**University of Alberta**

German *ver*-Verbs: Internal Word Structure and Lexical Processing

by

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# ABSTRACT

This dissertation investigates the visual word recognition of German verbs containing the inseparable prefix *ver-* (e.g., *verbittern* 'to embitter') in an experimental setting, using data obtained from adult native speakers of German. More specifically, it investigates the roles of morphology, morpheme salience, stimulus effects, and task effects in the lexical processing of these complex words. Although, on the surface, *ver*-verbs appear to constitute a homogeneous group, a closer inspection reveals subtle descriptive differences in their internal structure, namely, the existence of putative adjectival, nominal, verbal, and (synchronically) bound component forms such as those in *ver**bitter**n* 'to embitter' (*ver*-Adjective), *ver**kleid**en* 'to disguise' (*ver*-Noun), *ver**stopf**en* 'to block' (*ver*-Verb), and *ver**geud**en* 'to waste' (*ver*-Bound), respectively. The template [*ver*[ROOT]*(e)n*] can serve to show the commonality of these forms, which, from a descriptive point of view, differ only in their roots. This, in turn, provides a controlled framework in which the effects of root differences could be systematically explored. The results of a series of priming tasks, lexical decision tasks, and meta-linguistic judgment tasks suggest that morphology plays a role in the lexical processing of these verbs. More specifically, differential effects across the four subsets suggest the importance of morpheme salience. However, these two factors are also influenced by the type of stimulus and task employed. Overall, this suggests the existence of two kinds of internal structure for *ver*-verbs: a hierarchical right-branching structure for items in the Verb and Bound subsets, and a flat structure for items in the Adjective subset. Items in the Noun subset are split between those two alternatives as a function of base type.

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Gratiam dicit plurimam,

MKS

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# CHAPTER 1

# INTRODUCTION

## 1.0. The mental lexicon

How might complex words be represented and processed in the mind? Despite considerable research efforts during the past three decades, there is still no agreement in the psycholinguistic literature as to the organization of complex words such as English *disappeared* in the vast repository of words in the mind known as the mental lexicon (McQueen & Cutler, 1998). This is not necessarily surprising given the complexity of human language processing. The mental lexicon has to accommodate tens of thousands of words (or possibly even more) in any given language, including phonological, morphological, semantic, and syntactic information about these items in what are commonly called lexical entries (Emmorey & Fromkin, 1988; Zimmer, 1985). Furthermore, everyday experience and experimental results (e.g., from word association tasks) indicate that the human word-store not only contains information about individual words but also provides information about the relationships that different words can have among each other (Greber, 1997; Kess, 1992). Lastly, but perhaps most importantly, the language use of normal speakers suggests that all the information in the mental lexicon "is organized to function effectively in the millisecond time domain without conscious intervention" (Libben & Jarema, 2002, p. 2; but see Badecker & Caramazza, 1998, for an overview of how acquired language deficits affect language processing in impaired speakers).

In short, the breadth of linguistic information to be incorporated in the lexical entry for each word, the complexity of links between the entries for different words, and the subconscious nature of language processing in general have made it difficult to come up with a universally accepted model of the mental lexicon. If one likens the mental lexicon to a library, the challenge researchers have faced can be captured in the following statement by German philosopher Arthur Schopenhauer: "A library may be very large; but if it is in disorder, it is not so useful as one that is small but well arranged". Given the usually effortless use of language by normal speakers, the (unimpaired) mental lexicon *is* useful and must therefore be well arranged. Hence, from its very early days onwards, the rationale behind psycholinguistic research has been to uncover the details of the arrangement that is the basis for the representation of words in the mind.

### 1.1. Conceptualizing the representation of complex words in the mind

Simple words such as *black, walk, go*, or *book* afford the opportunity to investigate the potential impact of, for example, semantic factors on representation. Thus, one might examine the existence of links between the mental representations of *walk* and *go*, given that both items belong to the group of verbs that express MOVEMENT. One might also examine the influence of syntactic factors by asking whether or not adjectives such as *black* are represented differently than either verbs such as *go* or nouns such as *book*. While the insight that can be gained from the investigation of simple words is important for a basic understanding of the organization of the mental lexicon, it is of only limited usefulness in understanding the representation of semantically and morphologically more complex lexical structures such as *walked*, *disable*, *disappear*, or *disappeared*.

In descriptive linguistic terms, the complex word *walked* consists of two morphological constituents, namely, the verbal root *walk* and the suffix *-ed*; *disable* comprises the prefix *dis-* and the adjectival root *able*; *disappear* consists of the prefix *dis-* and the verbal root *appear*; *disappeared*, finally, comprises three morphological constituents, namely, the prefix *dis-*, the verbal root *appear*, and the suffix *-ed*. Alternatively, or perhaps at another level, *disappeared* could also be said to consist of the verbal base *disappear* and the suffix *-ed*. The question that arises is whether or not the descriptive morphological structure proposed for these items is part of their mental representation. If the answer were negative, the arrangement of the mental lexicon would be homogeneous in the sense that both monomorphemic and multimorphemic words would be stored as single unanalyzed wholes (e.g., [WALK] and [DISAPPEARED]).[1] However, as Sandra (1994) argued, both the considerable number of multimorphemic words across languages and speakers' lexical creativity suggest "that the lexical processing system of language users is fairly well designed for dealing with polymorphemic words" (p. 228). This, in turn, would mean that the answer to the question asked above is positive, and, thus, that the organization of the mental lexicon is likely to display greater diversity and complexity (for evidence of morphological creativity, see, e.g., Domínguez, Cuetos, & Segui, 2000; Donalies, 2002; Greber, 1997).

[1] Henceforth, items referred to as descriptive examples are given in italics, whereas items referred to in terms of access and represention or as stimuli are given in small caps and square brackets.

Based on the considerations outlined above, three types of representation are conceivable for the complex word *disappeared*, namely, a single unanalyzed representation ([DISAPPEARED]), independent representations for each component ([DIS], [APPEAR], [ED] and/or [DISAPPEAR], [ED]), and integrated representations with internal structure ([[DIS][APPEAR][ED]] and/or [[DISAPPEAR][ED]]). Since these three representational types are not mutually exclusive in principle, two basic types of morphological links between representations would be imaginable, namely, (a) those between whole words and constituents and (b) those between constituents, as indicated below.

(a) whole-word/constituent link

In this case, there would be a link between [DISAPPEAR] and [DISAPPEARED] due to the common base constituent *disappear*.

(b) constituent/constituent link

First, there would be a link between [DISAPPEAR] and [DISAPPEARED] due to the common root constituent *appear*.

Second, there would be a link between [DISAPPEAR], [DISAPPEARED], and [DISABLE] due to the common prefix *dis-*.

Third, there would be a link between [DISAPPEARED] and [WALKED] due to the common suffix *-ed*.

One account based on the rationale outlined above is Bybee's (1985, 1988, 1995a, 1995b) Network Model. According to that author, words are, initially, stored as full forms in the mental lexicon and their internal morphological structure becomes apparent only through multiple comparisons to related words, i.e., through usage. Words are said to be related in the lexicon if there are lexical connections, i.e., if these lexical items share phonological and semantic properties. Consequently, lexical items with both strong phonological and semantic links are said to be more closely related than words where these links are fewer or weaker. Words displaying similar patterns in their phonological and semantic connections are said to emphasize each other, which leads to the emergence of schemata (or generalizations). The applicability of a schema is seen as a function of its defining characteristics and its lexical strength, i.e., its frequency (see Langacker, 2000, for another usage-based model).

Figure 1.1. below provides a schematic illustration of Bybee's model.

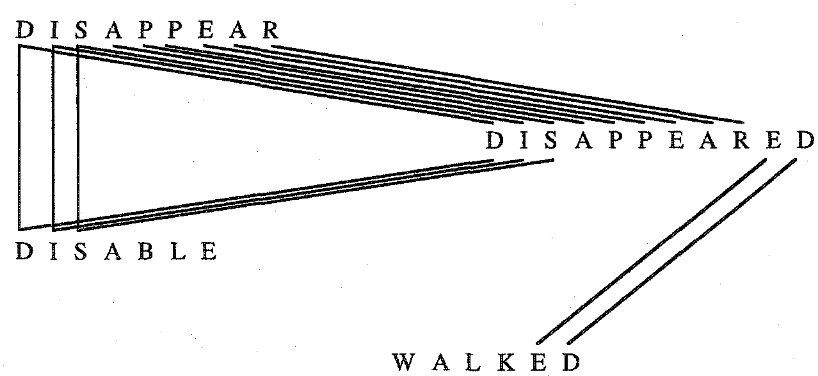


Figure 1.1. A schematic illustration of inter-word connections in Bybee's Network Model

It should be obvious that such an intricate arrangement of links could not be uncovered by investigating morphologically and semantically simple words only. Complex, multimorphemic words both in English and other languages, therefore, have been of particular interest in psycholinguistic modeling.

## 1.2. Conceptualizing the processing of complex words in the mind

Two notions in Bybee's Network Model of mental representation are of particular interest in the context of investigating the processing of complex words, namely, the idea of partial links between representations, and the emergence of schemata. The reason for this is that these notions allow for the investigation of the respective roles of four fundamental issues in the psycholinguistic literature on the processing of complex words:

(a) morphology,

(b) morpheme salience,

(c) stimulus effects,

(d) task effects.

The notion of partial links implies that the components of complex words and thus morphology might play a role in processing (see McQueen & Cutler, 1998, for an overview). The notion of the emergence of schemata based on similarity patterns implies that morpheme salience might be a factor in the processing of complex words.

Although these two notions are related, they do not denote the exact same phenomenon. In the present example, the role of morphology concerns the question of what the processing units of DISAPPEARED might be. If morphology did not affect processing at all, the processing unit of this complex word would be [DISAPPEARED]. By contrast, if morphology were a decisive factor in processing, the respective units would be [[DIS][APPEAR][ED]] and/or [[DISAPPEAR][ED]]. The notion of morpheme salience, on the other hand, concerns the question of the degree to which components embedded in composite words are easily retrievable. Furthermore, the question is whether some components are recognized more easily than others and whether this might affect processing. Figure 1.2. below illustrates how morphology and morpheme salience might play a role in the processing of a complex word such as DISAPPEARED.

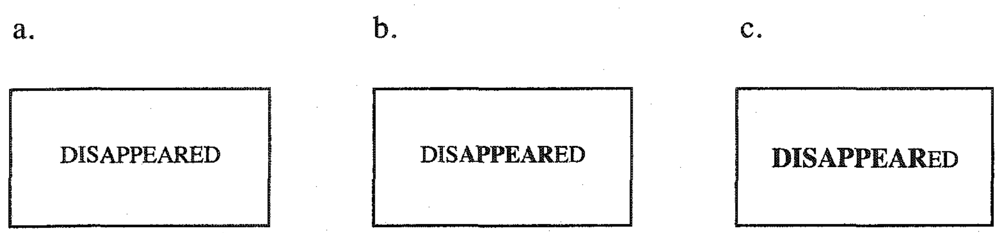


Figure 1.2. Three models of morpheme salience for DISAPPEARED

In (a) morphology does not play a role and neither does morpheme salience. By contrast, in (b) both factors play a role because the root APPEAR is identified as an embedded component (bold print). Furthermore, both factors also affect processing in (c). However, in comparison to the root component in (b) the base component DISAPPEAR in (c) is more easily retrievable, as indicated by the larger font (see also Beauvillain, 1994).

The issue of stimulus effects concerns the question of whether processing results for existing complex words such as DISAPPEARED might differ from those obtained for novel constructions such as **disjumped*. A strong argument in favor of the use of novel words in psycholinguistic experimentation is that in many cases these items are better suited than existing words to uncover the sensitivity of the word recognition system to morphology (e.g., Caramazza, Laudanna, & Burani, 1988). However, some researchers have voiced their concerns, arguing that the processing of nonsense or novel words does not necessarily allow for generalization to the processing of existing words (e.g., Henderson, 1989).

The issue of task effects concerns the question of whether processing results may differ as a function of the experimental paradigm employed. In order to avoid dealing with experimental artifacts, Derwing (1997) recommended to insure cross-methodological validation, i.e., employing qualitatively different tasks to investigate a given phenomenon. Along the same lines, Libben and Jarema (2002) pointed out that task effects may very well affect the conceptualization of lexical representation and processing.

## 1.3. Purpose of the present dissertation

The object of study in the present dissertation is a group of German prefixed verbs known as *ver*-verbs (e.g., *verbittern* 'to embitter') that belongs to the category of verbs with inseparable prefixes (VIPs). This category also includes verbs that take the prefixes *be*-, *ent*-, *er*-, and *zer*- (e.g., Dodd, Eckhard-Black, Klapper, & Whittle, 1996; Fleischer & Barz, 1995; Kühnhold, 1973; Schmidt, 1974; Schröder, 1992; Stepanowa & Fleischer, 1985). VIPs are characterized by descriptive inseparability, combinatorial variety, and internal word structure. The basic rationale behind the present dissertation is that these characteristics allow for a more detailed investigation of the four fundamental issues mentioned above, namely, the roles of morphology, morpheme salience, stimulus effects, and task effects in the processing of complex words.

