

Computation of Thematic Information in Accessing Deverbal Adjectives*

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Abstract: The goal of the present study is to determine whether features hypothesized to be encoded in the mental representations of derived nominals via transmission from their roots and affixes are used by the parser in the retrieval of these derived lexical items. We report on an on-line lexical decision task that probed whether speakers process Thematic Features (TFs) while accessing deverbal adjectives. The study provided evidence for the processing of TFs in deverbal adjectives, but only in cases where decomposition takes place during lexical access. The results of the study are discussed in terms of theoretical linguistic and psycholinguistic proposals regarding the organization of the lexicon.

Keywords: deverbal adjectives, thematic features, decomposition, lexical access, lexicon

1. Introduction

The *lexicon* is generally considered to contain information about the words and morphemes of a language. According to linguistic theory, such information may comprise phonological, morphological, morphosyntactic, semantic and pragmatic characteristics. In psycholinguistic theory, the mental lexicon is not merely a store of mental representations of words and morphemes, but also contains mechanisms for organizing and processing these mental representations in everyday language comprehension and production. Among the issues addressed in the psycholinguistic literature to date, those of particular relevance to the present study concern the identification of lexical entries in the mental lexicon, the nature of the information they carry and, most pertinently, the way they are accessed during language processing.

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A number of psycholinguistic models of lexical representation and access have emerged over the years, ranging from those that propose that lexical access proceeds through decomposition (see Taft & Forster 1975) to those that opt for full lexical listing and subsequent whole-word access (Butterworth 1983). With respect to derived words, the decomposition mechanism presupposes the computation of their individual morphemes, with the lexicon consisting of a list of morphemes. In contrast, the whole word access mechanism presupposes that derived words are represented in the lexicon as single units and that the lexicon contains a list of whole words (simple or derived).

Although neither of these extreme positions (whole word access or strict decomposition model) has received unequivocal experimental support, there have been findings in favour of both positions, depending, in some cases, on factors such as word frequency. Thus, a number of hybrid models have emerged in which the lexicon is seen as containing both whole words and individual morphemes. These hybrid models have been proposed both in the theoretical linguistic literature (Halle 1973, Lapointe 1980, Lieber 1980, Williams 1981, Mohannan 1982, Kiparsky 1982, Selkirk 1982, Jensen & Stong-Jensen 1984, and Ralli 1988 among others) and in the psycholinguistic literature (Caramazza et al. 1988, Burani & Caramazza 1987, Burani et al. 1999, Caramazza et al. 1985, Laudanna et al. 1989, Schreuder & Baayen 1995). In addition to providing us with insights into the processing of both whole words and morphemes, hybrid models also allow psycholinguists to investigate the possible effects of specific lexical features (morphological, morphosyntactic or phonological) during lexical access.

The fundamental assumption underlying such psycholinguistic investigations is that processing load increases with the number of features to be computed during on-line word recognition. A number of studies have shown that certain *features* related to meaning, such as ‘abstract’ as opposed to ‘concrete’ (Manouilidou & Kehayia 2004) or ‘mass’ as opposed to ‘count’ (Gillon et al. 1999), can increase processing load, as measured by reaction times (RTs). Multimorphemic forms involving *morphological operations* such as inflection, derivation and compounding also appear to require more processing time than simple forms (Taft

& Forster 1975, Laudanna et al. 1992, Niemi et al. 1994, Kehayia & Jarema 1994). This additional processing time has been attributed to the fact that during lexical access these forms must be decomposed¹ into their constituents. Similarly, with respect to grammatical category, verbs yield longer RTs than nouns (Deutch et al. 1998). This may be at least partially due to the processing of thematic features (TFs), which are considered to be an inherent property of verbs (see Section 2 below).

The present study, which is part of a series of lexical access studies contrasting verbs and various types of derived and non-derived nominals (see Manouilidou 2004, Manouilidou et al. 2004), looks for evidence that TFs also increase the processing load of lexical items that are derived from verbs. The derived lexical items under consideration are deverbal adjectives (DVAdjs), such as *trainable* (from *to train* + *able*). By contrasting the processing times of DVAdjs with that of denominal adjectives (DNAdjs), such as *agricultural* (from *agriculture* + *al*), and non-derived adjectives (NDAdjs), such as *brave*, it may be possible to tease apart the processing load associated with derivation from that associated with the processing of TFs inherited by DVAdjs. This is because, while both DNAdjs ('agricultural') and DVAdjs ('teachable') are multimorphemic and could be accessed through decomposition, only DVAdjs can be argued to carry TFs inherited from their verbal roots. Evidence from the processing of TFs in *verbs* suggests that these features could also affect the accessing of DVAdjs. The following section reviews the relevant literature in this area.

