes of this study, filler items were divided into three categories, depending on the stress position of the derivative. There were thus 15 pairs of filler items for each stress position: antepenultimate (derivatives in *-inos*), penultimate (derivatives in *-éɲos*), and ultimate (derivatives in *-dzís*), as exemplified in (11).

(11) a. atsáli → atsálinos
'steel' '(made/of) steel'

b. metáksi → metakséɲos
'silk' '(made) of silk'

https://doi.org/10.1017/S0008413100000529 Published online by Cambridge University Press

c. vjolí → vjolidzís
'violin' 'violinist'

Non-words (NW) were constructed (a) from existing words by changing the initial phoneme(s) of the first or second syllable or (b) by creating ungrammatical derivatives, as shown in (12).

(12) a. korífoma → *torífoma
'peak'

b. karékla -tis → *kareklatís
'chair' AGENTIVE (i.e., *'chairer' in English)

3.1.3 Experimental task

The auditory LD task was specifically selected to investigate the interaction of modality with the activation of stress cues in compound recognition. We had hypothesized that the results obtained in the cross-modal (CM) LD task of our earlier study (Tsiamas et al. submitted) could be the direct outcome of the interaction of the lexical properties of these formations and mode of activation, as a visual presentation of stimuli may not fully activate their phonological/prosodic features. By contrast, an auditory LD task should more readily tap into the prosodic cues used by the speakers during compound processing. Our stimuli ($n = 225$) were divided into four blocks. Although the number of filler pairs varied across blocks, the experimental stimuli were equally distributed, as exemplified in Table 1.

Table 1: Stimuli distribution

Block	NW	SC	NSC	Fillers	Total
1	25	10	10	11	56
2	25	10	10	12	57
3	25	10	10	12	57
4	25	10	10	10	55

The dependent variables for the task were Latency (reaction time, RT, in ms) and Error (failure to correctly identify words). The independent variables were the categories of compounds tested (NSC and SC compounds).

3.1.4 Procedure

The task was run on a Macintosh G4, using Psyscope X (Cohen et al. 1993). Instructions were provided both orally by the administrator and on the computer screen prior to the task. For the task itself, participants were auditorily presented with the prime starting at 500 ms after the beginning of each trial, consisting of the second constituent word of a compound (for example, *pónos* 'pain' in (9a) for SC and *voskós* 'shepherd' in (10a) for NSC) or a control word. The target (the whole compound) followed at 200 ms. As we were interested in capturing effects of stress change, which, for the majority of the data, occurs before the end of the word (there are only five tokens with penultimate stress), participants could provide an answer (by pressing

https://doi.org/10.1017/S0008413100000529 Published online by Cambridge University Press

the NAI ('yes') or OXI ('no') button on the computer keyboard) at any point after the onset of the presentation of the target. After a decision was made, the next trial ensued. The screen remained blank at all times. Eight training trials preceded the experimental trials.

3.1.5 Data analysis

First, the experimental items were separated from the non-words and fillers. Prior to any data analysis, erroneous responses and outliers (0.8%) were removed (RT > 3000 ms) from the data set. Means and standard deviations were next calculated for the group of words and data points above and below twice the standard deviation from the average ($\pm 1.96\%$) were removed as per standard procedure. Within the sets of words, the different subgroups of stimuli were separated into NSC compounds, SC compounds, experimental primes (EXP), and control primes (CONT). To ensure that our data were not skewed by the presence of abnormally low RTs or the removal of useful points, we ran normality tests for each subcategory pair (NSC $\sim$ EXP, NSC $\sim$ CONT, SC $\sim$ EXP, SC $\sim$ CONT) to verify their distribution. To examine whether stress change plays a key role to the processing of NSC and SC compounds and to what extent this is related to the underlying structure of these constructions, we ran a repeated measure mixed model ANOVA with one between-item and one within-item factor. As our stimuli were matched for frequency and word length, the model was further adjusted for the following covariates: lemma frequency and phonemic length.

3.2 Results and discussion

We report results for 21 participants. Eight of them had to be excluded from the study because of an overall high number of errors and outliers (i.e., RTs over and below twice the standard deviation (> 10%). Four of the participants who were excluded exhibited an unusually high error rate in non-words (> 29%). A more thorough investigation revealed that the performance of these four participants is not related to age (two participants were over 60 years old, two were below 40) or gender (two males, two females) and it is not driven by either of the two categories of non-word used. In particular, errors were made in 37.5% of non-words for the category reported in (12a) and 36.4% for the category reported in (12b). For the remaining 21 participants, overall error rates were at 5.6%. Finally, we do not report any unusually low RTs (> 600 ms) except from one instance of 11 ms in a filler item.

The normality tests we ran showed that our data are normally distributed. Overall, skewness and kurtosis were close to zero and the Shapiro-Wilk test did not reveal any statistical significance in any of the subgroups. The data distribution and descriptive statistics are presented in Table 2.

At a first step, we determined whether there is an effect of the main condition, that is, whether participants perform faster in the experimental stimuli compared to the controls. Planned comparisons across NSC and SC compounds revealed a main effect of condition ($p < .001$), as shown in Table 3.