*1.3.1. Investigating the role of morphology*

In contrast to most other prefixed verbs in German (e.g., Mungan, 1986), VIPs are said to be inseparable because the prefix cannot be detached from the simple component form of the composite verb construction without rendering the whole sentence ungrammatical (see Maylor, 2002, pp. 3-6, for a more detailed discussion of this issue). This contrast is illustrated below for the ordinary prefixed verb *anbellen* 'to bark at' and the VIP *verbellen* 'to keep barking at'.

(1) a. *Der Hund **bellt** das Pferd **an**.* [Infinitive: *anbellen*]

'The dog is **barking at** the horse.'

b. **Der Hund **anbellt** das Pferd.*

(2) a. **Der Hund **bellt** das Pferd **ver**.* [Infinitive: *verbellen*]

b. *Der Hund **verbellt** das Pferd.*

'The dog **keeps barking at** the horse.'

The question that arises is whether inseparability as a descriptive factor also affects the lexical processing and representation of these verbs. Are items such as *verbellen* accessed and represented in an inseparable holistic fashion ([VERBELLEN]) or rather as distinct morphological components (e.g., [[VER][BELL][EN]])?

*1.3.2. Investigating the role of morpheme salience*

The question of whether VIPs (and *ver*-verbs in particular) are accessed and represented in a holistic or componential fashion is closely linked to the issue of morpheme salience. The fact that individual prefixes have their own meaning and that the same simple component form can be combined with different prefixes to create separate composite verbs shows that VIPs are composite structures from a descriptive linguistic point of view, as is illustrated below with the simple component verb *sich setzen* 'to sit down' as a point of reference.

(3) *Die Kinder **setzen sich** auf die Bank.*

'The children **are sitting down** on the bench.'

a. *Die Soldaten **besetzen** das Dorf.*

'The soldiers **are occupying** the village.'

b. *Die Verbrechen **entsetzen** die Menschen.*

'The crimes **are horrifying** the people.'

c. *Die Mechaniker **ersetzen** die Batterien.*

'The mechanics **are replacing** the batteries.'

d. *Die Vorgesetzten **versetzen** den Beamten.*

'The superiors **are transfering** the public servant.'

e. *Die Chemikalien **zersetzen** das Metall.*

'The chemicals **are corroding** the metal.'

While such a high degree of combinatorial variety does not apply to all roots that can be used to form VIPs, this phenomenon nevertheless raises the question of the degree to which components embedded in composite structures are salient during processing.

This possibility is all the more intriguing in the case of *ver*-verbs. Although, on the surface, they all appear to look the same (e.g., *verbittern* 'to embitter', *verkleiden* 'to disguise', *verstopfen* 'to block', *vergeuden* 'to waste'), a closer inspection reveals (descriptive) differences in their internal word structure. Thus, one can putatively distinguish *ver*-verbs with adjectival constituents (e.g., *verbittern*), nominal constituents (e.g., *verkleiden*), verbal constituents (e.g., *verstopfen*), and bound constituents (e.g., *vergeuden*), as illustrated below (see also Baayen, Piepenbrock, & Gulikers, 1995; Belz, 1997; Schröder, 1992).

(4) *Die Beziehungen der beiden Länder ver**bitter**n.* [*bitter* 'bitter' Adj]

'Relations between the two countries are embittering.'

(5) *Die Kinder ver**kleid**en sich zu Fastnacht.* [*Kleid* 'garment' Noun]

'The kids are disguising themselves for carnival.'

(6) *Viele Autos ver**stopf**en die Landstrasse.* [*stopf* 'darn, sew' Verb]

'A lot of cars are blocking the country road.'

The existence of different descriptive root types embedded in composite *ver*-verbs allows for the investigation of whether these roots are recognized during processing and whether different root types might affect processing. If all *ver*-verbs were treated the same, a generic processing unit for *ver*-verbs in which components are easily interchangeable would be sufficient, as illustrated in Figure 1.3. below.

VER⟨...⟩(E)N

Figure 1.3. A generic processing unit for *ver*-verbs

If differences in the root type played a role in processing, separate processing units would be required, depending on whether *ver*-verbs were (a) deadjectival, (b) denominal, and (c) deverbal. This situation is illustrated in Figure 1.4.

| a. | b. | c. |
|---|---|---|
| VER⟨**BITTER**⟩$_{\text{ADJ}}$N | VER⟨**KLEID**⟩$_{\text{NOUN}}$EN | VER⟨**STOPF**⟩$_{\text{VERB}}$EN |

Figure 1.4. Root-specific processing units for *ver*-verbs

In this context *ver*-verbs with a bound component are a special case. Whereas the putative adjectival, nominal, and verbal constituents (here: roots) are lexical, the bound constituents are non-lexical from a synchronic point of view, as is illustrated in example (7b) below.

(7) a. *Sie ver**geuden** ihre Zeit mit Streitereien.* [**geud* '(?)' Bound]

'They are wasting their time engaging in quarrels.'

b. **Sie **geuden** ihre Zeit.*

The bound root can only be motivated from a diachronic perspective. In the present case, both the prefixed composite verb *vergiuden* and its corresponding simple component verb *giuden* 'to show off' are attested for as late as Middle High German (Drosdowski, 1989).[2] Hence, *ver*-verbs with bound components allow for the investigation of the influence of diachronic artifacts on the processing of *ver*-verbs.

In short, postulating a generic template [*prefix*[ROOT]*(e)n*] for VIPs in general and a generic template [*ver*[ROOT]*(e)n*] for *ver*-verbs in particular, suggests the possibility that subtle morphological differences in the internal structure of stimuli might impact on the way in which they are accessed and represented. In the case of *ver*-verbs, this would imply the existence of different types of representations, depending on the lexical class and the lexicality of the simple component form:

(a) deadjectival *ver*-verbs

[*ver*[BITTER]$_{ADJ}$*n*];

(b) denominal *ver*-verbs

[*ver*[KLEID]$_{NOUN}$EN], or [*ver*[KLEIDEN]$_{VERB}$];

(c) deverbal *ver*-verbs

[*ver*[STOPF]$_{VERB}$EN], or [*ver*[STOPFEN]$_{VERB}$];

(d) *ver*-verbs with bound components

[*ver*[GEUD]$_{BOUND}$EN], [*ver*[GEUDEN]$_{BOUND}$], or [VERGEUDEN].

Since *ver*-verbs constitute the largest group within the category of VIPs, comprising around 40% of the total (Schirmeier, 2003; Schröder, 1992), the focus of the present dissertation is on that particular group.

### *1.3.3. The investigation of stimulus effects*

The issue of stimulus effects concerns the question of whether the use of novel *ver*-verbs can lead to different processing results. In Chapter 8 of the present dissertation, the processing of existing *ver*-verbs such as VERBITTERN is compared to the processing of novel *ver*-verbs such as *VERBUNTEN (consisting of the unattested combination of *ver*-

[2] The Middle High German period *(Mittelhochdeutsch)* extended from *circa* AD 1050 to AD 1350 towards the end of which certain sound changes occurred (*iu* > *eu* /oi/), explaining the discrepancy between *vergiuden* and present-day German *vergeuden* (see Glück, 2000).

and *bunt* 'colored'). The rationale behind this comparison is that morphology and morpheme salience might play a more pronounced role in the case of novel *ver*-verbs, since it is reasonable to assume that no whole-word representations or processing units exist for these novel items.

### *1.3.4. The investigation of task effects*

The issue of task effects concerns the question of whether the use of different experimental paradigms to investigate *ver*-verbs leads to different results. In the present dissertation an array of experimental paradigms is used including both on-line techniques (to examine subconscious language processing) and off-line techniques (to examine conscious language processing). Five on-line techniques are employed (using the example *verarmen* 'to impoverish', *arm* 'poor' for illustrative purposes):

(a) root-to-whole-word priming [ARM-VERARMEN] (Experiment 1);

(b) base-to-whole-word priming [ARMEN-VERARMEN] (Experiment 2);

(c) whole-word-to-root priming [VERARMEN-ARM] (Experiment 5a);

(d) whole-word-to-base priming [VERSTOPFEN-STOPFEN] (Experiment 5b).

(e) simple lexical decision using four different "capitalization styles" for existing *ver*-verb targets and novel *ver*-verb targets (e.g., "VERBITTERn" *vs*. "verBITTERn" *vs*. "verBITTERN" *vs*. "verbittern"; Experiment 6, referred to as [CAPS]);

Furthermore, the following two off-line techniques are employed:

(a) meta-linguistic judgments on the potential etymological, morphological, or semantic connection between the members of *ver*-verb-ROOT pairs such as VERARMEN-ARM (Experiment 3, referred to as [ARM IN VERARMEN]);

(b) meta-linguistic judgments on the potential etymological, morphological, or semantic connection between the members of *ver*-verb-ROOT-*en* pairs such as VERARMEN-ARMEN (Experiment 4, referred to as [ARMEN IN VERARMEN]).

This variety of tasks has been selected in an effort both to minimize the risk of obtaining data that might be an experimental artifact based on the nature of a specific task only and to insure that various aspects of the access and representation of *ver*-verbs are illuminated.

## 1.4. Dissertation overview

The structure of the present dissertation is outlined below on a chapter-to-chapter basis.

Chapter 2 provides a detailed account of several major models of visual word recognition, with particular reference to the choice of stimuli and experimental techniques, and the role of morphological structure. Furthermore, this chapter provides a brief overview of previous accounts of *ver*-verbs. Information about experimental data on French prefixed verbs relevant to the present investigation and a distributional account of German *ver*-verbs also motivate the research questions guiding this dissertation.

Chapter 3 provides a description of Experiment 1 (referred to as [ARM-VERARMEN]) in which a root-to-whole-word priming paradigm is employed. Experiment 1 investigates whether the prior presentation of root primes belonging to the four different subsets (Adj *vs*. Noun *vs*. Verb *vs*. Bound) facilitates the processing of the *ver*-verbs in which they are embedded, and whether these primes display differences in their effectiveness.

Chapter 4 provides a description of Experiment 2 (referred to as [ARMEN-VERARMEN]) in which a base-to-whole-word priming paradigm is employed. Experiment 2 examines whether the prior presentation of base primes belonging to the four different subsets (Adj *vs*. Noun *vs*. Verb *vs*. Bound) facilitates the processing of the *ver*-verbs in which they are embedded, and whether these primes display differences in their effectiveness.

Chapter 5 provides a description of Experiment 3 (referred to as [ARM IN VERARMEN]) in which a meta-linguistic judgment task is employed. This experiment investigates how native speakers of German rate potential etymological, morphological, and semantic connections between *ver*-verbs and their putative roots on a 0-4 confidence scale. Experiment 3 functions as the off-line counterpart of Experiment 1.

Chapter 6 provides a description of Experiment 4 (referred to as [ARMEN IN VERARMEN]) in which another meta-linguistic judgment task is employed. This experiment examines how native speakers of German rate potential etymological, morphological, and semantic connections between *ver*-verbs and their putative bases on a 0-4 confidence scale. Experiment 4 functions as the off-line counterpart of Experiment 2.

Chapter 7 provides a description of Experiment 5a (referred to as [VERARMEN-ARM]) and Experiment 5b (referred to as [VERSTOPFEN-STOPFEN]). Whereas in Experiment 5a a whole-word-to-root priming paradigm is employed, the paradigm of choice in Experiment 5b is a whole-word-to-base priming paradigm. Experiment 5a investigates whether whole *ver*-verbs belonging to the four different subsets (Adj, Noun, Verb, Bound) prime their respective roots, and whether these primes display differences in their effectiveness. Thus, Experiment 5a functions as the reverse of Experiment 1. Experiment 5b specifically examines whether whole *ver*-verbs belonging to the Verb subset prime their respective bases. It thus functions as the reverse of Experiment 2 as far as the Verb subset is concerned.

Chapter 8 provides a description of Experiment 6 (referred to as [CAPS]) in which a lexical decision paradigm using four different "capitalization styles" is employed ("pref_root_cap", e.g., "VERBITTERn" 'to embitter'; "root_cap", e.g., "verBITTERn"; "root_suff_cap", e.g., "verBITTERN"; "no_cap", e.g., "verbittern"). Experiment 6 investigates the influence of the following factors during the visual word recognition of both existing *ver*-verbs (e.g., *verbittern*) and novel *ver*-verbs (consisting of the unattested combination of the prefix *ver*- and an existing constituent, e.g., **verbunten*, from *ver*-plus *bunt* 'colored'): the lexicality of the whole item (i.e., whether it is perceived as an existing word), the internal morphological structure of the whole item, the lexicality of the constituents, and the presence of different "capitalization styles".

Chapter 9 provides a summary of the findings of the present dissertation. Furthermore, an assessment of their implications for the structure and lexical processing of *ver*-verbs is given. Lastly, the findings are discussed in the context of the models introduced in Chapter 2.