2. Theoretical and experimental perspectives on TFs

According to linguistic theory, the *argument structure* of verbs is determined by the particular TFs they carry. These TFs specify the number of participants (*thematic roles*) involved in the event described by the verb, as well as how these participants map onto grammatical relations. The argument structure of the verb is then marked in syntax by word order or morphological case, according to the conventions of the

¹ Despite conflicting experimental evidence as to the precise role of decomposition as a psycholinguistic operation in lexical access, when decomposition does take place, it invariably increases RTs.

language. There is evidence from lexical access studies of verbs that verb argument structure is accessed as soon as a verb is encountered and that it constitutes part of a verb's mental representation. These studies reflect a variety of approaches, including on-line and off-line comprehension experiments (Maurer & Koenig 1999), classification tests (Bencini & Goldberg 2000), Event-Related Potentials (Friederici & Frisch 2000) and eye movement studies (Maurer et al. 2002).

There are sound theoretical arguments for assuming that verbal TFs are passed on to nominals derived from them. In the case of DVAdjs, two types of existing lexical elements are recruited, a verbal root and a suffix. In order to have a well-formed new word, the verb and the suffix must match with respect to a number of grammatical properties. In the case of the DVAdj *readable*, the root *read* is a transitive verb, it involves two participants ('a reader' and 'the object being read'), and it can be equated with the encyclopedic information regarding the type of event that one may refer to when using the word 'TO READ'. Similarly, the suffix *-able* has its own properties; for instance, it attaches to verbs involving at least two participants ('a doer' and an 'affected object'), it creates adjectives, and it semantically introduces a 'possibility operator'. Hence, the grammatical properties of the root 'to read' (being a verb associated with a particular number of participants) are in accordance with the requirements of the suffix '-able' (attaches to verbs with two participants) to form the legitimate word 'readable'.

Once the root is matched to the affix in the general terms described above, the feature specifications of the derived word must emerge through a melding of the *thematic* properties carried by each contributing morpheme.² For instance, *read* is predicated of the Agent and the Theme argument, with the Agent being the external and the Theme the internal argument (<Ag<Th>>). The suffix *-able* has an argument structure consisting of an external Theme argument together with an Event internal argument, which can be represented as <Th<Ev>>. As illustrated in (1), the internal argument of the verb (*the book*) in (1a) becomes external in (1b) when the addition of *-able* combines with the verb to derive the adjective *readable*.

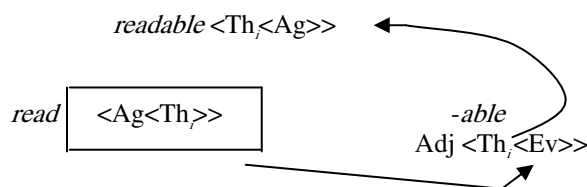
² Baker & Bobaljik (2002) provide a detailed account relating argument structure to derivation. Their descriptive tools and terminology are adopted in the present paper.

In other words, the suffix *-able* creates an adjective with a Theme external argument and an optional Agent internal argument.

- (1) a. Tom read the book
 b. The book is readable (by Tom)

The Theme argument of the DVAdj is also understood as being the same as the Theme of the verb root. Baker and Bobaljik (2002) call this *argument binding*.³ We can represent this by putting the same subscript on the binding argument and the bound argument. Thus, when it comes to the formation of *readable*, the argument structures of *read* and *-able* would be $\langle \text{Ag} \langle \text{Th}_i \rangle \rangle$ and $\langle \text{Th}_i \langle \text{Ev} \rangle \rangle$, respectively. The notation indicates that the two arguments must be interpreted as sharing an identity. The rest of the argument structure of the verb (the Agent argument) is substituted into the argument structure of *-able* and is passed on to the derived word. In other words, the Event argument gets replaced by the argument structure of the verb via *substitution linking*,⁴ as shown in Figure 1. The result is a two-argument adjective, with a Theme external argument and an Agent internal argument that is inherited from the verb root. This implies that both argument binding and substitution linking are involved in *-able* suffixation.

Figure 1: Thematic operations involved in the derivation of *readable*.



³ The term *argument binding* is used when a designated argument of the head may *bind* a designated argument of the nonhead as required by the lexical entry. When this happens, no distinct phrase will express the bound argument, and it will be understood that both argument roles are filled by a single element. (Baker & Bobaljik 2002: AS-39).

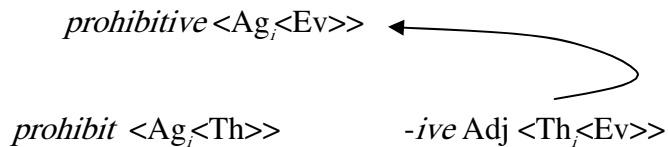
⁴ The term *substitution linking* is used to denote that the argument structure of the non-head of a word can replace one argument of the head (Baker & Bobaljik 2002: AS-31).

The derivation of the DVAdj *prohibitive*, whose verb root has similar thematic properties to those of *read*, illustrates how combining with a different derivational suffix (*-ive*) can affect the ultimate argument structure of the DVAdj. In the case of *prohibitive*, the argument structure is inherited from both the verb root and the affix *-ive*. The argument structure of the verb *prohibit* is $\langle \text{Ag}_i \langle \text{Th} \rangle \rangle$, while the argument structure of the suffix *-ive* is $\langle \text{Th}_i \langle \text{Ev} \rangle \rangle$. Note in examples (2a) and (2b) that the DVAdj *prohibit-ive* has the same external argument (*the law*) as the verb *prohibit*. In other words, the Agent argument of the verb and the Theme argument of the suffix are co-indexed because they are understood as being the same.