Table 2: Data distribution and descriptive statistics

Group	Skewness	Kurtosis	Mean	Median	Range	SD	Shapiro-Wilk (Pr < W)
SC ~ CONT	0.55	0.39	1378.7	1349.6	454.8	131.4	0.3105
SC ~ EXP	0.47	0.35	1242.7	1233.7	320.6	91.9	0.3496
NSC ~ CONT	0.63	0.18	1427	1423.6	490.9	144.2	0.2144
NSC ~ EXP	0.46	0.3	1279.7	1258.4	388.4	109.4	0.4007

Table 3: Auditory LD Task:
Reaction times (in ms) for NSC and SC compounds

	NSC	SC
Experimental primes	1259.65	1242.72
Control primes	1427.01	1378.73
Mean Difference	167.36	136.01

Next, we addressed our main research question, namely whether stress change is reflected in performance during auditory compound recognition. As shown in Table 3, NSC compounds exhibited higher mean differences (i.e., they were recognized faster compared to controls) than the SC ones; however, the difference in priming between NSC and SC compounds did not reach statistical significance [$F(1,36) = 0.05, p > .10$].

Results of the auditory LD task parallel those obtained from the naming task of Tsiamas et al. In both cases, greater mean differences are reported for the NSC compounds, possibly indicating the extra cost involved in the processing of SC compounds because of stress change. Auditory LD tasks are more prone to tap into the phonological cues speakers use during language processing. In fact, they have often revealed the role of phonological categories, as evident in effects of syllable priming (Corina 1992), phonological priming (Radeau et al. 1995), inhibitory phonetic and phonological priming (Goldinger et al. 1992), and expected vs. unexpected stress patterns (Slowiaczek 1990). However, such effects are not always found. For example, although Slowiaczek and Pisoni (1986) reported frequency effects in auditory tasks, they did not find any facilitation of the target as the phonetic similarity between the target and the prime is increased. Similarly, Marslen-Wilson et al. (1997), in an auditory task, found no effects of phonological (dis)similarity, replicating the results obtained from a previously run cross-modal (CM) task (Marslen-Wilson et al. 1994). It is possible that in these cases failure to uncover the effect of phonological cues may not be task specific but language-determined. As the results of the naming task in Tsiamas et al. uncover the utilization of stress cues by Greek speakers during compound processing, it is plausible that the auditory LD task also taps into the phonological properties of NSC and SC compounds, giving an advantage to the former because of the lack of stress change.

However, the present study did not replicate the result in Tsiamas et al., as there was no interaction effect between stress change and main condition. The lack off an effect of stress change in both the CM and auditory LD tasks could indicate that there is also some facilitation of SC compounds. One possible explanation for such facilitation could be that SC compounds are not as decomposable as NSC ones, thus there is no processing cost because of stress change. It has been argued in the literature that high frequency items are not as decomposable as low frequency ones (Bybee 1995). If SC compounds are more frequent than NSC ones, then this could give them an advantage for whole-word parsing, under a dual-route model of lexical processing (Schreuder and Baayen 1995, Baayen and Schreuder 1999). Our repeated measures model adjusted for the frequency covariant did not reveal any effect of word (W) frequency ([$F(1,36) = 0.40, p > .10$) or lemma (L) frequency ([$F(1,36) = 0.13$, $p > .10$), possibly a direct consequence of the low frequency values for both categories of compounds (Table 4).[8] An examination of relative frequency (RF) also did not confirm the existence of direct access in the case of SC compounds.[9] Furthermore, an examination of relative frequency did not shed light on the issue of compositionality of SC compounds.

Table 4: NSC and SC compound frequency measures

	Freq (L) ‰		Freq (W) ‰		$RF_{(log10)}$
	$n = 40$	$n = 21^a$	$n = 40$	$n = 21^a$	$n = 21^a$
NSC	0.00015	0.00012	0.00030	0.00024	1.3
SC	0.00017	0.00004	0.00030	0.00006	1.7

[a] 10 NSC, 11 SC

Taken together, our examination of word, lemma, and relative frequencies does not support a direct whole-word access route, and thus, facilitation for SC compounds. Therefore, it appears that frequency cannot be invoked to explain the lack of stress effects in the CM and auditory LD tasks.

Could SC compounds be facilitated because of their stress and/or structural properties? It is possible that their antepenultimate stress may act as a recognition cue. If this is the case, we expect that our subjects would be faster in NSC compounds with antepenultimate stress. This is corroborated by the data. As shown in Table 5, there are four masculine NSCs with antepenultimate stress that on average are recognized faster than both the remaining six of the masculine NSC with penultimate/ultimate stress and the NSC compounds overall (masculine and feminine; all feminine NSC compounds have penultimate stress).

[8] Excluding the compounds not found in the corpus (10 NSC, 9 SC) yielded similar frequency values.

[9] Hay (2001) claims that relative, rather than word, frequency affects the decomposability of morphologically complex forms. She demonstrates that derived words are accessed directly when the frequency of the derived form is lower relative to that of the base. We thus explored RFs under the rationale that our transparent compounds are derived from their base word (the compound head). RFs in Table 4 clearly point away from non-decomposition for SCs. This is not surprising, since all our stimuli are of lower whole-word frequency than their bases.