# CHAPTER 2

# TOWARDS AN EXPERIMENTAL ACCOUNT OF GERMAN VER-VERBS

## 2.0. Introduction

Complex words (e.g., *disappeared* in English) have been of particular interest in psycholinguistic research on visual word recognition because they afford the opportunity of investigating, for example, the role of morphology. If morphology did not play a role in the access and representation of complex items, it would be reasonable to assume a homogeneous organization and treatment of complex and simple words (e.g., *go*) in the mind. If, however, morphology did play a role in lexical processing, the opposite would be the case such that complex and simple words might be part of a much more complicated structure in the mind along the lines of what, for example, Bybee (1985, 1988, 1995a, 1995b) has envisaged (see Figure 1.1.).

The variability of results obtained in psycholinguistic experiments probing the processing of complex words has led to the postulation of a number of models of lexical processing and representation, several of which are discussed in more detail below. While being reflective of different processing results, they are equally reflective of different schools of thought in terms of how they conceptualize the mental representation of words.

Although German *ver*-verbs possess a number of characteristics that make them interesting from the point of view of lexical processing, these items thus far do not appear to have been used extensively in psycholinguistic modeling. However, as will be shown below, recent research has provided important information enabling the experimental investigation of these complex items. These developments motivate the research questions guiding this dissertation, which are outlined at the end of this chapter.

First, however, several models of lexical processing are presented both to illustrate the complexity of lexical processing in general and to provide some initial motivation for the investigation of German *ver*-verbs.

## 2.1. Several models of lexical processing

The description of each of the models in this section is based on the following set of four specific questions:

(a) What are the basic claims of the model?

(b) What are the experimental results leading to these claims?

(c) What are illustrative examples for these claims?

(d) What are the advantages and disadvantages of the model?

*2.1.1. Taft and Forster (1975)*

Taft and Forster's (1975) model is based on three main claims. First, word recognition proceeds in a serial fashion. Second, multimorphemic words are subject to morphological decomposition. Third, morphological decomposition is mandatory and is attempted before lexical entries are contacted.[3]

These claims are based on the results of a series of lexical decision tasks in which participants had to decide whether or not certain stimuli were existing words in English. In the first experiment, stimuli included bound stems such as JUVENATE (from the prefixed word *rejuvenate*) and pseudo-stems such as PERTOIRE (from the monomorphemic word *repertoire*). Results indicated that, on average, bound stems such as JUVENATE took longer to reject as non-words than pseudo-stems such as PERTOIRE. Taft and Forster reasoned that this must have been the case because participants perceived stimuli of the JUVENATE type as being generally more word-like than stimuli of the PERTOIRE type. Furthermore, they hypothesized that stimuli of the JUVENATE type must have a representation in the mind, whereas stimuli of the PERTOIRE type do not. In other words, they argued that multimorphemic words such as *rejuvenate* are accessed in the mental lexicon via their stems (here: JUVENATE).

In the last experiment of the study, Taft and Forster employed whole-word stimuli consisting of the illegal combination of either a real prefix and a real bound stem (e.g., DE+JUVENATE to form DEJUVENATE) or the same prefix and a pseudo-stem (e.g., DE+PERTOIRE to form DEPERTOIRE). The results of this experiment revealed a pattern similar to that of the first, in that stimuli of the DEJUVENATE type took longer to classify as non-words than those of the DEPERTOIRE type. Taft and Forster interpreted this as additional support for their initial claim that multimorphemic words are represented via their stems. Furthermore, the increased processing cost for the non-words of the DEJUVENATE type was seen as indicative of morphological decomposition: since the stimuli had been matched for frequency, this additional cost was assumed to have occurred as a function of the salience of the stem. By the same token, the relatively faster processing of the non-words of the DEPERTOIRE type was seen as the consequence of misparsing pseudo-prefixed DEPERTOIRE into DE and PERTOIRE.

Based on these findings, Taft and Forster proposed the following model in which stimuli are processed in serial fashion according to a checklist procedure (see also Taft & Forster, 1975, p. 644). In the case of DEJUVENATE, five such checks would be necessary to be able to make a lexical decision. The first check would be to verify whether the stimulus was divisible into prefix and stem. Since this is the case, the next check would consist of looking for a lexical entry for the stem. Again, the outcome would be positive and trigger the next step, namely, to verify whether prefix and stem are compatible. This time, however, the outcome would be negative and lead to a new search for a lexical entry for the stem. Since no such entry would be found, a search for an entry for the whole word would be initiated. The failure to locate such an entry, finally, would lead to the decision of classifying DEJUVENATE as a non-word.

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[3] Libben (1994) conceptualizes morphological decomposition as "a mechanism of morphological parsing which operates in a left-right fashion but allows for the excitation of all lexical entries in a multimorphemic string" (p. 382). See also Taft (2003).

In the case of DEPERTOIRE only three checks would be necessary to make a lexical decision. The first check would be to verify whether the stimulus was divisible into prefix and stem. Since the outcome would be positive, a search for a lexical entry for the stem would be initiated. However, as no such entry exists, the search would now concentrate on finding a lexical entry for the whole word. The negative outcome of this final search would lead to the decision of classifying DEPERTOIRE as a non-word.

As this description indicates, DEJUVENATE takes longer to reject as a non-word than DEPERTOIRE because for the former five checks are necessary until a lexical decision can be made, whereas for the latter only three such steps would be required. The first check illustrates the occurrence of morphological decomposition "prior to lexical search" (p. 643), since such a decomposition is the first step in processing. The second check illustrates the claim that multimorphemic words are accessed via their stem. The fact that searching for a lexical entry based on a whole word is the final check applied only when other strategies fail, illustrates that whole-word processing is a fall-back strategy in this model.

Taft and Forster's (1975) model has been seminal as far as the investigation of the morphological processing of multimorphemic words is concerned. Although endorsing a model involving mandatory morphological decomposition, these authors also gave an outlook on possible alternative accounts that were actually realized in subsequent research: a model based on whole-word processing in which decomposition serves as a fall-back strategy (see Butterworth, 1983, Section 2.1.2. below), and a model in which whole-word and constituent-based processing occur in parallel (see Caramazza, Laudanna, & Romani, 1988, Section 2.1.3. below).

Still, Taft and Forster's model also raises some questions. One concerns the status of the prefixes of multimorphemic words and another the assumptions underlying the concept of a morphological analysis "prior to lexical search" (p. 643). As to the first question, the initial check in this model requires a prefix to be "discarded temporarily" (p. 644), whereas a subsequent check requires a decision concerning the compatibility of a prefix and a stem. In this context the authors do not make it clear where the subcategorization information critical for the assessment of the compatibility of prefix and stem comes from. Is it part of the stem-based lexical entry but becomes available only at this point? Or is there a separate representation for the prefix, some kind of "prefix store", that is linked to the representation of the stem? This question is also important as to the concept of a morphological analysis "prior to lexical search: Where does the processing system get the information about prefixes in order to identify them? It is only in the general discussion of their paper that the authors mention in passing that an item such as *rejuvenate* could also be stored as an integrated representation with internal structure such as [RE[JUVENATE]] or [RE[JUVEN][ATE]] instead of simply [JUVENATE]. Taft and Forster conclude that these possibilities "differ *only* in assumptions about how the prefixes are represented in the lexical entry" (p. 645; italics added). In light of the issues raised above and the discussion of mental representations and their links in Section 1.1., however, these differences are more than minor details. Only if one assumes representations such as [RE[JUVENATE]] or [RE[JUVEN][ATE]] can the issue concerning the status of the prefixes and the nature of the morphological analysis "prior to lexical search" (p. 643) be illuminated in a satisfactory way.

In the next section, Butterworth's (1983) full-listing approach is described, which instantiates one of the alternative models mentioned by Taft and Forster (1975).

*2.1.2. Butterworth (1983)*

Butterworth's (1983) model is based on two main claims. First, the mental representation and processing of words draws on a full listing of simple and multimorphemic words, i.e., both simple and multimorphemic words have their own lexical entries. Second, the use of decomposition and lexical rules permitting the computation of regular multimorphemic words from their constituents is a fall-back strategy, i.e., a strategy used only when the primary full listing approach fails.

These claims are primarily based on that author's considerations regarding the preferable structure of lexical representations (LRs), i.e., those entities "that could be ... candidate[s] for the form of representation of words in the mind" (Butterworth, 1983, p. 257). Butterworth explains in more detail:

> Intuitively, LRs are those linguistic elements that are permanently listed in the heads of speakers of a language, and which serve as terminal elements in grammatical constructions. Linguists have traditionally been concerned to characterize regularities in such a listing in order to minimize the number of items needed, and to capture speakers' knowledge about the relations among items listed. From a statement about such regularities one can set a lower theoretical bound to the number of items a speaker needs, but one cannot set an upper bound. For example, a rule which adds *-s* to form the third person singular *sings* from the

> base from *sing*, and to other appropriate verb forms, theoretically allows speakers to list only *sing* plus the general rule for adding *-s*. Psychologically, however, we are concerned ... not with a theoretically minimal listing, but with the listing that speakers actually employ. (p. 258)

In short, Butterworth seems to reject an organization of LRs based on decomposition, minimal listing, and rules that allow for the identification of links among words (see Section 1.1. above). Instead, he favors LRs that display psychological validity in the sense that they matter to speakers and can be witnessed in actual language use.

To illustrate his opposition to an obligatorily decompositional account based on minimal listing and rules, Butterworth mentions cases that appear to pose problems for such an account. One such case is the polysemous verb *induce* and its derivations. For example, *induce* in the sense of 'persuade' can have a corresponding derivative *inducement* meaning 'something that persuades'. However, this derivation is not possible when *induce* is employed in the sense of 'produce current'; in this case the appropriate nominal form has to be *induction* meaning 'process/result of producing current'. Furthermore, *induction* can also mean 'process/result of inference' when it is derived from *induce* 'infer from cases'. Butterworth sees this as a challenge for minimal listing accounts because it "would require derivational rules to be sensitive to meaning and not just to lexical identity" (p. 264).

Concerning the structure of lexical representations (i.e., lexical entries) in a minimal listing account, then, Butterworth (1983) sees a need for the following five components (see p. 262): first, a list of simple forms (e.g., *sing*); second, a set of rules allowing for the computation of all regular complex forms (e.g., 3rd person singular present V → V + *-s*); third, a list for irregular complex forms (possibly with a tag indicating where rules are not applicable, e.g., past participle V → *sung*); fourth, a set of syntactic rules dealing with subcategorization frames (e.g., to be V + *ing*); fifth, a set of semantic rules for complex words.

By contrast, Butterworth suggests the following arrangement for lexical entries in his full-listing account: "a form (e.g. *sings*) associated with a meaning (e.g. *sings'*, which is intended to denote the meaning of *sings*), a major category (V), and a list of suitable syntactic contexts, or subcategorization frames" (1983, p. 262).

In order to support his full-listing account, Butterworth provides a review of empirical literature as it pertains to the "full-listing hypothesis" (FLH), "unit types" (for lexical representations), "modality-specific lexical representations", and the "organization of lexical representations". Under the heading "full listing hypothesis", for example, the author introduces evidence for speech errors involving affixation. Although these data could actually be seen as pointing towards a decompositional, rule-based account, Butterworth states: "A supporter of FLH is not forced to deny that affixing rules are unknown to speakers (as opposed to linguists), but only that they are not *routinely* [italics added] used" (1983, p. 269). Similarly, under the heading "unit types" the author presents evidence that would be compatible with a decompositional model endorsing minimal listing and the use of rules. Still, Butterworth's assessment reflects a hesitation to acknowledge this:

> Very little evidence has emerged from studies of any of the modalities which would point to units [for lexical representations] other than words. The most problematic data come from speaking and writing, where subjects produce errors

> that are not real words. How can such errors arise is [sic] subjects have only a listing of word-forms? I have suggested that rules might be used as *fall-back* [italics added] procedures. (1983, pp. 279-280)

As this quotation underlines again, Butterworth sees full-listing as the genuine approach to the mental representation and processing of words.

One of the merits of Butterworth's model is its focus on the possible structure of mental representations since these are a key component as far as word recognition is concerned. In this respect, it differs from Taft and Forster's (1975) model, which puts more emphasis on the mechanisms guiding lexical access than on a detailed discussion of mental representations as such. Butterworth's goal to focus on lexical representations that have psychological validity in the sense that they can be witnessed in actual language use is equally laudable.

However, there are also severe limitations to Butterworth's approach. One of them directly relates to the issue of psychologically valid representations. As mentioned above, under the heading "unit types" Butterworth reports on experimental and other empirical data, for example speech errors, that could be interpreted as being compatible with a minimal listing account. Although, by his own admission, these constitute "the best evidence" for morpheme-based lexical representations, he thinks this evidence "can be explained away" (1983, p. 289). This point raises the question of how committed Butterworth is to the goal of uncovering psychologically valid lexical representations. Data from speech errors such as the ones mentioned above can certainly be seen as the product of actual, albeit incorrect, language use. If *psychologically valid* is interpreted as 'what speakers actually employ' (see p. 258), why would such evidence have to be "explained away"?