- (2) a. The law prohibits the use of drugs
 b. The law is prohibitive

Thus, only *external* argument binding is involved in *-ive* suffixation. Furthermore, it is the lack of substitution linking that prevents this DVAdj from inheriting its argument structure entirely from the verb root. The derivation of *prohibitive* is illustrated in Figure 2.

Figure 2: Thematic operations involved in the derivation of *prohibitive*.



The derivations of *readable* and *prohibitive* illustrate how the thematic properties of the verbal root and suffix trigger the various thematic operations, such as argument binding and substitution linking, which take place during derivation. These thematic operations, which combine properties from the verb and the suffix, are responsible for the presence of specific TFs in newly formed DVAdjs. These TFs are presumably catalogued in the mental lexicon alongside the other features that the newly derived word has inherited through the process of derivation.

Despite the theoretical basis for assuming that DVAdjs inherit TFs that constitute part of their lexical entry, and despite the considerable amount of research on verb TFs, only two studies have looked at whether TFs are processed during the lexical access of deverbal nominals (Manouilidou 2004, Manouilidou et al. 2004). Using stimuli from Modern Greek (MG), Manouilidou (2004) targeted the on-line processing of TFs in deverbal nouns and adjectives. The study looked into the effect of two specific operations that manipulate TFs during derivation, Theta Role Saturation⁵ (for nouns) and Argument Externalization⁶ (for adjectives). RTs to deverbal nouns with Theta Role Saturation, formed with the suffix *-tis* (agentive *-er*) as in *agorastis* ‘buyer’, were compared to RTs obtained from deverbal nouns without Theta Role Saturation (e.g. *lytromos* ‘deliverance’). A similar comparison was carried out for adjectives, comparing those which demonstrated Argument Externalization, formed with the suffix *simos* (-able) as in *anagno-simos* ‘read-able’, with those without Argument Externalization (e.g. *vevaio-tikos* ‘affirmat-ive’). The results indicated longer RTs for adjectives with Argument Externalization (e.g. *katanoi-simos* ‘comprehensible’) than for their controls. However, the same significant difference was not observed for nouns with Theta Role Saturation (e.g. *kataktitis* ‘conqueror’), which yielded RTs similar to those of their controls (*lytromos* ‘deliverance’). Although this dissociation was originally attributed to the nature of the suffix⁷ and the thematic operations following derivation, it could equally reflect a difference in the processing of nouns and adjectives bearing TFs.

⁵ An example of a word with theta role saturation is *teacher*. In the derivation of *teacher*, the suffix *-er* binds the external argument of the base verb, saturating it into the derived nominal. As a result, both the external argument and the suffix have the same referential index. In Baker and Bobaljik’s (2002) terms, this operation could be described as External Argument Binding.

⁶ The term is from Williams (1981). The basic thesis of his paper is that morphological rules can alter argument structure in two ways: a rule can either externalize an internal argument (Argument Externalization) or internalize an external one (Argument Internalization). Argument Externalization can be described in the same way as Internal Argument Binding.

⁷ Namely, in Manouilidou (2004) it was claimed that a coincidence of semantic and thematic processing of the suffix *-tis* (*-er*) was observed, with a resulting acceleration of the recognition process of the whole word. The same coincidence was not observed for the suffix *-simos* (*-able*), thereby making the processing of TFs more visible.

To further explore the role that specific suffixes might play in determining the number and processing of TFs in deverbal word formations, Manouilidou et al. (2004) studied a number of deverbal nouns formed with different suffixes and involving a number of distinct thematic operations. More specifically, they examined how different numbers of arguments (one versus two) and numbers of thematic operations (for example, argument binding + substitution linking versus only substitution linking) might affect the processing of attested deverbal nouns. Their results revealed no significant differences between nouns with one argument position (for example, *walker*) versus those with two (for example, *translator*). Similarly, no significant differences were observed in the RTs for deverbal nouns whose derivations involved different numbers of thematic operations (for example, *translator* versus *translation*). As adjectives were not examined in this study, the possibility remained that TFs are only accessed during the processing of deverbal adjectives and not deverbal nouns.⁸

3. Research questions and hypotheses

As our previous studies (Manouilidou 2004, Manouilidou et al. 2004) provided no evidence that TFs are accessed in the retrieval of deverbal nouns, the present study focuses exclusively on the processing of adjectives. It addresses the following questions:

- 1) Is the processing of TFs reflected in the RTs obtained during the lexical access of DVAdjs and can this be differentiated from the effects of the derivational process itself?
- 2) Is it possible to show RT differences between types of DVAdjs based on the number of thematic operations involved in their derivation?