Table 5: NSC and SC reaction times (in ms) per stress position and gender

	NSC (APU) MASC	NSC (PU/U) MASC	NSC MASC/FEM	NSC FEM	SC MASC/FEM
	$n = 4$	$n = 6$	$n = 16$	$n = 10$	$n = 20$
Reaction times	1269.52	1302.63	1283.03	1273.23	1242.72

It has been reported that Greek monolinguals (Tzakosta 2009) and L2 learners of Greek (Tzakosta 2011, Tzakosta and Mamadaki 2013) show an overwhelming preference for stem–stem compounds. To interpret speaker's performances, following Revithiadou (1995), Tzakosta (2011) argues that the cohesion of a Prosodic Word (PrWd) is directly related to its internal branching (i.e., more coherent PrWrds branch less). For Tzakosta (2011), SC compounds are more coherent than NSC ones because they branch less, as there is only one word level, while for NSC, the first constituent stem attaches to an already formed word (as in (4)).[10] Thus, although a compound word like *lemonoðasos* 'lemon tree forest' can receive either antepenultimate stress (e.g., *lemonóðasos*; stem–stem reading) or a penultimate stress (e.g., *lemonoðásos*; stem–word reading), speakers seem to prefer the first because it forms a more coherent PrWd.

Speaker preference for antepenultimate stress may not be restricted to compounding. Revithiadou (1999), under an Optimality Theory analysis of Greek stress, argues that antepenultimate stress is one of the default patterns in the language (other than penultimate in disyllabic words). This proposal departs from Nespor and Ralli's (1994, 1996) account of compounding in Greek, where the stress patterns of stem–stem (SC) compounds are attributed to the application of a compound stress rule. If Revithiadou's insight is correct (but cf. Protopapas et al. 2006 for a different approach), this can also explain the performance of participants on filler items, where the derivatives stressed on the antepenultimate were recognized faster than the ones stressed on the penultimate and ultimate (see Table 6). However, since each "stress group" of filler items constituted a single derivational group (i.e., antepenultimate stress ~ derivatives in *-inos*, penultimate stress ~ *-éɲos*, ultimate stress ~ *-dzís*), we cannot be certain this effect is driven only by stress. If there is a bias for default antepenultimate stress in the language, this further strengthens the lexical advantage of SC compounds and possibly accounts for the results obtained in the auditory LD task.

However, if there is some facilitation for SC compounds because of stress and/or structural properties, this does not seem to completely cancel out the impact of stress change. After all, NSC compounds with antepenultimate stress may be activated faster than the rest of the group yet still exhibit greater latencies compared to SC

[10]The analysis of Tzakosta (2011) departs somewhat from that in (4) in the details of the morphological structure. Tzakosta assumes the presence of a derivational suffix between the stem and the inflectional suffix. What is pertinent for our study is her proposal that speakers' preference for SC compounds is a direct result of their phonological structure (more coherent PrWds).

Table 6: Filler items reaction times (in ms)

	APU stress -inos	PU stress -éɲos	U stress -dzís
Reaction times	1173.12	1210.38	1221.77

compounds. In fact, even if we considered these compounds as SC, Table 3 would not be significantly altered (see Table 7).

Table 7: Revised reaction times (in ms) for NSC and SC compounds

	NSC	SC
	$n = 16$	$n = 24$
Experimental primes	1183.38	1205.81
Control primes	1406.05	1400.23
Mean difference	222.67	194.42

In principle, the higher RTs for NSC compounds could also be attributed to the fact that SC are slightly shorter than NSC ones with respect to the number of syllables (< 0.3) and phonemic length (< 0.5), something that could impact recognition latencies. However, this difference is minimal and a more thorough investigation revealed no significant effect of phonemic length [$F(1, 36) = 1.67, p > .10$]. Finally, Table 5 revealed a somewhat unexpected different performance between masculine and feminine compounds. This is also reported for SC compounds, where feminine compounds are recognized faster (1278.68 ms vs. 1206.76 ms). This is surprising because Tsiamas et al. did not report a main effect of gender. A more thorough investigation revealed similar results in our study, as we also do not report a significant interaction of gender with the main condition [$F(1, 37) = 0.62, p > .10$].

4. General discussion

In this study, we investigated the role of stress change in Greek compound processing by employing an auditory-auditory lexical decision task in an attempt to tap into phonological cues that may not be detectable in other modalities. We believe that in order to obtain a more comprehensive understanding of the experimental results obtained, we must take into consideration three fundamental factors, intrinsically intertwined during Greek compound stress processing. The first is stress itself, its nature and how it manifests itself in compounding. The second is compound structure (i.e., the manner in which morphological units interact with each other to form greater units) and the properties of these formations. Thirdly, such an analysis must examine the way in which specific task demands interact with stress features and with the structural properties of the categories of compounds under investigation.

With respect to stress, and focusing only on the issues pertinent to this study, there is a general consensus in the literature that what is physically manifested as dynamic stress in the language is "visible" only at the word level. This stems from the

https://doi.org/10.1017/S0008413100000529 Published online by Cambridge University Press

assumption that primary stress manifests itself in the domain of a phonological word (Nespor and Vogel 1986). Roots may have some lexically encoded "prominence" (i.e., the right edge of a root is aligned with a binary or a unary foot, Drachman and Malikouti-Drachman 1996:912–914; lexical accent, which can be assigned in or outside the domain of the root, is linked to a specific root, Revithiadou 1999); however, this does not constitute "stress" per se. For Nespor and Ralli (1994, 1996), the proposal that compound stems do not enter word formation with a previously assigned stress is crucial, as this guarantees that the compound stress rule is free to apply in a stem–stem configuration without violating the stress preservation principle.