Another related limitation concerns the issue of fall-back strategies. Although Butterworth generally dismisses the notion of a decompositional account based on minimal listing and rules and argues that "LRs are routinely accessed from a full listing", he concedes that "in certain circumstances - for new items, for items not accessible from the list for some other reason - ... rules may serve as fall-back procedure" (p. 263). In this context it is interesting to note that the postulation of fall-back procedures constitutes a weakening of the full-listing hypothesis. Furthermore, it is not clear from the description of a lexical entry based on the full-listing approach how these procedures would be incorporated. It is only later in the paper that Butterworth mentions the possibility "in a full listing for all forms to have an internal structure marking morpheme boundaries" (p. 273) and that "even if all words are listed, there may still be an organizational principle in the lexicon which groups compound forms under their base" (p. 288). At the same time, however, the author insists that data supporting the influence of morphological principles "do not compel us to accept the idea of grouping under a base, or some other heading" (p. 289). In principle, then, Butterworth insists on full-listing being the primary manner of representing words in the mind.

In the next section, Caramazza, Laudanna, and Romani's (1988) Augmented Addressed Morphology Model is described, which offers an architecture to reconcile the seemingly conflicting views of the minimal and full listing approaches.

*2.1.3. Caramazza, Laudanna, and Romani (1988)*

Caramazza, Laudanna, and Romani's (1988) model is based on three main claims. First, morphological structure plays a role in lexical processing. Second, lexical representations are based on the components of composite structures. Third, word recognition proceeds in a parallel activation fashion involving whole-word and morpheme-based access units.

More precisely, Caramazza et al. proposed the Augmented Addressed Morphology (AAM) Model. According to the authors the

> 'Addressed' part of the model's name reflects the assumption that morphological representations for known (previously experienced) words are not accessed through an active, pre-lexical decomposition (or parsing) of the orthographic input string; the 'Augmented' part of the model's name indicates that the model has been extended to include a procedure for access of words not previously experienced (novel words). (1988, p. 300)

A major assumption of the model is the existence of a parallel activation system such that "a letter string activates both whole-word representations (where available - that is, for known words) as well as the morphemes that comprise a word .... The orthographic representation that first reaches a preset threshold will activate its corresponding lexical entry" (Caramazza et al., 1988, p. 298). Crucially, however, these authors claimed that "the activation of a whole-word orthographic representation proceeds more rapidly than the activation of the combined morphemes that comprise the word" (Caramazza et al., 1988, p. 298).

The assumptions of the model were tested in three lexical decision tasks in which participants had to decide whether or not certain stimuli were existing words in Italian. In the first experiment, stimuli included four types of non-words:

(a) items such as CANTEVI consisting of the inappropriate combination of an existing stem (here: CANT 'sing') and an existing affix (here: EVI);

(b) items such as CANZOVI constituting non-decomposable forms;

(c) items such as CANTOVI consisting of the combination of an existing stem (here: CANT 'sing') and a pseudo-affix (here: OVI); and

(d) items such as CANZEVI consisting of the combination of a pseudo-stem (here: CANZ) and an existing affix (here: EVI).

Results indicated the following average pattern: stimuli of the CANTEVI type took significantly longer to reject as non-words than any of the other three types. Furthermore, error rates for the CANTEVI type were also significantly higher than the ones for the other types; stimuli of the CANZEVI type took significantly longer to reject as non-words than stimuli of the CANZOVI type. Finally, error rates for the CANTOVI type were significantly higher than the ones for the CANZOVI type. According to Caramazza et al.,

> these results may be interpreted as reflecting the involvement of different levels of representation in processing morphologically-decomposable and morphologically-nondecomposable nonwords; that is, these results are incompatible with the hypothesis that the only units of access to the lexicon are whole-word representations. Instead, it appears that the lexical access system does allow the direct activation of morphologically defined units - stems or roots and affixes. (1988, p. 308)

Thus, Caramazza et al. interpreted the results of the first experiment as indicating a general sensitivity of the word recognition system to the degree of morphological structure within non-words: the higher the degree of morphological structure, the more difficult it is to reject an item as non-word.

In the second experiment, these authors sought to gain more detailed insight into the mechanisms of representation and access. Caramazza et al. were particularly interested in testing assumptions related to the information necessary for the lexical access system to determine the legality of morpheme combinations. Therefore, the authors introduced two new types of non-words in the stimulus set:

(a) items such as CORRUTO consisting of the combination of the stem of an irregular verb (here: CORR from *correre* 'to run') and an affix (here: UTO) that, while belonging to the same conjugation, was appropriate for the stems of regular verbs only;

(b) items such as COPRUTO consisting of the combination of the stem of an irregular verb (here: COPR from *coprire* 'to cover') and an affix (here: UTO) that was inappropriate since it belonged to a different conjugation; and

(c) items of the CANZEVI, CANTOVI, and CANZOVI types familiar from the first experiment.

Results indicated the following average pattern: stimuli of the CORRUTO type took significantly longer to reject as non-words than any of the other four types; furthermore, error rates for the CORRUTO type were also significantly higher than the ones for the other types; the same two observations applied to stimuli of the COPRUTO type; furthermore, whereas rejection times and error rates were similar for stimuli of the CANZEVI and

CANTOVI types, both types took significantly longer to reject as non-words than stimuli of the CANZOVI type. Caramazza et al. interpreted these results as a replication and strengthening of the results obtained in the first experiment. Especially the fact that the partially decomposable stimuli of the CANZEVI and CANTOVI types yielded similar patterns, while at the same time being significantly different from the non-decomposable stimuli of the CANZOVI type was seen as endorsing the claim that morphological structure plays a role in the processing of complex items. The same applies to the phenomenon that the even more "morphological" CORRUTO and COPRUTO types showed significantly elevated latencies and error rates in comparison to these three types of stimuli. As to further details of access and representation, Caramazza et al. argued that the significant differences between the CORRUTO and COPRUTO types themselves indicate that whereas stems and affixes belonging to the same conjugation are linked (CORRUTO), this is not the case with stems and affixes belonging to different conjugations (COPRUTO). In the case of CORRUTO, these authors argued, the intra-conjugational links between the stem CORR and the affix UTO have to be inhibited since the stem belongs to the irregular verb CORRERE to which UTO cannot be added; this was seen as the reason for an elevated processing cost. On the other hand, this cost would not apply to COPRUTO since the stem and the affix belong to distinct conjugations with no links.

In the third experiment, Caramazza et al. sought to gain even more fine-grained insight into the mechanisms of access and representation. They were particularly interested in finding out whether there were differences between items belonging to major *vs.* minor stem classes. Therefore, the stimulus set now consisted of the following types of items:

(a) CORSUTO consisting of the combination of the *minor* stem of an *irregular* verb (here: CORS- from *correre* 'to run') and an affix (here: UTO) that, while belonging to the same conjugation, was appropriate for the stems of *regular* verbs only;

(b) items of the CORRUTO and COPRUTO types familiar from the second experiment.

(To recapitulate, the items of the CORRUTO type consisted of the combination of the *major* stem of an *irregular* verb (here: CORR- from *correre* 'to run') and an affix (here: UTO) that, while belonging to the same conjugation, was appropriate for the stems of *regular* verbs only; items of the COPRUTO type consisted of the combination of the stem of an irregular verb (here: COPR from *coprire* 'to cover') and an affix (here: UTO) that was inappropriate since it belonged to a different conjugation.)

Results indicated the strongest effects in the error analysis: items of the CORRUTO type yielded significantly higher error rates than the other two types (COPRUTO, CORSUTO). The results for these latter two did not differ significantly. According to Caramazza et al. these findings indicate that *minor* stems of irregular verbs such as CORS do not have links to affixes that, while being conjugation-appropriate, are correct for use with regular verbs only. On the other hand, *major* stems of irregular verbs such as CORR do have such links and, therefore, incur an elevated processing cost.

Caramazza et al. (1988) proposed an ambitious model that provides a comprehensive account of the role of morphology in lexical processing. However, one of the major assumptions of this account, the existence of a parallel activation system in which whole-word representations are activated faster than morpheme-based representations, is supported only by indirect evidence. This is because the investigation focuses on the processing of non-words (which can provide evidence only for morpheme-based access representations) and none of the three experiments examines the processing of existing words (which would be crucial in providing evidence for whole-word and morpheme-based access representations). All Caramazza et al. do is make reference to other studies in which existing words were used (unsuccessfully) to examine the effects of morphological structure in lexical processing (see p. 326). Furthermore, they mention the usefulness of whole-word and constituent frequency effects in the investigation of the processing of existing words to conclude that these effects are "consistent with predictions derived from the AAM model" (1988, p. 326). Hence, the corroboration for this particular aspect of the model is not completely compelling.

Apart from this weakness, however, the merits of Caramazza et al.'s (1988) model are considerable because the authors make explicit reference to a number of important issues. The fact that the model is "addressed" means that all known words and morphemes are assumed to have a representation. This makes it clear that no pre-lexical decomposition, i.e., parsing prior to the involvement of the lexical system in word recognition, is required. As the idea of pre-lexical decomposition has been somewhat controversial and a challenge to conceptualize since its inception in Taft and Forster's (1975) study (see Section 2.1.1. above), dispensing with it provides some clarity (see also McQueen & Cutler, 1998). This is especially true of the treatment of affixes (see also Babin, 1994, 1996, who advocates prefix activation rather than prefix stripping; Section 2.3. below). Furthermore, the "augmented" character of Caramazza et al.'s model makes it possible to deal with novel words and thus handle productivity in a principled way. Another merit of Caramazza et al.'s model is the distinction between two levels of processing, namely, an access level and a lexical-semantic level. As these authors elaborate,

> the only type of information captured at the level of the lexical access procedures in the AAM model is that contained in the surface representation of words - orthographic structure in the present case .... [L]exical/linguistic information is represented at the level of the orthographic input lexicon. It is at this level that information about the combinability of morphemes is specified. (1988, p. 323)

The postulation of these two levels is useful in terms of providing a unified account of results based on stimuli with varying degrees of morphological structure. It is also useful in explaining effects of productivity in the context of novel words.

The main advantage of Caramazza et al.'s (1988) model, therefore, is its principled and unifying character. Each experiment is motivated by specific hypotheses and predictions. Furthermore, from the beginning the authors explicitly put their model in the context of the two major competing models at the time, i.e., whole-word accounts along the lines of Butterworth (1983) (see Section 2.1.2. above) and fully decompositional accounts along the lines of Taft and Forster (1975) (see Section 2.1.1. above). This strategy certainly enhances the validity of their own model. Nevertheless, Caramazza et al. are also open to the possibility that the lexical processing system might be "of a radically different functional architecture" (1988, p. 330), namely, a connectionist one.

In Section 2.1.5. below, Plaut and Gonnerman's (2000) connectionist model, in which language-specific morphological characteristics play a central role, is described. First, however, a concise description of the so-called past-tense debate is given in order to illustrate how the connectionist approach differs from more traditional symbolic approaches.

*2.1.4. The past-tense debate: Rumelhart & McClelland (1986) vs Pinker & Prince (1988)*

The connectionist approach to lexical processing outlined in Rumelhart and McClelland (1986) triggered what has become known as the "past-tense debate", i.e., an intense exchange concerning the question of whether the representation and processing of the regular and irregular past tense forms in English can best be captured in a connectionist framework or in symbolic frameworks along the lines of the three models described above.

Rumelhart and McClelland (1986) proposed a connectionist model in which processing occurs within a pattern-association network that consists of an encoding network (for input), a decoding network (for output), and a pattern associator mediating between these two. Crucially, within the pattern associator simple neuron-like units are said to represent the phonemes of which words consist. Each of these units is associated with a connection weight and a modifiable threshold. Processing consists of computing the representation of a word by establishing a stable activation pattern, i.e., exceeding the thresholds of the component units of that word. The representation resulting from this computation is then compared to the correct representation that has been presented to the network in a prior training phase. If this mapping reveals discrepancies between the two, positive or negative adjustments are made to the unit weights of the computed representation. In this way, the network is said to be adjusting or learning over time. Most importantly, the connectionist network acquires regular and irregular past tense forms using the same basic mechanisms, which distinguishes it from symbolic accounts.

In response to Rumelhart and McClelland's (1986) connectionist model, Pinker and Prince (1988) argued in favor of a symbolic account, Words-and-Rules theory, to deal with the issue of how regular and irregular past tense forms in English are represented and processed in the mind. According to this approach, retrieving regular and irregular past tense forms involves accessing the lexicon and grammar in parallel. Whereas the lexicon is said to contain roots, affixes, and irregular forms, the grammar is said to contain abstract information on concatenation rules. Thus, the inflected past tense form of an irregular verb (e.g., HELD) would be looked up directly in the lexicon where it is linked to its regular stem (here: HOLD). Subsequently, an inhibitory link from the lexicon to the grammar would prevent the application of concatenation rules to the regular stem and the generation of an incorrect overregularized form (here: HOLDED). In the case of regular verbs (e.g., WALK), by contrast, the search for an inflected past tense form in the lexicon would be unsuccessful; therefore, links between the lexicon and the grammar would result in the grammatical processor applying the appropriate concatenation rules to the stem and the generation of a regular past tense form (here: WALKED). Thus, the representation and processing of regular and irregular past tense forms in this symbolic approach involves using different mechanisms. Also, in contrast to the connectionist approach, this approach postulates the *a priori* existence of mental representations for both forms and rules.