⁸ The possibility that TFs might only be processed for DVAdjs and not DVNs could find a theoretical basis in proposals which attribute to adjectives mixed noun and verb properties. For instance, Chomsky (1975) breaks down the four major parts of speech (Nouns, Verbs, Adjectives, and Adpositions) into composites of two binary features, N and V. Nouns consist of [+N, -V], verbs of [-N, +V], while adjectives bear both the nominal and the verbal feature [+N, +V]. More recently, Berg (2000) talks about the “equidistance hypothesis” which places adjectives at an intermediate position between nouns and verbs. Thus, if future research shows that TFs are processed for DVAdjs, but not for DVNs, this could be due to the fact that adjectives appear to have more similarities with verbs than nouns do. However, these are speculations that need to be tested.

3.1 Hypotheses

The present study compares on-line lexical access times for three groups of adjectives (DVAdjs, DNAdjs and NAdjs) that differ with respect to their structural complexity and thematic features. Our hypotheses are based on three working assumptions. The first of these is that decomposition is at least partially responsible for longer RTs observed during the processing of complex forms. Therefore, Hypothesis 1 states that we expect derived forms (DVAdjs and DNAdjs) to take longer to process than non-derived forms (NAdjs). Our second assumption is that representations stored in the mental lexicon carry a certain amount of information that is reflected in on-line processing. Specifically, we assume that the lexical entry of a DVAdj is specified for TFs inherited from both the verbal root and the suffix through various operations taking place during derivation. Thus Hypothesis 2 states that DVAdjs will take longer to process than DNAdjs. Finally, if we assume that a greater number of thematic operations further increases the complexity of DVAdjs, then this should be reflected in longer RTs. Therefore, Hypothesis 3 states that DVAdjs with a greater number of thematic operations will take longer to process than those with fewer thematic operations.⁹

4. Experiment

4.1 Materials and method

In order to test these hypotheses, we carried out an on-line, simple lexical decision task using stimuli from MG. The experiment was completed in two phases.

4.1.1 Phase I: Frequency verification

To select the stimulus set, and in the absence of frequency and familiarity tables for MG, off-line **familiarity** ratings were obtained for a total of 238 derived and non-derived words. Using a scale from 1 to 5 (1 being less frequently and 5 being very frequently), Greek university students were asked to indicate how often their friends use each word. These ratings were employed to match stimuli with controls.

⁹ Although this hypothesis was not born out in the study with Deverbal Nouns, we decided to further investigate it in the present study with Deverbal Adjectives.

4.1.2 Phase II: On-line experiment

The second phase of the study consisted of an on-line, visual lexical decision task. Letter strings were presented to the participants, who had to indicate whether or not they constituted MG words. Both RTs in milliseconds and the number of errors were recorded. The program PsyScope 1.2.5 for Power Macintosh was used to present the stimuli and record responses.

4.1.3 Stimuli

Stimuli included three sets of MG adjectives (DVAdjs, DNAdjs and NDAjds) with an average familiarity rating of 3.5. The inclusion of non-derived adjectives (NDAjds) allowed us to factor out the effect of derivation (which was expected for both DVAdjs and DNAdjs) from the effect of derivation plus TFs (which was only expected for the DVAdjs). To determine whether DVAdjs and DNAdjs are actually accessed in a similar manner (either as whole words or through decomposition) each group was matched with a control set of NDAjds (see below). DVAdjs were further divided into four categories depending on the thematic operations involved in their derivation, such as internal/external argument binding and substitution linking. The characteristics of each group of derived adjectives are described in the following paragraphs.

4.1.3.1 Deverbal Adjectives (DVAdjs)

Four categories of DVAdjs were employed in the study, with 8 adjectives in each. Each category is formed with a different suffix. The thematic operations involved in the derivation of each category are summarized in Figure 3.

1. DVAdjs-*simos*. Formed by adding the suffix *-simos* (the semantic equivalent of English *-able*) to a strictly transitive verb, these adjectives manifest both internal argument binding and substitution linking.

Example: *anatrepo* > *anatrep-simos*
'to reverse' > 'reversible'

2. DVAdjs-*menos*. Formed by adding the suffix *-menos* to a transitive verb, these DVAdjs also demonstrate internal argument binding and substitution linking.

Example: *skepazo* > *skepas-menos*
'to cover' > 'covered'

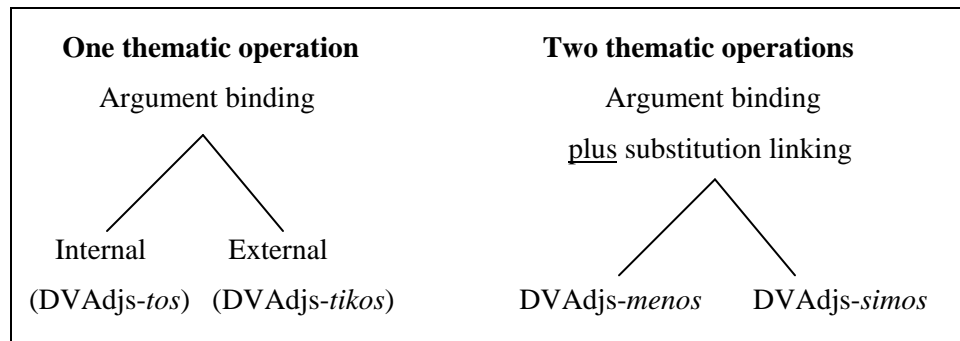
3. DVAdjs-*tikos*. Formed by adding the suffix *-tikos* to a transitive verb, these DVAdjs carry only external argument binding, but not substitution linking.¹⁰