These theoretical assumptions have consequences for the phonological structure of NSC and SC compounds and the manner in which they are realized psychologically. In particular, stem–stem compounds are argued to be phonologically more cohesive than stem–word ones. They branch less (Tzakosta 2011) and they form a single stress field (Malikouti-Drachman 1989), while stem–word compounds have a second constituent that has already been assigned stress, as it is a fully formed word (Nespor and Ralli 1994, 1996). All things being equal, we would expect the stress properties of SC compounds to provide a structural advantage, as they facilitate their recognition as compounds.

Alternatively, the antepenultimate stress of these constructions could be the manifestation of the language's default pattern, as the behaviour of NSC compounds and filler items with antepenultimate shows. In fact, our results could also be related to those obtained in a recent stress perception study by Revithiadou et al. (2013). This study investigated whether Greek speakers have specific preconceptions as to where words are or can be stressed. It comprised two experiments testing the perception of unstressed constructed disyllabic and trisyllabic non-words. Interestingly, speakers not only perceived stress where there was none but, crucially, exhibited a preference for specific stress patterns which were related to various inflectional endings. In particular, antepenultimate stress was preferred over penultimate and ultimate in trisyllabic words that end in *-os*. On the other hand, for words ending in *-a* and *-as*, there was a minor preference for penultimate stress over antepenultimate but with antepenultimate stress also preferred. For Revithiadou et al. (2013), these results are important because they indicate that a theoretical construct such as "default stress" is active in speakers' grammar. These results may also reflect, to some degree, frequency effects as there is a relation between the bias for stress position/inflectional ending pairs and their lexical frequency. In particular, antepenultimate nouns in *-o* are more frequent than penultimate and ultimate ones.

In our study, since we do not have any feminine stimuli with ultimate stress or any masculine stimuli with penultimate stress, we cannot directly examine this effect. For the SC compounds (which receive antepenultimate stress), it seems that feminine ones are recognized faster than the masculine, something that is not expected. Overall though, there is a preference for antepenultimate stress (SC compounds are recognized faster). If this occurs because antepenultimate stress is treated as default, it may level out any advantage (because of stress preservation) of the NSC compounds and account for the lack of significance in the interaction of stress with the main condition.

In addition, following Nespor and Ralli (1994, 1996) and Ralli (2007) and under the premise of Tzakosta (2011) that less branching is related to a more phonologically coherent structure, we would expect that SC (stem–stem) compounds are also morphologically more coherent than NSC (stem–word) ones. This indeed appears to be the case, as evidenced in the morphology of these categories. In a stem–stem configuration, a new compound stem is consistently formed which, as a novel item, does not always reflect the morphology of the head stem. This is the reason why only stem–stem compounds may undergo change of morphological categories such as gender or inflectional class. On the other hand, in stem–word compounds, the head of the structure is an already formed word. The properties of the new compound word are intrinsically related to the head word and cannot be altered.[11]

If stem–word compounds are morphologically more coherent with the head constituents than stem–stem ones, this may also have consequences for processing. In particular, we expect stem–word compounds to be more decomposable than their stem–stem counterparts, as, morphologically speaking, their second constituent is virtually identical to its corresponding independent word and, semantically speaking, the former are more transparent than the latter. In the literature, high frequency items have been associated with non-compositionality and semantic opacity (see Baayen 1994, Bybee 1995). Given that our compounds have overall very low frequencies, we should expect some level of decomposition to take place for both SC and NSC compounds. As our stimuli are all semantically transparent, if there is a driving force for decomposition of SC compounds, it has to be their morphological structure. This way, we may have an additional account for the greater RTs reported for NSC compared to SC; morphological structure provides the latter with a processing advantage that is reflected in smaller latencies.

If the phonological and morphological structures and the stress properties of NSC and SC compounds give a processing advantage to the latter, we need to address why this is not reflected in the experimental results obtained in Tsiamas et al. (submitted) and in this study. We would like to suggest that two additional parameters may be at work and should be taken into account: modality and task effects. With respect to modality, there seems to be a dichotomy between recognition-LD and production-naming tasks, because LD and naming tasks are not always sensitive to the same degree when it comes to language features (e.g., phonological structure, morphological transparency, etc.) and effects (e.g., frequency, neighborhood density, etc.). Lorch et al. (1986), focusing on inhibition in a series of LD tasks, argue that a LD task is more likely to tap into post-lexical processes while a naming task taps into an earlier processing stage. In addition, several researchers (Hudson and Bergman 1985, Besner and McCann 1987, Paap et al. 1987) have pointed out that frequency effects are stronger in lexical decision than in naming. However, as Grainger (1990) argues, the actual factor differentiating the two tasks is not

[11] In fact, as already noted, morphological structure has consequences also for the semantic properties of these constructions. Although all our compounds were specifically selected to be transparent, overall stem–stem compounds show a greater degree of semantic drift and opacity than stem–word ones, which may be the result of a more coherent structure.

frequency but neighborhood density, to which naming is not sensitive. Unfortunately, measures of neighborhood density in our study cannot give us further insight into the role of modality, as there is a only handful of data points (four NSC, four SC) where neighborhood density was reported in the corpus and, overall, it is very low for both categories of compounds.