As a recent series of articles indicates (McClelland & Patterson, 2002a, 2002b; Pinker & Ullman, 2002a, 2002b), the controversy concerning the question whether a connectionist approach or a symbolic approach can best capture the representation and processing of the regular and irregular past tense forms in English is still continuing.

Meanwhile, updated versions of the connectionist approach have also been applied to other phenomena than past tense inflection (see Christiansen & Chater, 2001, for an overview). Plaut and Gonnerman's (2000) study, which is described in more detail below, used the connectionist framework to deal with the question: "Are non-semantic morphological effects incompatible with a distributed connectionist approach to lexical processing?"

*2.1.5. Plaut and Gonnerman (2000)*

Plaut and Gonnerman's (2000) model is based on three main claims. First, lexical processing can be seen in terms of facilitatory and inhibitory interactions among simple neuron-like units. Second, morphological processing mirrors a sensitivity to systematic mappings of form and meaning. Third, the overall structure of a language in terms of morphology has a decisive influence on lexical representation and processing.

These claims follow both from five general connectionist principles and from the results of two simulations carried out by these authors. The five connectionist principles underlying Plaut and Gonnerman's (2000) account are (a) DISTRIBUTED

REPRESENTATIONS, (b) SYSTEMATICITY, (c) LEARNED INTERNAL REPRESENTATIONS, (d) COMPONENTIALITY , and (e) ONE SYSTEM. Definitions for these principles are listed in Table 2.1.

Table 2.1. Five general connectionist principles and their definitions as given in Plaut and Gonnerman (2000, p. 457)

| Principle | Definition |
|---|---|
| DISTRIBUTED REPRESENTATIONS | Items are represented by patterns of activity such that similar items are assigned similar patterns |
| SYSTEMATICITY | Similar inputs tend to produce similar outputs; mappings that maintain similarity structure are easier to learn |
| LEARNED INTERNAL REPRESENTATIONS | 'Hidden' representations develop similarity structure midway between input structure and output structure |
| COMPONENTIALITY | Parts of the output may depend only on parts of the input; supports combinatorial generalization |
| ONE SYSTEM | All items are processed by the same set of weights; systematic and unsystematic aspects coexist but interact |

In their study, Plaut and Gonnerman were particularly concerned with the general connectionist claim that

> morphology is a characterisation of the learned mapping between the surface forms of words (orthography, phonology) and their meanings (semantics) .... To the extent that a particular surface pattern occurs in many words and maps consistently to certain aspects of meaning, the internal representations will come to reflect this structure and treat the pattern *componentially* - that is, represent and

process it relatively independently of the other parts of the word .... (2000, p. 448; italics in original)

However, in morphologically rich languages such as Hebrew that use non-concatenative morphology, the authors mentioned, there is evidence for morphological effects even if there is a lack of semantic similarity. One example is the root GDL that occurs in MIGDAL 'tower', GADOL 'big', and GYDUL 'tumor': MIGDAL and GADOL have both a morphological relationship (since they share the same root) and a semantic relationship (since 'big' is a semantic feature of 'tower'); by contrast, MIGDAL and GYDUL have only a morphological relationship. Bearing connectionist principles such as DISTRIBUTED REPRESENTATIONS and COMPONENTIALITY in mind, Plaut and Gonnerman (2000) investigated the question whether non-semantic morphological effects (such as those between MIGDAL and GYDUL) are incompatible with a distributed connectionist approach to lexical processing.

In two simulations, Plaut and Gonnerman employed a connectionist network that was trained to learn two artificial languages, one morphologically rich (analogous to Hebrew) and the other morphologically impoverished (analogous to English). Both languages consisted of a 1,200-word training corpus. The task was a paired priming paradigm which was used to investigate whether or not the network could produce facilitatory or inhibitory effects in reaction time (RT) in the context of identical, morphological, and control priming conditions.

In the first simulation, orthographic representations consisted of bisyllabic words, featuring a stem and an affix. As for semantic representations, there were four distortion levels. First, *transparent* representations kept all features of their transparent meanings.

Second, *intermediate* representations kept two thirds. Third, *distant* representations kept one third of their transparent meanings. Fourth, *opaque* representations kept none of these. Whereas in the morphologically rich language 720 words were transparent, in the morphologically impoverished language the same number of words was opaque. The remaining 480 words, featuring these four distortion levels, were shared by both languages and served as the critical items in the investigation.

Results indicated that the network acquired the morphologically rich language faster than the morphologically impoverished one: whereas it took 300 sweeps through the corpus to achieve a low error rate in the former, it took 600 sweeps to achieve the same rate in the latter. Furthermore, analyses of variance (ANOVAs) revealed significant main effects of RT for the following factors: *language* (morphologically rich < morphologically poor); *priming* (identical < morphological < control); *morphological transparency* (transparent < intermediate < distant < opaque). Thus, transparent morphological prime-target pairs such as RUNNING-RUNNER, to use English examples, were processed faster than intermediate morphological pairs such as DRESSING-DRESSER, which were, in turn, processed faster than distant morphological pairs such as TENDING-TENDER, and, finally, opaque morphological prime-target pairs such as CORNISH-CORNER. Importantly, the results also showed that priming for opaque items could be obtained only in the morphologically rich language

Plaut and Gonnerman (2000) interpreted these results in the context of the second and fifth connectionist principles mentioned above, namely, SYSTEMATICITY and ONE SYSTEM. Thus, the fact that the network acquired the morphologically rich language faster than the morphologically impoverished one is seen as a consequence of the higher level of systematicity of the former, which facilitates the process of mapping inputs and outputs. On the other hand, the fact that priming for opaque items was obtained only in the morphologically rich language is seen as a consequence of the one-system principle:

> If the overall language has relatively little morphological structure, as in English, then opaque items are free to develop fairly idiosyncratic representations, even though their surface forms happen to contain segments (e.g., CORN, -ER) that operate as morphemes in other contexts. Hence, processing one such item as a prime will have little impact on processing another as target, relative to non-affixed control primes. By contrast, in a language that is highly morphologically structured, the processing of the stem and pseudo-affix in opaque items is more strongly influenced by how these elements are handled throughout the rest of the language. (p. 472)

This argumentation was corroborated by an investigation of the hidden representations that mediate between inputs and outputs, which showed that these representations were more similar in the morphologically rich language.

In the second simulation, the structure of the morphologically rich and impoverished languages, respectively, remained the same as in Simulation 1, affecting 720 words of each 1,200-word training corpus. The remaining 480 shared by both languages, however, were now structured such that "semantic transparency varied in a graded manner within the set of words derived from each stem" (Plaut and Gonnerman, 2000, p. 475). This measure was thought to enhance the naturalness and, hence, the validity of the stimuli.

Results indicated that, again, the network acquired the morphologically rich language faster than the morphologically impoverished one, although it took slightly longer than in Simulation 1 (360 and 650 sweeps *vs.* 300 and 600 sweeps, respectively). ANOVAs revealed a replication of the effects obtained for Simulation 1 such that morphological priming was a function of semantic transparency and priming for opaque items could be obtained only for the morphologically rich language. Crucially, the "more natural" stimuli in Simulation 2 not only yielded a replication of the results of the first simulation, but also provided more pronounced patterns.

Still, even Plaut and Gonnerman themselves admit that there is room for improvement as far as their connectionist approach to language processing is concerned. They mention three points as critical: first, the need to approximate actual language systems to an even greater extent; second, the need to take into account type and token frequencies; and, third, the need to take into account other distributional properties relevant to language processing (see also Section 2.4. below).

Another question that arises in the context of connectionist modeling is how complicated the hidden representations that are responsible for the network's learning process can get. In particular, the question is to what extent information traditionally subsumed under the term *subcategorization frame* can be handled by these representations. Thus, could hidden representations capture the distinction between different parts of speech? Moreover, could these representations capture potential links between patterns of internal structure for complex words and potential processing effects related to that structure? Hence, could hidden representations capture the phenomenon that items possessing the internal structure [[*dis*][VERB][*ed*]] such as *disappear* might be processed differently from items possessing the internal structure [[*dis*][ADJECTIVE][*ed*]] such as *disabled*?

On the other hand, the connectionist approach also has a number of advantages that could be helpful in overcoming some of the classical challenges in modeling lexical processing. The connectionist principle of distributed representations that holds that words are represented as patterns of activity of neuron-like processing units, for example, calls into question the necessity of postulating elaborate abstract representations for words. As has been illustrated above (see Sections 2.1.1. to 2.1.3.), previous models have postulated a variety of such representations and there is a continuing debate in the literature concerning this point (e.g., Greber, 1997; McClelland & Patterson, 2002a, 2002b; McQueen & Cutler, 1998; Pinker & Ullman, 2002a, 2002b). Proposing simple neuron-like processing units could also circumvent issues of psychological validity that traditional accounts using elaborate representations have faced. Similarly, the ONE SYSTEM principle, according to which all items are processed within the same framework, eliminates the need to postulate distinct processing mechanisms for different kinds of words. Since such mechanisms would have to be motivated by a set of possibly elaborate assumptions, the connectionist approach might again provide more psychological validity.

Possibly the most appealing aspect of the connectionist approach from the perspective of morphological processing is the principle of COMPONENTIALITY, according to which the output may depend only on parts of the input. This principle, therefore, allows for the flexible treatment of a range of morphologically complex words, which is seen as an increasingly important issue in the literature on lexical processing (e.g., Babin, 1994, 1996; Frost & Grainger, 2000; Laudanna & Burani, 1995; Laudanna, Burani, & Cermele, 1994; Libben & Jarema, 2002).

*2.1.6. Summary*

Two types of models dealing with lexical processing have been described in detail: traditional symbolic models (Taft & Forster, 1975; Butterworth, 1983; Caramazza et al., 1988) and a connectionist model (Plaut & Gonnerman, 2000).

In general, the traditional symbolic models described above could be subsumed under the schematic model illustrated in Figure 2.1. below, as suggested by Drews, Zwitserlood, Bolwiender, and Heuer (1994).

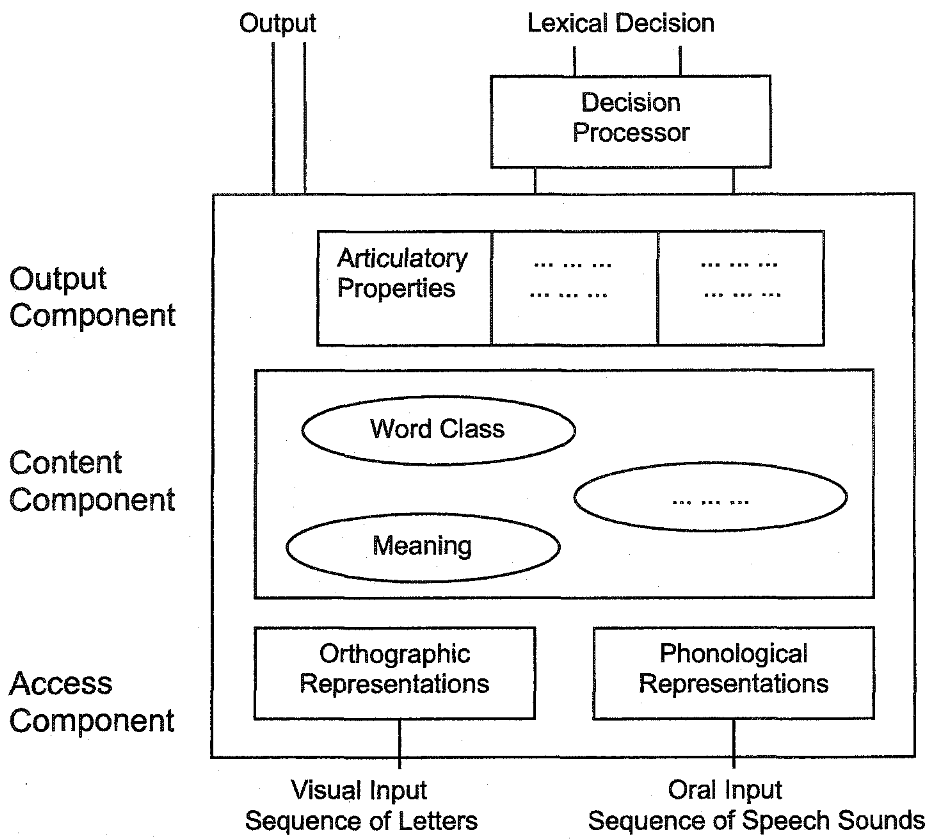



Figure 2.1. A generic model of word recognition and the mental lexicon (adapted from Drews et al., 1994, p. 274)

While this schematic model comprises all aspects of speech (production *vs.* comprehension, oral *vs.* visual), the aspect of visual word recognition is of particular interest here. According to this schematic model, visual stimuli (i.e., a string of letters) function as input for modality-specific access representations of the mental lexicon, where they are said to be checked against orthographic representations. If the incoming stimuli match any of the stored representations, this is assumed to trigger the activation of modality-independent central representations which provide, for example, details about the class or the meaning of a word.