Example: *periorizo* > *periorist-tikos*
 ‘to restrict’ > ‘restrictive’

4. DVAdjs-*tos*. Formed by adding the suffix *-tos* to a transitive verb, DVAdjs-*tos* demonstrate internal argument binding, but not substitution linking.¹¹

Example: *skalizo* > *skalis-tos*
 ‘to engrave’ > ‘engraved’

Figure 3: DVAdjs according to type and number of thematic operations.



4.1.3.2 Denominal Adjectives (DNAdjs)

There were two groups of denominal adjectives, with 8 adjectives in each group. In contrast to the DVAdjs, the denominal adjectives lack TFs:

¹⁰ The lack of substitution linking is responsible for the fact that the derived adjective does not inherit the Argument Structure of the base verb. In the case of DVAdjs-*tikos*, although their base verbs are transitive, the derived adjectives are intransitive. For example, *the law prohibits the use of drugs* > *the law is prohibitive* *(of the use of drugs).

¹¹ The two latter instances of deverbal adjectives (*-menos* and *-tos*) form adjectival passives (Alexiadou & von Stechow 2001, Anagnostopoulou 2002). However, Markantonatou et al. (1996: 200), in a direct comparison between *-menos* and *-tos*, conclude that the *-tos* adjectives lack one semantic argument, the “agent” or “cause”, which is present in *-menos* adjectives. The same authors observe that while the DVAdjs-*menos* denote the result of the activity described by the base verb, the DVAdjs-*tos* denote the state that corresponds to the result, thereby by-passing some aspects of the verb meaning. In this sense, DVAdjs-*menos* carry more verbal features, since they receive complements that denote agent as well as complements that denote instrument. In contrast, DVAdjs-*tos* do not allow these types of complements, as the following examples illustrate: *Vrika tin porta anoig-meni me losto* (I found the door opened-MENOS/fem. with crowbar), **Vrika tin porta anoix-ti me losto* (I found the door opened-TOS/fem. with crowbar).

1. DNAdjs-*ikos*. Formed from various nouns plus the suffix *-ikos*.

Example: *georgia* > *georg-ikos* ('agriculture' > 'agricultural')

2. DNAdjs-*eros*. Formed from various nouns plus the suffix *-eros*.

Example: *vrohi* > *vroheros* ('rain' > 'rainy')

4.1.3.3 Non-derived Adjectives (NDAdjs)

The stimulus set also comprised 48 NDAdjs that were matched for frequency, length, and number of syllables with the actual experimental stimuli. There were six groups of 8 NDAdjs, each serving as controls for a group of derived adjectives. Within each non-derived group, attention was paid to matching the final letter strings of the controls with the actual suffixes used in the corresponding derived group (such as NDAdj: *thetikos* 'positive' vs. DVAdj: *perioris-tikos* 'restrictive').

4.1.3.4 Fillers

In addition to the test items, the stimulus set also included filler word targets to distract participants from the purpose of the experiment. The 44 filler words consisted of various types of non-derived verbs.

4.1.3.5 Non-words

The 138 non-words in the list were obtained by replacing one or two letters of a real MG word in accordance with the phonotactic constraints of the language. The presence of non-words allowed participants to legitimately reject some of the stimuli as not being words in MG.

4.1.4 Procedure

Stimuli were presented in a standard lowercase Greek typeface. Participants first saw a mask comprising a series of pound signs (#####) in the center of the screen, matching the number of characters of the preceding stimulus. The mask was presented for 200ms and was followed by a pause of 150 ms. The target appeared immediately after the pause. Stimuli were presented in blocks of 80. The actual test was preceded by a practice session comprising 10 items and a pretest comprising 10 trial items.

4.1.5 Participants

Twenty-four (24) native speakers of MG participated in the study. All were undergraduate and graduate students at Aristotle University of Thessaloniki.

4.1.6 Scoring and analysis

The dependent measure for all analyses was lexical decision latency reported as RTs in milliseconds. In all analyses, separate ANOVAs by item and by subject were conducted, treating items as independent variables. Additionally, paired t-tests were also conducted when licensed as necessary. All reported RTs represent a mean of subject responses. Prior to the analysis, erroneous responses were removed, resulting in a loss of less than 3% of observations. Furthermore, responses exceeding 1500ms were considered to be ‘off-line’ and were removed as well. Outliers (response times below and above two standard deviations from the mean) were also removed from the dataset. This resulted in a by subject loss of data varying from 2 to 7%.