If naming tasks tap into an earlier processing stage, this may account for the results obtained by Tsiamas et al. In this task, participants are asked to read aloud a visually presented target. The nature of the task calls for mapping of orthographic cues onto phonological and prosodic cues. NSC compounds, which are primed with a phonologically (and morphologically) identical prime, will have an advantage during reading, as part of the necessary mapping has already been activated by the prime. However, the production of SC compounds may be subject to opposing forces at work. Thus, one would expect that the phonologically distinct prime slows down the production of the target, as participants are forced to implement online the time-costly process of stress shift to the antepenultimate syllable. In contrast, SC compounds, because of their morphological and phonological structure, may have a stress advantage as discussed above, because their antepenultimate stress acts as a compound recognition strategy, thus facilitates their production. The complex interaction between the task demands (primed reading), the feature activated (stress), and the underlying compound structure results in the seemingly contradictory findings obtained.

Furthermore, the results obtained in the two LD tasks may also be subject to task effects and, in particular, to the way stimuli are presented. In a study by Tsapkini et al. (1999) probing phonological change during derivation, it was shown that forms subject to phonological change were always recognized significantly more slowly than those without phonological alteration when the prime was auditorily presented. It is therefore plausible that the auditory presentation of the target in the auditory LD task employed in the present study also taps into the phonological similarity of the prime and NSC compounds, giving them an edge over the SC ones, an option not available for the CM task in Tsiamas et al.

For the auditory LD task, we would like to suggest that since both the prime and the target are auditorily presented, participants are able to fully activate the stress properties of the target and fully match it with an identical prime, as the task triggers a stress edge for NSC compounds. However, auditory LD tasks are far from "blind" to non-phonological features. Among other processes, they have revealed the role of semantic (Slowiaczek 1994) and morphological (Emmorey 1989) priming as well as of word frequency (Slowiaczek and Pisoni 1986). Thus, in the present study, the auditory LD task also taps into the structural advantage of SC compounds, something that could explain the lack of significant interaction between stress change and the main condition. While we cannot be certain of the degree of activation of a NSC target by an auditorily presented prime in both LD tasks, we would like to suggest that it is this interaction between task effects, the properties of the linguistic feature(s), and the structural representations involved that may account for the experimental results reported in this study.

One of the main questions of this study was whether stress properties of compounds are activated during processing. In a number of studies, stress patterns seem to be accessed during derivation. Tsapkini et al. (1999) show that English speakers are sensitive to the phonological change triggered by stress-shifting affixes. In a study of the effects of lexical frequency on children's production of primary stress in English, Jarmulowicz et al. (2006) show that children must have access to and make use of stress representations. This is true not only for derivational affixes but also for stems, as children need this information to combine stem and affix and create a properly stressed word; because lexical access involves both decompositional and whole-word processing routes, they need and make use of specific stress information that, consequently, has to be mentally represented. In our study, the lack of statistical significance of the effects of stress change in compound processing does not allow us to draw any definitive conclusions. Nevertheless, we hold that our results do reflect the effects of stress activation during compound processing, pointing to the mental representation of this linguistic feature.

We would like to suggest that stress features are underlyingly present and active during compound processing and that the lack of statistical significance is the result of the different ways in which stress is activated for each of the subgroups. For NSC compounds, stress (in terms of absence of stress change) facilitates their recognition with respect to unrelated primes, hence the higher priming. For SC compounds, stress, in particular, antepenultimate stress, facilitates their overall recognition perhaps because it is an instance of default stress in the language or because it acts as a compound recognition cue. In both cases, speakers use the specific aspects of stress cues that help them process a compound word efficiently. In the case of NSC compounds, where prime and compound feature identical stress patterns, they opt for decomposed access; in the case of SC compounds, which have a more coherent phonological structure (Tzakosta 2011), a whole-word access is preferred.

This performance is compatible with the predictions made by Libben's (2006) model of compound processing. One of the main characteristics of this model is that it argues for a dual representation of compounds, as both whole units and as decomposed. This gives it power to capture constituent activation effects in both opaque (Libben et al. 1997) and novel (Libben et al. 1999) compounds. In principle, Libben (2006) argues for a "maximization of opportunity" (p. 6) (i.e., "all representations that can be activated are activated", p. 12). Greek compounds have some distinct stress patterns and morphological and semantic properties that are intrinsically related to their underlying structure and that native speakers are aware of. However, what "is or can be activated" depends greatly on the nature of the feature(s) involved, on modality, and on the experimental task and the particular demands it makes on the processing system.

To conclude, using a theoretically informed framework to probe the processing of compound stress in Greek, this study showed that linguistic constructs come into play in language performance and offers support for their psychological reality. However, although linguistic theory postulates distinct types of grammatical features and operations in word formation, their specific roles during performance cannot always be easily disentangled. In the case of Greek compounds, the morphological and phonological analyses of compounding adopted in this study underscore the intrinsic relation and interaction between the morphological structure and the stress properties of these constructions.

REFERENCES

Baayen, Harald. 1994. Productivity in language production. *Language and Cognitive Processes* 9:447–469.

Baayen, Harald and Rob Schreuder. 1999. War and peace: Morphemes and full forms in a noninteractive activation parallel dual-route model. *Brain and Language* 68:27–32.

Besner, Derek and Robert S. McCann. 1987. Word frequency and pattern distortion in visual word identification and production: An examination of four classes of models. In *Attention and performance XII: The psychology of reading*, ed. Max Coltheart, 201–219. Hillsdale, NJ: Lawrence Erlbaum.

Béland, Renée, David Caplan, and Jean-Luc Nespoulous. 1990. The role of abstract phonological representations in word production: Evidence from phonemic paraphasias. *Journal of Neurolinguistics* 5:125–164.

Browman, Catherine P. 1978. Tip of the tongue and slip of the ear: Implications for language processing. *UCLA Working Papers in Phonetics* 42:1–149.