In the context of the present dissertation both the structure of the orthographic representations in the access component *(Zugriffskomponente)* and the structure of the content component *(Inhaltskomponente)* are of particular interest because these issues bear directly on the question of what role morphology plays in lexical processing. Whereas Taft and Forster (1975) focused on the access component, postulating the existence of decomposed representations on this level, Butterworth (1983) focused on the content component. Caramazza et al. (1988) focused on both levels, postulating decomposed as well as whole-word representations in the access component and decomposed representations in the content component. By contrast, in connectionist models such as that of Plaut and Gonnerman (2000) the need for symbolic representations to account for language data is questioned. Rather, in these models processing results are accounted for in terms of patterns based on excitatory and inhibitory links between neuron-like nodes.

While all these models have made valuable contributions to a more comprehensive understanding of the role of morphology in lexical processing, it is thus far unclear how they would account for the lexical processing of more elaborate internal structures such as those manifested by German *ver*-verbs.

As already mentioned (Section 1.3.2. above) these items can be summarized as conforming to the template [*ver*[ROOT]*(e)n*], with the root being either a simple adjective, noun, verb, or a bound form (e.g., *verbittern* 'to embitter', *verkleiden* 'to disguise', *verstopfen* 'to block', and *vergeuden* 'to waste', respectively). From the perspective of symbolic models, the examination of the lexical processing of *ver*-verbs might be helpful in gaining a more detailed insight into the format of mental representations and processing units. From the perspective of connectionist models, which do not posit such representations, the investigation of the lexical processing of *ver*-verbs might be interesting in terms of insuring that the system captures the complexity of these composite structures.

## 2.2. Previous accounts of German *ver*-verbs

### *2.2.1. Descriptive accounts*

*Ver*-verbs have been an object of study as early as the 19th century when the Grimm brothers provided a detailed semantic account of these items in their *Deutsches Wörterbuch* (Dictionary of German) of 1854. The Grimms based their account on the claim that there are two overarching meanings for the prefix *ver-*:

> *[D]ie bedeutung spaltet sich nach zwei richtungen, sie bezeichnet a) ein hinweggehen, hinwegschaffen vom bisherigen wege, b) ein fortgehen, fortschaffen auf dem eingeschlagenen wege bis zum vorgesteckten ziele.*
>
> The meaning bifurcates such that it denotes a) a departure from the previous path, b) a continuation on the present path up to the predetermined endpoint. (1854/1956, p. 54; italics and non-capitalization of nouns in the original; translation by MKS)

They then presented an elaborate classificatory system for *ver*-verbs with the focus of that system being mainly on semantics. This seemed to have set a precedent for subsequent research because most of the relevant literature has a clear emphasis on semantics. Nevertheless, there is considerable variation in the way these descriptions carve up the semantic space of *ver*-verbs, i.e., the proposed classificatory schemes differ to varying degrees (for overviews, see Belz, 1997; Mungan, 1986).

As Schröder (1992) pointed out, prefixation has three functions, namely, semantic, syntactic, and morphological: the semantic function being reflected in changes in meaning (e.g., German *lernen* 'to learn' *vs. verlernen* 'to forget'); the syntactic function being reflected in changes in transitivity (e.g., intransitive *schlafen* 'to sleep' [*__NP] *vs.* transitive *verschlafen* 'to sleep through' [__NP]); the morphological function, finally, being reflected in changes in internal structure (take, e.g., the template [*ver*[ROOT]*(e)n*]).

While there is a substantial literature on *ver*-verbs both in the form of individual studies (e.g., Kim, 1983; Kühnhold, 1973; Mungan, 1986; Schröder, 1988a, 1988b, 1988c, 1988d) and of dictionaries (e.g., Deutsche Akademie der Wissenschaften, 1956 [Grimm & Grimm, 1854]; Müller, 1985; Wahrig, Krämer, & Zimmermann, 1984), these accounts are focused largely on the semantic and syntactic effects of adding *ver-* as a prefix. They were not designed with the aim of investigating the lexical processing of *ver*-verbs. Recently, however, Belz (1997) provided a cognition-based account of *ver*-verbs. Since such a treatment is psychologically more plausible than traditional descriptions that are more or less arbitrary (as witnessed in the variety of classificatory systems in the studies cited above), Belz's account is of potential importance for any experimental investigation of *ver*-verbs.

*2.2.2. An image-schematic account of German* ver-*verbs: Belz (1997)*

The basic question underlying Belz's work is the following: "What are the relations between the disparate senses of NHG [New High German] *ver-*?" (1997, p. 84).[4] Rather than answering this question on descriptive grounds, however, the three theoretical pillars of Belz's work are (a) prototype theory (e.g., Rosch, 1973), (b) contemporary metaphor theory (e.g., Lakoff & Johnson, 1980), and (c) the notion of image schema (e.g., Langacker, 1987, 1991). In Belz's words,

> prototype theory is a theory of categorization where category membership is based on family resemblance to a prototypical member. A conceptual metaphor ... is a unidirectional mapping between conceptual domains, which enables us to understand one domain in terms of another without thinking that the two domains are objectively similar. An image schema is a recurrent pattern used in structuring activity, which emerges from our bodily and perceptual experience. (1997, pp. 145-146)

The following example illustrates Belz's approach:

(8) *Er* ***verspielt*** *beim Lotto jede Woche zehn Mark ....*
'Every week he **wastes** ten marks on the lottery.'
(cited in Belz, 1997, p. 268)

This example can be understood in terms of the metaphor CONSUMPTION IS MOVEMENT ALONG A PATH, which is one instantiation of the prototypical image schema for *ver-*, MOVEMENT ALONG A PATH (see also the Grimm brothers, Section 2.2.1. above). In the

[4] The New High German period *(Neuhochdeutsch)* began *circa* AD 1650 and extends to the present day (see Glück, 2000).

present case, the image schema for *ver-* is instantiated in the following way: the simple verb *spielen* indicates the type of movement; the ten German marks constitute the entity that is being moved along a path from *existence* to *disappearance*; movement on this path thus indicates *consumption*.

In total, Belz (1997) distinguishes five prototypical meanings for the prefix *ver-* that are represented by image schemata and linked in a polysemy network. Each of these schemata is illustrated below with sentential examples for either literal or metaphorical meanings.

Schema 1 conveys the notion of DISPLACEMENT:

(9) *Unter den Augen Hunderter Zuschauer machten Ingenieure und Techniker auf dem Potsdamer Platz einen neuen Anlauf, den historischen Kaisersaal ... zu* ***versetzen****.*

'With hundreds of spectators looking on, engineers and technicians in Potsdam Square made another attempt to **move** the historic *Kaisersaal*.'

(cited in Belz, 1997, p. 152)

Schema 2 illustrated in (10) conveys the notion of PHYSICAL INTEGRATION:

(10) *Man* ***verschmilzt*** *Kupfer ... und zinkhaftige Erze ... zu Messing.*

'Copper and zinc-containing ores can be **blended** into brass.'

(cited in Belz, 1997, p. 219)

Schema 3 conveys the notion of PREVENTION OF ACCESS:

(11) *Ein Neubau* ***versperrt*** *uns jetzt den Blick auf den See.*

'A new building **blocks** our view of the lake.'

(cited in Belz, 1997, p. 237)

Schema 4 conveys the notion of MISTAKE:

(12) *Ich ... hatte mich bei dem Nebel* ***verfahren***.

'I got **lost** in the fog [**while driving**].'

(cited in Belz, 1997, p. 244)

Schema 5, finally, conveys the notion of THRESHOLD (in the sense that something is only tolerable and desirable to a certain extent):

(13) *Sie hat die Suppe ...* ***versalzen***.

'She **put too much salt** in the soup.'

(cited in Belz, 1997, p. 245)

In summary, besides giving this unified semantic account of the prefix *ver-*, Belz (1997) also touches upon the interface of semantics and syntax and the interface of semantics and morphology as they relate to *ver*-prefixation. Concerning the semantics-morphology interface, Belz notes: "Viewing the derivative base as a specification of some component of the image schema symbolized by the prefix runs contrary to traditional analyses of prefix semantics in Modern German which view prefixation as semantic modification of the verbal base" (1997, p. 279). In this respect, her approach can be seen as the mirror image of more traditional semantic accounts of *ver-* (e.g., Kühnhold, 1973; Mungan, 1986).

Crucially, Belz (1997) makes functional distinctions among composite *ver*-verbs on the basis of the lexical class of their simple component forms. Thus, she claims that deverbal bases such as *setzen* 'to put' in *versetzen* 'to move', or *fahren* 'to drive' in *verfahren* 'to get lost while driving' indicate the type of movement within the image schema for *ver-*. Deadjectival bases are said to indicate either the manner of movement (e.g., *untreu* ‘disloyal’ in *veruntreuen* ‘to embezzle’), or the endpoint of this movement (e.g., *besser* ‘better’ in *verbessern* ‘to improve’). Finally, denominal bases are considered to specify the unit of measure of the path (e.g., *Jahr* ‘year’ in *verjähren* ‘to expire’), the instrument which affects the change of location, either physical or metaphorical (e.g., *Schleier* ‘veil’ in *verschleiern* ‘to veil’), or the substance with which something comes into contact (e.g., *Gold* ‘gold’ in *vergolden* ‘to gold-plate’).

Belz’s cognition-based claim that the different component forms from which composite *ver*-verbs can be derived (adjectives, nouns, and verbs)[5] have different functional roles is relevant to the present dissertation in two important ways. First, it increases the psychological plausibility of the argument that *ver*-verbs possess the internal morphological structure [*ver*[ROOT]*(e)n*] (see Section 1.3.2. above). Second, it would also be compatible with the notion of morpheme salience in the sense that some functional roles might be more prominent than others. In short, Belz’s account provides a plausible cognitive basis for root-specific processing units for *ver*-verbs of the kind illustrated in Figure 2.2. (which reproduces Figure 1.4.).

| a. | b. | c. |
|---|---|---|
| VER⟨**BITTER**⟩$_{ADJ}$N | VER⟨**KLEID**⟩$_{NOUN}$EN | VER⟨**STOPF**⟩$_{VERB}$EN |

Figure 2.2. Root-specific processing units for *ver*-verbs

[5] In Belz’s account *ver*-verbs featuring bound elements, e.g., **geud* in *vergeuden* ‘to waste’, are interpreted as lexicalized forms.

While Belz's findings are intriguing, they still need to be corroborated in psycholinguistic experimentation. As the results of Babin's (1994, 1996) studies on French prefixed verbs indicate, the internal structure of composite verbs might very well play a role in lexical processing.

### 2.3. The access and representation of French prefixed verbs: Babin (1994, 1996)

In a series of lexical decision tasks and masked priming tasks, Babin (1994, 1996) investigated the access and representation of a similar set of prefixed and pseudo-prefixed verbs in French. More precisely, the prefixed verbs consisted of the following three categories:

(a) PN: denominal, e.g., *débourser* 'to pay' (from *bourse* 'bag'),

(b) PV: deverbal, e.g., *regonfler* 'to inflate again' (from *gonfler* 'to inflate')

(c) PNV: both denominal and deverbal, e.g., *recoller* 'to glue again' (from *colle* 'glue' and *coller* 'to glue').

The results of the lexical decision tasks indicated a differential pattern of response latencies that was attributed to the differences in morphological structure. Whereas deverbal stimuli such as REGONFLER took the longest to recognize, stimuli such as RECOLLER that were interpretable as both denominal and deverbal were recognized the fastest. In order to account for this difference, Babin postulated "double activation" for the items derivable from both nouns and verbs, which would speed up recognition. In general, Babin interpreted these results as evidence in favor of the notion of morphological decomposition and the importance of morphological structure in lexical processing.

The results of the masked priming tasks indicated a differential pattern of facilitatory and inhibitory effects depending on both the internal structure of the target and the structure of the prime. Whereas priming targets of the PNV type (e.g., RECOLLER) and PN type (e.g., DÉBOURSER) with their roots (here: COLLE/COLLER and BOURSE, respectively) led to inhibition, there was facilitation when these same targets were primed with a multimorphemic word containing the same stem (e.g., DÉCOLLER 'to take off' and REMBOURSER 'to reimburse'). Targets of the PV type (e.g., REGONFLER) were strongly facilitated in all but one condition. On the basis of these results, Babin concluded that items of the PNV and PN types are more likely to have whole-word representations linked by morphological families, whereas items of the PV type are more likely to have individual representations for roots and prefixes.