5. Results and Discussion

Table 1 displays RTs and standard deviations for each group of stimuli. An ANOVA revealed a main effect of category both by subject ($F(3, 69) = 15.59, p < .0001$) and by item [$F(3,92) = 10.41, p < .0001$], while pairwise comparisons showed a significant difference between DVAdjs and DNAdjs [$t(69) = -4.63, p < .0001$], as well as between DVAdjs and NAdjs [$t(69) = -6.04, p < .0001$]. However, no significant difference was found between DNAdjs and NAdjs [$t(69) = 1.06, p < .29$].¹²

Table 1: Mean RTs in Milliseconds by Stimulus Type.

Type	RTs (SD)
DVAdjs	688 (46)
DNAdjs	644 (46)
NAdjs	634 (45)
Fillers	646 (59)
Non-words	783 (60)

¹² Fillers and Non-words were not analyzed, since they are not relevant to the research questions of the present study.

Hypothesis 1, which predicted that derived forms (both DVAdjs and DNAdjs) would yield longer RTs than NAdjs, was only partially supported. However, Hypothesis 2 was fully supported, as DVAdjs yielded significantly longer RTs than DNAdjs. Thus, it seems that the presence of TFs increased processing load in the lexical access of DVAdjs. According to our third hypothesis, RTs to DVAdjs would differ depending on the number of thematic operations involved in their derivation. Table 2 displays the RTs for each group of DVAdjs formed by a different number of thematic operations. The results indicate that DVAdjs involving two thematic operations take significantly longer to process than those involving only one [$t(23) = 3.055, p = 0.006$]. Thus, Hypothesis 3 appears to be supported. However, the partial support for Hypothesis 1 ultimately required some additional analyses and the revisiting of the findings with respect to Hypotheses 2 and 3.

Table 2: Mean RTs in Milliseconds for DVAdjs Grouped by Number of Thematic Operations.

Type	RTs (SD)
DVAdjs with 1 thematic operation (-tikos, -tos)	674 (36)
DVAdjs with 2 thematic operations (-simos, -menos)	702 (42)

6. Additional analyses

The reasoning behind the present study was that both the process of derivation (with the consequent need to decompose derived words) and the presence of TFs would independently add to processing times. We presumed that the presence of TFs would account for longer RTs for DVAdjs than for DNAdjs, while decomposition alone would account for a difference between DNAdjs and NAdjs. Both factors would contribute to a difference between DVAdjs and NAdjs. Although DVAdjs did take significantly longer to process than DNAdjs, we did not find a significant difference between DNAdjs and NAdjs. If we assume that NAdjs are normally accessed as whole words, then the lack of difference between DNAdjs and NAdjs suggests that derivation alone did not

increase the processing load for DNAdjs. This raises the possibility that the DNAdjs tested here may have been accessed as whole words, instead of being decomposed. If this were the case, then we would not be able to reliably attribute the difference between DVAdjs and DNAdjs to the added weight of processing TFs, despite the fact that the number of thematic operations apparently affects processing within the DVAdj category. The difference between DVAdjs and DNAdjs could equally well be due to whether or not decomposition occurs.

To address this issue, we carried out a more detailed analysis of the variation within and across all three groups of adjectives, with the goal of shedding some light on the relative processing weights of derivation and TFs. The first part of this analysis looked at how the issue of derivation may have interacted with lexical access route. To this end, we conducted a repeated-measures ANOVA in which each group of adjectives derived with the same suffix was compared with the group's non-derived control adjectives. This differed from the previous analyses, where all non-derived adjectives were treated as a single group. The results, shown in Table 3, indicate that all groups of DVAdjs, with the exception of the DVAdjs-*tos* group, differ significantly from their non-derived controls. The two groups of DNAdjs show divergent results. The DNAdjs-*eros* group differs significantly from its non-derived controls, while the DNAdjs-*ikos* group does not. As there were only two groups of DNAdjs, this divergence may explain the lack of a significant difference between DNAdjs and NAdjs noted earlier.

Table 3: Comparison of Each Adjective Group with its ND Controls.

Derived Adjectives with Mean RTs and (SDs)	Non-derived Controls with Mean RTs and (SDs)	F-values	p-values
DVAdj- <i>simos</i> 711 (43)	NAdjs- <i>simos</i> 632 (24)	F(1,23)= 6.15	p< 0.0001
DVAdjs- <i>menos</i> 695(42)	NAdjs- <i>menos</i> 636 (39)	F(1,23)= 5.94	p< 0.0001
DVAdjs- <i>tikos</i> 687 (31)	NAdjs- <i>tikos</i> 633 (57)	F(1,23)=17.4	p< 0.0001
DVAdjs- <i>tos</i> 661 (38)	NAdjs- <i>tos</i> 640 (41)	F(1,23)= 0.18	p=0.89NS
DNAdjs- <i>eros</i> 657 (39)	NAdjs- <i>eros</i> 615 (59)	F(1,23)=19.9	p< 0.0001
DNAdjs- <i>ikos</i> 629 (39)	NAdjs- <i>ikos</i> 627 (20)	F(1,23)= 0.01	p=0.90NS