Brown, Roger and David McNeil. 1966. The "tip of the tongue" phenomenon. *Journal of Verbal Learning and Verbal Behavior* 5:325–337.

Butterworth, Brian. 1992. Disorders of phonological encoding. *Cognition* 42:261–286.

Bybee, Joan. 1995. Diachronic and typological properties of morphology and their implications for representation. In *Morphological aspects of language processing*, ed. Laurie Beth Feldman, 225–246. Hillsdale, NJ: Lawrence Erlbaum.

Chomsky, Noam. 1986. *Knowledge of language: Its nature, origins and use*. New York: Praeger.

Cohen, Jonathan, Brian MacWhinney, Matthew Flatt, and Jefferson Provost. 1993. PsyScope: An interactive graphical system for designing and controlling experiments in the psychology laboratory using Macintosh computers. *Behavior Methods, Research, Instruments, and Computers* 25:257–271.

Cooper, Nicole, Anne Cutler, and Roger Wales. 2002. Constraints of lexical stress on lexical access in English: Evidence from native and nonnative listeners. *Language and Speech* 45:207–228.

Corina, David. 1982. Syllable priming and lexical representations: Evidence from experiments and simulations. In the *Proceedings of the 14th Annual Conference of the Cognitive Science Society*, ed. David P. Corina, 779–784. Hillsdale, NJ: Lawrence Erlbaum.

Cutler, Anne. 1986. "Forbear" is a homophone: Lexical prosody does not constrain lexical access. *Language and Speech* 29:201–220.

Cutler, Anne and Donald J. Foss. 1977. On the role of sentence stress in sentence processing. *Language and Speech* 20:1–10.

Cutler, Anne and Wilma van Doselaar. 2001. Voornaam is not (really) a homophone: Lexical prosody and lexical access in Dutch. *Language and Speech* 44:171–195.

Drachman, Gaberell and Angeliki Malikouti-Drachman. 1996. Greek accentuation. In *Word prosodic systems in the languages of Europe*, ed. Harry van der Hulst, 897–946. Berlin: Mouton de Gruyter.

Emmorey, Karen D. 1989. Auditory morphological priming in the lexicon. *Language and Cognitive Processes* 4:73–92.

Fromkin, Victoria. 1971. The non-anomalous nature of anomalous utterances. *Language* 47:27–52.

Goldinger, Stephen D., Paul A. Luce, David B. Pisoni, and Joanne K. Marcario. 1992. Form-based priming in spoken word recognition: The roles of competition and bias. *Journal of Experimental Psychology: Learning, Memory and Cognition* 18:1210–1238.

Grainger, Jonathan. 1990. Word frequency and neighborhood frequency effects in lexical decision and naming. *Journal of Memory and Language* 29:228–244.

Grimshaw, Jane. 1990. *Argument structure*. Cambridge: MIT Press.

Hay, Jennifer. 2001. Lexical frequency in morphology: Is everything relative? *Linguistics* 39:1041–1070.

Hudson, Patrick T.W. and Marjike W. Bergman. 1985. Lexical knowledge in word recognition: Word length and word frequency in naming and lexical decision tasks. *Journal of Memory and Language* 24:46–58.

Jarmulowicz, Linda, Valentina L. Taran, and Sarah E. Hay. 2008. Lexical frequency and third-graders' stress accuracy in derived English word production. *Applied Psycholinguistics* 29:213–235.

Kohn, Susan E. and Katherine L. Smith. 1994. Distinctions between two phonological output deficits. *Applied Psycholinguistics* 15:75–95.

Libben, Gary. 2006. Why study compound processing? An overview of the issues. In *The representation and processing of compound words*, ed. Gary Libben and Gonia Jarema, 1–22. New York: Oxford University Press.

Libben, Gary and Gonia Jarema, eds. 2006. *The representation and processing of compound words*. New York: Oxford University Press.

Libben, Gary, Bruce L. Derwing, and Roberto G. de Almeida. 1999. Ambiguous novel compounds and models of morphological parsing. *Brain and Language* 68:378–386.

Libben, Gary, Martha Gibson, Yeo Bom Yoon, and Dominiek Sandra. 1997. Semantic transparency and compound fracture. *CLASNET Working Papers* 9:1–13.

Lorch, Robert F., David A. Balota, and Edward E. Stamm. 1986. Locus of inhibition effects inthe priming of lexical decisions: Pre- or post-lexical access? *Memory and Cognition* 14:95–103.

Lukyanchenko, Anna, William J. Idsardi, and Nan Jiang. 2012. Opening your ears: The role of L1 in processing of non-native prosodic contrasts. In *Selected Proceedings of the Second Language Research Forum 2010*, ed. Gisela Granena, Joel Koeth, Sunyoung Lee-Ellis, Anna Lukyanchenko, Goretti Prieto Botana, and Elizabeth Rhoades, 50–62. Somerville, MA: Cascadilla Press.

Malikouti-Drachman, Angeliki and Drachman, Gaberell. 1989. Tonismós sta elliniká [Stress in Greek]. *Studies in Greek Linguistics* 9:127–143.

Manouilidou, Christina. 2004. Morfologiki epeksergasia kai thematiki roloi se paragoges leksis: I periptosi tis ikanopiisis thematiku rolu ki eksoterikefsis orismatos. [Theta role saturation in derived words: Evidence from Modern Greek]. In *Studies in Greek Language — Proceedings of the 24th Annual Meeting of the Department of Linguistics*, Marianna Margariti-Rogka, Georgios Papanastasiou, and Nikos Liosis, 429–440. Thessalonika: Aristotle University of Thessaloniki.