A crucial conclusion drawn by Babin that is bearing directly on the investigation of *ver*-verbs is the following:

> *De plus, compte tenu des résultats obtenus au cours de ce travail, il semble qu'une théorie générale de l'identification des mots morphologiquement complexes, quel que soit leur statut, ne soit pas envisageable.* (1994, p. 333; italics added)
>
> Furthermore, based on the results obtained in the present study, it seems that a general theory of the recognition of morphologically complex words, whatever their status, is not easy to envision.

This statement suggests that in psycholinguistic experimentation it is not sufficient to merely acknowledge the involvement of morphology in lexical processing, but that the "micro structure" of morphology also needs to be taken into account. As already argued in Section 1.2. and again in the context of the discussion of Belz (1997) in Section 2.2.2., morpheme salience can be seen as an important part of this micro structure in the sense that characteristics of components appear to influence the treatment of the composite structures in which they are embedded. These characteristics are part of what are usually called *distributional properties*. Their importance is discussed in more detail below.

## 2.4. Distributional properties and lexical processing

Over the past several years, distributional properties, i.e., structural characteristics of words and their constituents and the occurrence of these items within a language, have been claimed to play an important role in the lexical processing of multimorphemic words. The argument for the importance of distributional properties has been made in a number of studies dealing with different languages. Thus, for example, in a study on the lexical statistics of Dutch and English, Schreuder and Baayen (1994) found that the ratio of prefixation and pseudo-prefixation in these languages would turn an obligatory mechanism of prefix stripping as postulated in Taft and Forster's (1975) model (see Section 2.1.1. above) into a rather inefficient tool due to frequent misparsings (e.g., English RE- in REALITY *vs.* RE- in REANALYSIS). In a series of investigations on Italian, Laudanna, Burani, and Cermele (1994) and Laudanna and Burani (1995) argued that prefixed words comprise a heterogeneous category from the point of view of representation and processing due to the potential influence of factors such as the overall number of types, the co-occurrence of affixes with different kinds of bases, or the various prefix/pseudo-prefix ratios. The argument in favor of the investigation of the morphological particularities of individual languages has been reiterated more recently by Frost and Grainger (2000). These authors see such particularities as different "experimental conditions", the employment of which creates the opportunity to gain a more comprehensive picture of the access and representation of multimorphemic words.

## 2.5. A distributional account of German *ver*-verbs: Schirmeier (2002a, 2002b, 2003)

Since the guiding principle in all the studies just mentioned is a thorough understanding of the lexical statistics of multimorphemic words, an adequate investigation of *ver*-verbs should, likewise, be based on a thorough knowledge of the numerical distribution of the patterns of these items. Therefore, the focus of the description below is on three distributional properties as they relate to VIPs in general and *ver*-verbs in particular:

(a) the overall number of types,

(b) the prefix/pseudo-prefix ratios,

(c) the relative frequencies of different root types.

The following description is based on a recent series of studies (Schirmeier, 2002a, 2002b, 2003) that investigated information contained in the CELEX lexical database (Baayen et al., 1995), more precisely the CELEX German lemma lexicon, which lists types. Whereas the overall number of types and the prefix/pseudo-prefix ratios are presented from a comparative perspective including all the five different VIP sets (*be-*, *ent-*, *er-*, *ver-*, and *zer-*), the relative frequencies of different root types are presented for the *ver*-set only, i.e., as they manifest themselves within that particular set. For the purpose of convenience, the overall results are summarized in Table 2.2. below.

Table 2.2. Breakdown of the number of items in five different sets of *ver*-verbs in the CELEX lexical database and selected distributional ratios

| | Individual Set | | | | | |
|---|---|---|---|---|---|---|
| Level of Analysis/Ratios | *be-* | *ent-* | *er-* | *ver-* | *zer-* | Total |
| Types | 1,313 | 365 | 683 | 1,643 | 153 | 4,157 |
| Verbal Types | 545 | 199 | 243 | 708 | 87 | 1,782 |
| Pseudo-Prefixed Verbal Types | 21 | 1 | 10 | 3 | 2 | 37 |
| Genuine VIPs | 524 | 198 | 233 | 705 | 85 | 1,745 |
| Complex VIPs | 131 | 43 | 20 | 131 | 7 | 332 |
| Simple VIPs | 393 | 155 | 213 | 574 | 78 | 1,413 |
| xA Subset | 21 | 16 | 42 | 72 | 1 | 152 |
| xN Subset | 138 | 68 | 23 | 196 | 12 | 437 |
| xV Subset | 234 | 71 | 148 | 306 | 65 | 824 |
| Genuine VIPs | | | | | | |
| /Total Verbal Types | (29) | (11) | (13) | (40) | (5) | --- |
| /Total GenuineVIPs | (30) | (11) | (13) | (40) | (5) | --- |
| Simple VIPs | | | | | | |
| /Total Genuine VIPs | (23) | (9) | (12) | (33) | (5) | --- |
| /Total Simple VIPs | (28) | (11) | (15) | (41) | (6) | --- |
| Simple VIPs (xA Subset) | | | | | | |
| /Total Simple VIPs | (2) | (1) | (3) | (5) | (<1) | --- |
| */Simple VIPs Individual Set* | *(5)* | *(10)* | *(20)* | *(13)* | *(1)* | --- |
| Simple VIPs (xN Subset) | | | | | | |
| /Total Simple VIPs | (10) | (5) | (2) | (14) | (<1) | --- |
| */Simple VIPs Individual Set* | *(35)* | *(44)* | *(11)* | *(34)* | *(15)* | --- |
| Simple VIPs (xV Subset) | | | | | | |
| /Total Simple VIPs | (17) | (5) | (11) | (22) | (5) | --- |
| */Simple VIPs Individual Set* | *(60)* | *(46)* | *(70)* | *(53)* | *(83)* | --- |
| *Pseudo-Prefixed Verbal* Types | | | | | | |
| */Verbal* Types *Individual Set* | *(4)* | *(<1)* | *(4)* | *(<1)* | *(2)* | --- |

Note. Figures indicate the number of types found in the CELEX German lemma lexicon. Numbers in parentheses indicate (rounded) percentages; percentages reflect the numerical values of the ratios mentioned in the left-most column. Percentages in italics reflect ratios within a particular Individual Set, while percentages in normal print reflect ratios across sets. The column for the *ver*-set has been highlighted in gray since the focus of the present study is on that particular set of *ver*-verbs.

*2.5.1. Overall number of types and prefix/pseudo-prefix ratios*

Determining the overall number of types for multimorphemic words featuring the same initial sequence or prefix provides a simple measure of the salience of that sequence or prefix (or, alternatively, its lack thereof) in the formation of multimorphemic words. Determining the prefix/pseudo-prefix ratios among the five different verb sets provides a measure of the prominence of genuine VIPs (that contain real prefixes) as opposed to verbs that merely contain non-morphemic homographic bigrams or trigrams (i.e., two-letter or three-letter strings) in word-initial position. Both of these distributional properties are thus intertwined.

The CELEX lexical database for German lists a total of 4,157 entries with the word-initial sequences or prefixes *be-*, *ent-*, *er-*, *ver-*, and *zer-*, which includes adjectival entries such as *verstockt* 'defiant', nominal entries such as *Bekenntnis* 'confession', and verbal entries such as *zersetzen* 'to corrode'. Out of the 4,157 entries, 1,782 (43%) are verbal entries. Furthermore, the vast majority of these, namely 1,745 entries (98%), are genuine VIPs, i.e., entries such as *zersetzen*, where the word-initial sequence *zer-* is an actual prefix and not a non-morphemic homographic trigram (or pseudo-prefix) such as in the Latinate form *zertifizieren* 'to certify'. Conversely, this means that the pseudo-prefixation rate for the total number of verbal entries is only about 2%.

The distribution of the 1,782 verbal entries containing any of the five word-initial sequences under investigation is as follows: the set containing the word-initial sequence *ver-* is the largest one with 708 entries (40% of the total); the set containing *be-* is the second largest with 545 entries (29%); this is followed by the set with the initial sequence *er-* comprising 243 entries (13%); the set containing *ent-* comprises 199 entries (11%);

finally, the set containing the word-initial sequence *zer-* is the smallest one with 87 entries (5%).

Taking into account only genuine VIPs, i.e., those instances of verbal entries in which the word-initial sequences constitute actual prefixes, the distribution among the respective 1,745 entries in the CELEX lexical database is as follows: the *ver*-set is the largest group, comprising 705 entries (40% of the total); the second largest group is the *be*-set, which contains 524 entries (30%); the *er*-set comprises 233 entries (13%); the *ent*-set contains 198 entries (11%); finally, the smallest group is the *zer*-set, which contains only 85 entries (5%). As can be seen, the percentages for genuine VIPs are almost identical to those for verbal entries as such, which means that instances of pseudo-prefixation are few.

The magnitude of the pseudo-prefixation rate within the five verbal sets is as follows: the verbal sets containing *er-* and *be-* have the highest rates with about 4% (10 instances/243 verbal entries, and 21/545, respectively); the set containing *zer-* has a rate of about 2% (2/87); both the sets containing *ent-* and *ver-* have very low rates of less than 1% (1/199 and 3/708, respectively).

Given the numerical distributions outlined above, it is reasonable to assume that the prefix *ver-* is the most frequent among this group of five prefixes. By extension, this also means that, based on the overall number of types (*not* individual type frequencies), the multimorphemic verbs of the *ver*-set as such can be assumed to be the most salient. Furthermore, as the prefix/pseudo-prefix ratios indicated, VIPs formed with *ver-* are the least likely to be subject to pseudo-prefixation. While the numerical salience of the *ver*-verbs implies that these items should have prominent mental representations, the low pseudo-prefixation rate implies that the processing of *ver*-verbs should be highly efficient due to a limited risk of misparsings. Thus, the combination of these two distributional properties distinguishes *ver*-verbs from the other sets of VIPs. The investigation of the internal structure of such sets in the next section is, therefore, limited to the *ver*-set (as is the remainder of this dissertation).

*2.5.2. Relative frequencies of different root types*

Determining the relative frequencies of different root types for the *ver*-set elucidates the patterns of morphological structure within this particular set and provides a measure of salience for the various patterns. In a number of previous studies (e.g., Fleischer, 1982; Kühnhold, 1973; Schröder, 1992) the morphological structure [*ver*[ROOT]*(e)n*] has been assumed in the description of *ver*-verbs. This template has already been mentioned earlier (see Section 1.3.2. above) in order to motivate the claim that *ver*-verbs can be said to have adjectival, nominal, verbal, and bound roots. Belz (1997) provided a plausible cognitive basis for this notion (see Section 2.2.2. above), and Babin (1994, 1996) provided experimental support for the importance of internal word structure in the processing of prefixed verbs (see Section 2.3. above).

Since the *ver*-verbs with bound roots are not overtly marked in the CELEX lexical database, only the following instantiations of the generic template [*ver*[ROOT]*(e)n*] are of interest in the present investigation:

(a) prefix plus simple adjectival root (xA)[6]

such as in *verbittern* (ver-*bitter*);

(b) prefix plus simple nominal root (xN)

such as in *verkleiden* (ver-*garment*);

(c) prefix plus simple verbal root (xV)

such as in *verstopfen* (ver-*darn*).

However, not all of the 705 genuine VIPs in *ver-* listed in the CELEX lexical database conform to the morphological template [*ver*[ROOT]*(e)n*] and its instantiations xA, xN, and xV. There are 131 cases (19%) where a pattern such as xxA (double prefixation) is instantiated instead, as, for example, with the complex *ver*-verb *verabscheuen* 'to despise'. The distribution of the remaining 574 simple *ver*-verbs (81%) that do conform to the xA, xN, and xV patterns is as follows. There are 306 simple *ver*-verbs such as *verstopfen* conforming to the xV pattern (henceforth called the Verb subset), which makes this the largest of the three subsets, comprising 53% of all the cases. The 196 simple *ver*-verbs that follow the xN pattern (the Noun subset) such as *verkleiden* account for 34% of the total. Finally, the least common of the three morphological patterns of interest is xA (the Adj subset) with 72 simple *ver*-verbs such as *verbittern* accounting for 13% of the total.

Given the numerical distributions outlined above, it is reasonable to assume that the Verb subset is the most salient among the three subsets of interest. Furthermore, one could assume that this salient subset lends itself better to constituent-based representation

[6] This notation has been adopted from the CELEX lexical database (Baayen et al., 1995): "x" stands for the prefix, and the second letter indicates the lexical class of the root of the prefixed verb.

and processing, thus reflecting the importance of the internal structure captured in the morphological template [*ver*[ROOT]*(e)n*]. By contrast, the Adj subset, which was the least salient, might lend itself better to holistic representation and processing, thus reflecting a less pronounced role of internal structure for these items. In other words, *ver*-verbs such as *verstopfen* might be accessed and represented as [*ver*[STOPF]*en*], whereas *ver*-verbs such as *verbittern* might be accessed and represented as [VERBITTERN].

Although the assumptions made above appear to be reasonable, they need to be corroborated in actual experimentation. The research questions guiding the experimental part of this dissertation are outlined in detail below.