The lack of significant differences between DVAdjs-*tos* and DNAdjs-*ikos* and their respective non-derived controls suggest that adjectives derived with *-tos* and *-ikos* may not be accessed through decomposition and raises the issue of lexicalization for certain groups of derived adjectives. In the light of these new findings, we decided to further re-examine Hypothesis 2 by attempting an additional analysis for which we divided the DVAdjs and DNAdjs into two groups, based on whether or not they differed from their non-derived controls. Thus the DVAdjs *-menos*, *-simos* and *-tikos* were placed in the *decomposed* category, separate from *-tos*, which did not differ from its non-derived controls. DNAdjs with *-eros* were considered *decomposed*, while the *-ikos* group was not. We then ran a one-way ANOVA comparing the mean for all DVAdjs accessed through decomposition to the decomposed DNAdjs-*eros*. A one-way ANOVA was also run for the apparently non-decomposed DVAdj-*tos* group versus the non-decomposed DNAdj-*ikos* group. By holding the presence or absence of decomposition constant in each analysis, we hoped to isolate the effects of the processing of TFs. Based on Hypothesis 2, our prediction was that the decomposed DVAdjs would differ significantly from the decomposed DNAdjs-*eros*. We also expected a significant difference between non-decomposed DVAdjs-*tos* and non-decomposed DNAdjs-*ikos*.

The results, shown in Table 4, bear out our prediction for decomposed DVAdjs versus decomposed DNAdjs-*eros*. We view this result as providing additional evidence for the processing of TFs of DVAdjs, as stated in Hypothesis 2. The lack of a significant difference in RTs between non-decomposed DVAdjs-*tos* and DNAdjs-*ikos* is more difficult to interpret, as the presence of TFs does not appear to add to the processing load of DVAdjs-*tos*. This result strongly suggests that decomposition may be a necessary prerequisite to the processing of TFs of DVAdjs.

Table 4: DVAdjs versus DNAdjs, Grouped by Lexical Access Route.

Decomposed with Mean and (SD)	Nondecomposed with Mean and (SD)	
DVAdjs- <i>menos/simos/tikos</i> 697 (38)	DNAdjs- <i>eros</i> 657 (39)	F2(1,32) = 6.236, p = 0.018
DVAdjs- <i>tos</i> 661 (38)	DNAdjs- <i>ikos</i> 629 (39)	F2(1,15) = 2.637, p = 0.127

In the light of the results reported in Table 4, further analysis was also conducted with respect to Hypothesis 3. The reasoning behind this hypothesis was that a greater number of thematic operations would increase the complexity of DVAdjs and, consequently, their processing time. However, in order to avoid confounding the processing of TFs with that of decomposition, nondecomposed DVAdjs-*tos* were excluded from the reanalysis. The subsequent analysis compared the mean RTs for decomposed DVAdjs-*simos*, -*menos* (with two thematic operations) with those for decomposed DVAdjs-*tikos* (with one thematic operation). Table 5 displays the means and standard deviations for this regrouping of items. A one way ANOVA [$F2(1,23) = 0.862, p = 0.36$] as well as a paired samples t-test [$t(23) = 1.273, p = 0.216$] failed to show any statistically significant difference between DVAdjs involving two thematic operations (-*simos*/*menos*) versus DVAdjs involving one thematic operation (-*tikos*). Consequently, Hypothesis 3 is no longer confirmed. Thus, in spite of evidence in support of Hypothesis 2 that TFs are detected during the lexical access of DVAdjs, the parser does not seem to differentiate between different numbers of thematic operations involved in their derivation.¹³

Table 5: Mean RTs in Milliseconds for DVAdjs Regrouped by Number of Thematic Operations Controlling for Decomposition.

DVAdjs with 1 thematic operation (- <i>tikos</i>)	687 (31)
DVAdjs with 2 thematic operations (- <i>simos</i> + - <i>menos</i>)	702 (42)

¹³ It is also possible that a simple lexical decision task may not be sensitive enough to detect subtle differences of this nature.

7. Theoretical Implications

Our study was based on the premise that derivational processes and other lexical properties are reflected in increased RTs during lexical access. We investigated this question with respect to the processing of TFs in DVAdjs, finding that TFs of DVAdjs are processed during word recognition depending on the **access route**. Although only the **decomposition** access route permits processing of TFs, our results nonetheless suggest that inherited features play a distinct role both in the formulation of the mental representations and in the lexical access of DVAdjs. Furthermore, the role of these inherited features is not diminished by a change in grammatical class from verb to adjective.