Marslen-Wilson, William, Lorraine K. Tyler, Rachelle Waksler, and Lianne Older. 1994. Morphology and meaning in the English mental lexicon. *Psychological Review* 101:3–33.

Marslen-Wilson, William, Xiaolin Zhou, and Mike Ford. 1997. Morphology, modality andlexical architecture. In *Yearbook of morphology*, ed. Geert Booij and Jaap van Marle, 117–134. Amsterdam: Kluwer Academic.

Nakatani, Lloyd H. and Judith A. Shaffer. 1978. Hearing "words" without words: Prosodic cues for word perception. *Journal of the Acoustical Society of America* 63:234–245.

Nespor, Marina and Angela Ralli. 1994. Stress domains in Greek compounds: A case of morphology–phonology interaction. In *Themes of Greek linguistics*, ed. Irene Philippaki-Warburton, Katerina Nikolaidis, and Maria Sifianou, 201–208. Amsterdam: John Benjamins.

Nespor, Marina and Angela Ralli. 1996. Morphology-phonology interface: Phonological domains in Greek compounds. *The Linguistic Review* 13:357–382.

Nespor, Marina and Irene Vogel. 1986. *Prosodic phonology*. Dordrecht: Foris.

Peperkamp, Sharon and Emmanuel Dupoux. 2002. A typological study of stress "deafness". In *Laboratory phonology* 7, ed. Carlos Gussenhoven and Natasha Warner, 203–240. Berlin: Mouton de Gruyter.

Paap, Kenneth R., James E. McDonald, Roger W. Schvaneveldt, and Ronald W. Noel. 1987. Frequency and pronounceability in visually presented naming and lexical decision tasks. In *Attention and performance XII: The psychology of reading*, ed. Max Coltheart, 221–243. Hillsdale, NJ: Lawrence Erlbaum.

Petrounias, Evaggelos V. 2002. *Neoellinikí grammatikí kai sigkritikí análisi*, tómos A: *Fonitikí kai eisagogí sti fonología* [*Modern Greek grammar and comparative analysis*, vol. A: *Phonetics and introduction to phonology*]. Thessalonika: Ziti.

Prince, Allan and Paul Smolensky. 2004. *Optimality Theory: Constraint interaction in Generative Grammar*. Oxford: Blackwell.

Protopapas, Athanasios, Svetlana Gerakaki, and Stella Alexandri. 2006. Lexical and default stress assignment in reading Greek. *Journal of Research in Reading* 29:418–432.

Protopapas, Athanassios, Marina Tzakosta, Aimilios Chalamandaris, and Pirros Tsiakoulis. 2012. IPLR: An online resource for Greek word-level and sublexical information. *Language Resources and Evaluation* 46:449–459.

Radeau, Monique, José Morais, and Juan Segui. 1995. Phonological priming between monosyllabic spoken words. *Journal of Experimental Psychology: Human Perception and Performance* 21:1297–1311.

Ralli, Angela. 2000. A feature-based analysis of Greek nominal inflection. *Glossologia* 11–12: 201–228.

Ralli, Angela. 2002. The role of morphology in gender determination: Evidence from Modern Greek. *Linguistics* 40:519–551.

Ralli, Angela. 2007. *I sinthesi ton lekseon* [*Compounding of Words*]: Athens: Pattakis.

Revithiadou, Anthi. 1995. Stress patterns and morphological structures in Greek nominal prefixation. *Studies in Greek Linguistics*. Thessalonika: Kiriakides.

Revithiadou, Anthi. 1997. Prosodic domains in Greek compounding. In *Proceedings of the 2nd International Congress on Greek Linguistics*, ed. Gaberell Drachman, Angeliki Malikouti-Drachman, Celia Klidi, and John Fykias, 107–116. Graz: Neubauer Verlag.

Revithiadou, Anthi. 1999. Headmost accent wins. Doctoral dissertation, University of Leiden/HIL.

Revithiadou Anthi, Angelos Lengeris, and Dimitra Ioannou. 2013. In search of the default stress in Greek: Evidence from perception. Paper read at the 10th Old World Conference in Phonology (OCP), Boğaziçi University, Istanbul.

Schreuder, Rob and Harald R. Baayen. 1995. Modeling morphological processing. In *Morphological aspects of language processing*, ed. Laurie Beth Feldman, 131–154. Hillsdale, NJ: Lawrence Erlbaum.

Sekiguchi, Takahiro. 2006. Effects of lexical prosody and word familiarity on lexical access of spoken Japanese words. *Journal of Psycholinguistic Research* 35:369–384.

Slowiaczek, Louisa M. 1990. Effects of lexical stress in auditory word recognition. *Language and Speech* 33:47–68.

Slowiaczek, Louisa M. 1994. Semantic priming in a single-word shadowing task. *American Journal of Psychology* 107:245–260.

Slowiaczek, Louisa M. and David B. Pisoni. 1986. Effects of phonological similarity on priming in auditory lexical decision. *Memory and Cognition* 14:230–237.

Soto-Faraco, Salvador, Núria Sebastián-Gallés, and Anne Cutler. 2001. Segmental and suprasegmental mismatch in lexical access. *Journal of Memory and Language* 45:412–432.

Tsakpini, Kyrana, Eva Kehayia, and Gonia Jarema. 1999. Does phonological change play a role in the recognition of derived words across modalities? *Brain and Language* 68:318–323.

Tsiamas, Athanasios, Gonia Jarema, Eva Kehayia, and Gevorg Chilingaryan. 2015. Stress matters! Investigating stress priming effects in Greek compounds. Ms., Université de Montréal and Research Center, Institut universitaire de gériatrie de Montréal (IUGM); McGill University and Center for Interdisciplinary Research in Rehabiliation (CRIR); Center for Interdisciplinary Research in Rehabiliation (CRIR) and Jewish Rehabilitation Hospital.

Tzakosta, Marina. 2009. Perceptual ambiguities in the formation of Greek compounds by native speakers. In *E-Proceedings of the 8th International Conference of Greek Linguistics*, ed. Georgios K. Giannakis, Mary Baltazani, Georgios I. Xydopoulos, and Tassos Tsangalidis, 547–557. Ioannina: Department of Philology, University of Ioannina.

Tzakosta, Marina. 2011. L1 transfer in L2 learning: Compound forms in the speech of Turkish learners of Greek. In *Selected Papers from the 19th International Symposium on Theoretical and Applied Linguistics*, ed. Eliza Kitis, Nikolaos Lavidas, Nina Topintzi, and Tassos Tsangalidis, 459–468. Thessalonika: Department of English Studies, Aristotle University of Thessaloniki.

Tzakosta, Marina and Maria Mamadaki. 2013. Compound formation in L2 learning: The case of Bulgarian, Romanian and Russian learners of Greek. In *The E-Proceedings of the 10th International Conference of Greek Linguistics*, ed. Zoe Gavriilidou, Angeliki Efthymiou, Evangelia Thomadaki, and Penelope Kambakis-Vougiouklis, 578–583. Komotini: Democritus University of Thrace.

APPENDIX A: EXPERIMENTAL STIMULI

	NSC			SC	
Target	Prime	Control	Target	Prime	Control
lemonanθós	anθós	azvós	tsimendóliθos	líθos	líkos
anemostróvilos	stróvilos	strófalos	stomaxóponos	pónos	pólos
jiðovoskós	voskós	vomós	laxanócipos	cípos	cívos
patatoceftés	ceftés	cesés	mandrótiços	tixos	táfos
laxanodolmás	dolmás	dorvás	axlaðókambos	kámbos	káðos
scilokavγás	kavγás	kazmás	keramiðóγatos	γátos	γónos
nixtokórakas	kórakas	kóðonas	linarósporos	spóros	spóŋgos
avlokólakas	kólakas	kókoras	nerólakos	lákos	lóŋgos
rinofáriŋgas	fáriŋgas	fínikas	gazófurnos	fúrmos	faros
ksilopásalos	pásalos	pápiros	kastrópirgos	pírγos	páŋgos
domatosaláta	saláta	sarðéla	klimatóverγa	vérγa	véspa
marmarokolóna	kolóna	koróna	krasókupa	kúpa	kúɲa
pondikopajíða	pajíða	patáta	psaróvarka	várka	vána
jipsosaníða	saníða	sofíta	bananófluða	flúða	fléva
pefkovelóna	velóna	volíða	oðodóvurtsa	vúrtsa	váta
ðrosostála	stála	stámna	θimaróriza	ríza	ríγa
psarokaséla	kaséla	kaðéna	ksilósomba	sómba	sóða
açirokalíva	kalíva	kambána	kremiðósupa	súpa	súvla
nerostaγóna	staγóna	stafíða	sapunófuska	fúska	fústa
krasokanáta	kanáta	kanéla	kariðópsixa	psíxa	psíra

https://doi.org/10.1017/S0008413100000529 Published online by Cambridge University Press

APPENDIX B: FILLERS

-inos (antepenultimate stress)		-eɲos (penultimate stress)		-dzis (ultimate stress)	
Target	Prime	Target	Prime	Target	Prime
brúndzinos	brúndzos	platinéɲos	platína	sovadzís	sovás
pétsinos	pétsa	zmaraɣðéɲos	zmaráɣði	boɟadzís	boɟá
psáθinos	psáθa	kariðéɲos	karíða	fiɣuradzís	fiɣúra
xálkinos	xalkós	kriθaréɲos	kriθári	kafedzís	kafés
atsálinos	atsáli	vamvacéɲos	vamváci	vjolidzís	vjolí
pílinos	pilós	ðandeléɲos	ðandéla	paɣotadzís	paɣotó
tríçinos	tríxa	susaméɲos	susámi	patomadzís	pátoma
ɟípsinos	ɟípsos	pupuléɲos	púpulo	gafadzís	gáfa
velúðinos	velúðo	ðjamandéɲos	ðjamándi	kopanadzís	kopána
ðermátinos	ðérma	luluðéɲos	lulúði	liradzís	lira
ifazmátinos	ífazma	nerajðéɲos	nerájða	blofadzís	blófa
elefándinos	eléfandas	sitaréɲos	sitári	patsadzís	patsás
ðáfninos	ðáfni	sirmatéɲos	sírma	xoratadzís	xorató
ɣúninos	ɣúna	lastixéɲos	lástixo	kulurdzís	kulúri
kristálinos	krístalo	metakséɲos	metáksi	samatadzís	samatás

https://doi.org/10.1017/S0008413100000529 Published online by Cambridge University Press