The role of decomposition also suggests that the processing of TFs occurs in later stages of processing, after morphological parsing has taken place. This further implies that lexical representations are reached in stages, with decomposition at an earlier stage, followed later by the processing of TFs. Such staged accessing is well demonstrated in the literature and has implications for several theoretical proposals regarding the nature of lexical representation, lexical access and the organization of the lexicon. Priming studies provide the majority of evidence supporting a differential or independent time-course of activation for various processes and features that influence lexical access. For instance, Rastle et al. (2000) report two sets of visual priming experiments in which the morphological, semantic, and orthographic relationships between primes and targets varied in three stimulus onset asynchrony (SOA) conditions (43ms, 72ms, and 230ms). Results showed distinct priming effects for each set of primes (morphological, semantic, orthographic) in different SOAs. Tsapkini et al. (2002) also demonstrated that different kinds of information influence lexical access at different time intervals. Their masked priming study investigated whether morphological relatedness can affect processing independently from the confounding factor of differential orthographic similarity in the lexical access of regular and irregular verbs in MG. Schreuder & Baayen's (1995) model of lexical access is in accordance with this line of thinking. According to Schreuder & Baayen (1995), each stimulus at an initial stage is transformed into an *intermediate access representation* which can be

identical either to the whole word (e.g. *distraction*) or to the word decomposed into its constituents (e.g. *distract-ion*). They also claim that the recognition of a lexical item involves activation of its various concept nodes in order for its final lexical representation to be accessed. What is of particular relevance for our study is that these nodes receive feedback from syntactic and semantic representations associated with them. The speed of activation depends on the complexity of the mapping process from the intermediate stages to the access representation proper. Since TFs do not appear to be accessed for every DVAdj, but only for those accessed after decomposition, we can postulate that when the *access representation* has the form of the whole word, activation feedback from TFs is not a necessary step in accessing the lexical representation. In the opposite case, when the access representation is in a decomposed form, the concept nodes receive activation feedback from TFs and this process is reflected in longer RTs.

The results of the present study imply that not all features of a word are immediately accessible. Thus, although TFs may constitute part of the lexical entry of DVAdjs, their staged access, filtered through decomposition, suggests that TFs might only be necessarily part of the recognition process of a DVAdj under certain circumstances, at least for visual word recognition. Since TFs are inherited features for DVAdjs, stemming from the verbal root, and since decomposition appears to be a special condition which triggers their surfacing, we could assume that it is *viewing the verbal root* that activates the processing of TFs in DVAdjs. This is in accordance with the fact that TFs are highly salient features of verbs which are always processed during lexical access. Unfortunately, the present study does not allow us to determine with certainty either the role of decomposition or the role of the verbal root in the processing of DVAdjs. This is the focus of an upcoming study, which has two major aims. The first is to confirm that the lexical access route opted for during lexical access actually matters, with decomposition favoring the processing of TFs. The second aim is to explore to what extent the verbal root plays a key role in triggering the processing of TFs.

Finally, the fact that lexical decisions for some (nondecomposed) DVAdjs are made before subjects have accessed the component containing thematic

information strongly suggests that accessing of the TFs of these particular nominals is not a necessary prerequisite to identifying them. This implies that thematic information may not be as prominent as other types of information constituting the mental representation of at least these nondecomposed types of DVAdjs. The later stage at which TFs are processed in decomposed types of DVAdjs is also suggestive of a less prominent role for TFs in their representation. However, further evidence is required before we can make more definitive claims regarding the role of TFs in DVAdjs or in deverbal word formations in general. Additional research is also required to confirm the findings of the present study regarding varying access routes for DVAdjs derived with different suffixes.

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Appendix

DVAdjs-menos

Kallymenos	‘covered’
Kentimenos	‘embroidered’
Thremmenos	‘bred’
Sfigmenos	‘squeezed’
Skalismenos	‘engraved’
Stefanomenos	‘crowned’
Stolismenos	‘decorated’
Trimmenos	‘grated’

DVAdjs-simos

Amfisvitisimos	‘doubtful’
Anastrepsimos	‘reversible’
Efarmosimos	‘applicable’
Ekpaideusimos	‘trainable’
Episkeuasimos	‘repairable’
Katedafisimos	‘demolishable’
Prosarmosimos	‘adjustable’
Sygkrisimos	‘comparable’

DVAdjs-tikos

Anastaltikos	‘suspensive’
Xalarotikos	‘relaxing’
Diegertikos	‘stimulating’
Ependytikos	‘investive’
Epibaryntikos	‘damaging’
Eksorgistikos	‘infuriating’
Katathliptikos	‘depressing’
Parigoritikos	‘comforting’

DVAdjs-tos

Antilptos	‘detectable’
Epitreptos	‘permissible’
Katanoitos	‘comprehensible’
Latreutos	‘beloved’
Misitos	‘hateful’
Pothitos	‘desirable’
Skalistos	‘graven’
Ypofertos	‘bearable’

DNAdjs-ikos

Adelfikos	‘fraternal’
Eirinikos	‘peaceful’
Emporikos	‘commercial’
Epistimonikos	‘scientific’
Georgikos	‘agricultural’
Kommatikos	‘partying’
Paidikos	‘childish’
Sfairikos	‘spherical’

DNAdjs-eros

Vronteros	‘booming’
Vromeros	‘dirty’
Farmakeros	‘poisonous’
Flogeros	‘flaming’
Karperos	‘fructuous’
Pageros	‘frosty’
Thanateros	‘deadly’
Sixameros	‘disgusting’

NAdjs

Vevaios	‘certain’
Epitivdeios	‘dexterous’
Gennaios	‘brave’
Malakos	‘soft’
Nistikos	‘foodless’
Panourgos	‘cunning’
Parthenos	‘virgin’
Skouros	‘dark’