## 2.6. Research questions

This chapter has provided both general information about a number of models of lexical processing and specific information relevant to the experimental investigation of German *ver*-verbs. Based on these pieces of information a set of five research questions has emerged, each of which is motivated below.

(a) Does morphology play a role in the lexical processing of *ver*-verbs?

*Ver*-verbs are inseparable from the point of view of descriptive morphology. This creates the opportunity of investigating whether descriptive characteristics of these complex words are reflected in lexical processing. On a more general level, this investigation would allow for the gathering of more evidence concerning the role of morphology in lexical processing. As the multitude of processing models suggested in the literature indicates, there is still no consensus in psycholinguistics when it comes to the details of the involvement of this factor.

(b) Does morpheme salience play a role in the lexical processing of *ver*-verbs?

*Ver*-verbs have a complex internal structure with four descriptive root types (adjectival, nominal, verbal, and bound). This creates the opportunity of investigating whether some of these components which are embedded in composite structures are more easily retrievable during processing than others. More generally, this phenomenon would imply the existence of root-specific processing units. Belz's (1997) cognition-based claim that the roots of *ver*-verbs show functional differences enhances the psychological plausibility of this argumentation. Babin (1994, 1996) provided experimental evidence that, at least in French, the lexical class of the components of prefixed verbs plays a role in processing. In a larger context, the investigation of *ver*-verbs might provide novel insights into the internal architecture of mental representations and processing units.

(c) Do stimulus effects play a role in the lexical processing of *ver*-verbs?

In the present dissertation both existing *ver*-verbs such as *verbittern* and novel *ver*-verbs such as **verbunten* are employed as stimuli. This creates the opportunity of investigating whether there are any differences in processing that might depend on the factor *lexicality*. As the discussion of models has shown, not all of them are based on data from both stimulus types. This has led to criticism within the psycholinguistic literature because it might create experimental artifacts that might impact on the conceptualization of lexical processing.

(d) Do task effects play a role in the lexical processing of *ver*-verbs?

In the present dissertation an array of on-line and off-line techniques is employed to insure that various aspects of the lexical processing of *ver*-verbs are investigated. As the discussion at the beginning of this chapter has revealed, many processing models are based exclusively on the results of chronometric techniques. On a larger scale, this might again have implications on the way lexical processing is conceptualized, because certain types of experimental techniques might only tap into certain aspects of a given phenomenon.

(e) How are *ver*-verbs structured?

This question allows for a summary of experimental results and for putting them into context.

# CHAPTER 3

# EXPERIMENT 1: MORPHOLOGICAL ROOT PRIMING

## 3.0. Introduction

The issues of whether morphology and morpheme salience play a role in the visual recognition of complex words have been identified as fundamental in psycholinguistic research (see Section 1.2.). In this context, three possible answers were presented: first, neither of these factors plays a role; second, morphology plays a role; third, morphology and morpheme salience play a role. These possibilities were then illustrated in Figure 1.2.. It was also shown that the morphological template [*ver*[ROOT]*(e)n*] seems to serve as a useful tool in the descriptive or theoretical analysis of *ver*-verbs. Moreover, Belz's (1997) claim that *ver*-verbs formed from different roots can be distinguished on cognitive-functional grounds was argued to enhance the psychological plausibility of the template [*ver*[ROOT]*(e)n*], which would allow for the postulation of root-specific representations and/or processing units (see Figure 1.4.).[7] However, to date, it is not clear whether this template plays a role in the actual subconscious processing of *ver*-verbs.

In the present experiment, therefore, a lexical decision task with morphological root priming was employed in order to investigate the psychological status of the template [*ver*[ROOT]*(e)n*]. On a micro scale, the rationale behind the experiment was the

[7] The following illustrative examples first introduced in Chapter 1 will be used throughout the remainder of this dissertation: *verbittern* 'to embitter' (*bitter* 'bitter'; Adj subset), *verkleiden* 'to disguise' (*Kleid* 'garment'; Noun subset), *verstopfen* 'to block' (*stopf* 'darn'; Verb subset), and *vergeuden* 'to waste' (**geud*; Bound subset).

following: (a) if the morphological template [*ver*[ROOT](*e*)*n*] plays a role in the subconscious processing of *ver*-verbs, the prior presentation of a morphological root prime such as BITTER should lead to a priming effect (processing time advantage) for a whole *ver*-verb target such as VERBITTERN, as compared to the prior presentation of a morphologically unrelated prime such as SAUBER 'clean'; (b) if differential priming effects across the various root types occur, this would suggest that the processing system is sensitive to the lexical class of the root constituents of *ver*-verbs, and, thus that it is sensitive to subtle differences in morphological structure. On a macro scale, the rationale was as follows: priming effects as described in (a) would suggest that, in general, morphology plays a role in the processing of *ver*-verbs, while priming effects as described in (b) would suggest that also morpheme salience is an important factor.

Furthermore, these pieces of information would be helpful in revealing the nature of the mental representations of the constituent morphemes and the full forms of *ver*-verbs and potential links between them. On the one hand, the strength of priming effects could be seen as a measure of the salience of particular mental representations. On the other hand, the occurrence of these effects in the context of a prime-target paradigm (e.g., BITTER-VERBITTERN) would indicate a mental link between the representations of target and the prime.

Figure 3.1. serves to illustrate the line of argumentation underlying this experiment.

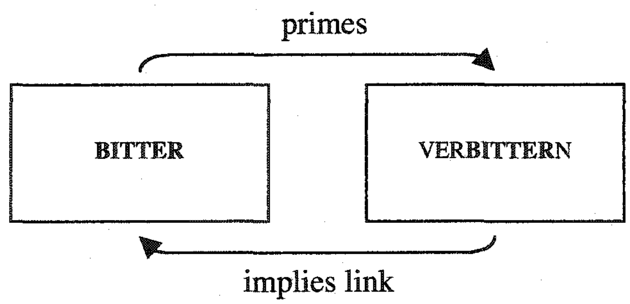



Figure 3.1. Conceptualization of root-to-whole-word priming in terms of the relationships between the mental representations of whole *ver*-verbs and their (presumed) roots

## 3.1. Method

### *3.1.1. Participants*

A total of 74 native speakers of German volunteered to participate. Fifty-three of these were enrolled in undergraduate Philology courses at Albert-Ludwigs-Universität in Freiburg im Breisgau, Germany. The remaining 21 participants were enrolled in Translation Studies at Zürcher Hochschule Winterthur in Zurich, Switzerland, and were mostly users of Swiss German in daily spoken conversation.

### *3.1.2. Materials*

The critical stimuli consisted of 72 *ver*-verb targets. Eighteen of these contained monomorphemic adjective roots and were dubbed the Adj subset, 18 contained monomorphemic noun roots (Noun subset), 18 contained monomorphemic verb roots (Verb subset), and, finally, 18 contained bound roots (Bound subset). The roots in these four subsets, together with unrelated controls, served as primes.

All of the *ver*-verbs were taken from the CELEX lexical database (Baayen et al., 1995). With the exception of the Bound items, the whole verbs (and their roots, see below) were subject to matching procedures in order to minimize the influence of several factors known to bias lexical processing (e.g., Chialant & Caramazza, 1995). Thus, as subsets, the whole verbs were matched as closely as possible on the factors of orthographic length, Mannheim frequency per six million (i.e., 5.4 million on written language and 0.6 million on spoken language), and Mannheim frequency per 5.4 million (written language only). All these frequency and length counts were taken from the CELEX lexical database. Matching was achieved by performing analyses of variance (ANOVAs) using the indicated control factors as dependent variable and Subset (Adj *vs.* Noun *vs.* Verb) as a between-group factor. Table 3.1. shows the results of these analyses. Since the basis for all frequency counts was the CELEX "German lemma lexicon" (which lists types), all counts are summed over inflectional variants.

Table 3.1. Results of the statistical matching procedures for whole *ver*-verbs

| | Subset | | | | |
|---|---|---|---|---|---|
| Measure | Adj | Noun | Verb | *F*-Value | *p*-Value |
| Mannheim | 22.4 (7.4) | 20.5 (4.1) | 22.9 (4.6) | $F_2(2, 51) = 0.05$ | .95 |
| Mann. Written | 20.6 (6.7) | 19.1 (4.0) | 22.0 (4.5) | $F_2(2, 51) = 0.08$ | .92 |
| Orth. Length | 9.6 (0.2) | 9.7 (0.1) | 9.8 (0.3) | $F_2(2, 51) = 0.31$ | .73 |

Note. *Ver*-verbs as whole-word forms were divided into three subsets of 18 roots each (Adj, Noun, and Verb) and matched as closely as possible on two frequency measures and orthographic length as listed in the CELEX lexical database (Baayen et al., 1995). Separate items ANOVAs were performed using the respective measures as dependent variables and Subset as a between-group factor. Numbers for Subsets indicate mean values. *Ver*-verbs belonging to the Bound subset were not included in this analysis due to their peculiar morphological status. Numbers in parentheses indicate standard errors.

In addition to these critical target stimuli, the stimulus set also contained fillers which were included both to achieve a balance between existing words and non-words and to minimize the probability of participants developing extraneous test-taking strategies. Hence, 36 nonsense verbs were created by joining the prefix *ver-* to invented elements functioning as roots, and the same number of nonsense words was created from these by using the pseudo-prefix *ker-* in place of the existing prefix *ver-*. Furthermore, 36 existing bisyllabic but non-prefixed words were added to the target set: nine of these were adjectives, nine of them nouns, and 18 of them verbs. Finally, another 36 nonsense words were created from these bisyllabic words by replacing the first letter of each item.

Each target was also associated with a prime. In the case of the 72 critical *ver*-verbs, two different primes were employed, namely, a root prime and a neutral prime. Thus, for the Adj, Noun, and Verb subsets, the root prime consisted of the free monomorphemic adjective, noun, or verb[8] that can be seen as the descriptive root constituent of each whole *ver*-verb (e.g., *bitter* in [*ver*[BITTER]*n*]). For the Bound subset, the root primes consisted of the synchronically unattested orthographically transparent root-like elements (e.g., **geud* in [*ver*[GEUD]*en*] 'to forget').[9] The neutral primes chosen for *ver*-verb targets were all monomorphemic and either adjectives, nouns, or verbs, in order to make them comparable to their root prime counterparts. In the case of the Bound subset, low frequency verbs served as neutral primes.

[8] In order to obtain monomorphemic words as the verb root primes, the unsuffixed "familiar imperative" form was used.

[9] Since none of these bound "roots" are used elsewhere in the language, they have much the same status as pseudo-elements (although three of them, DAMM, DERB, and SEHR were accidentally homographic with independent forms that are completely unrelated to the derived verbs in question).

Matching procedures for the primes involved (a) balancing the different subsets of root primes and the different subsets of neutral primes among each other, and (b) achieving a balance between the different subsets across the neutral and root types. The following factors were involved in this procedure: orthographic length, family size, family frequency[10] and the same two Mannheim frequency measures mentioned above for the critical targets. A balance was achieved by performing the same type of ANOVAs already used for the *ver*-targets. Table 3.2. and Table 3.3. show the results of the analyses of the root and neutral primes, respectively. Critically, neutral primes were semantically unrelated both to their root prime counterparts and to the whole *ver*-verbs themselves.

Table 3.2. Results of the statistical matching procedures for root primes

| | Subset | | | | |
|---|---|---|---|---|---|
| Measure | Adj | Noun | Verb | *F*-Value | *p*-Value |
| Family Size | 9.8 (2.6) | 12.2 (2.1) | 10.5 (1.6) | $F_2(2, 51) = 0.32$ | .73 |
| Fam. Frequency | 162.2 (52) | 169.8 (34) | 173.8 (34) | $F_2(2, 51) = 0.02$ | .98 |
| Mannheim | 146.4 (45) | 125.0 (26) | 141.7 (37) | $F_2(2, 51) = 0.09$ | .91 |
| Mann. Written | 131.1 (38) | 119.4 (25) | 131.6 (33) | $F_2(2, 51) = 0.05$ | .96 |
| Orth. Length | 4.9 (0.2) | 5.3 (0.1) | 4.9 (0.3) | $F_2(2, 51) = 0.82$ | .45 |

Note. Root primes in the Adj, Noun, and Verb subsets were matched as closely as possible on four frequency measures and orthographic length as listed in the CELEX lexical database (Baayen et al., 1995). Separate items ANOVAs were performed using the respective measures as dependent variables and Subset as a between-group factor. Numbers for Subset indicate mean values. The orthographically transparent root-like elements of the Bound subset were not included in this analysis due to their peculiar morphological status Instead, they were paired with monomorphemic real words of exact orthographic length and Mannheim frequencies of zero. Numbers in parentheses indicate standard errors.

[10] See de Jong, Schreuder, and Baayen (2000) for more details on the relevance of family size and family frequency in lexical processing.

Table 3.3. Results of the statistical matching procedures for associated neutral primes

| | Subset | | | | |
|---|---|---|---|---|---|
| Measure | Adj | Noun | Verb | *F*-Value | *p*-Value |
| Family Size | 7.9 (2.1) | 10.8 (1.4) | 10.8 (1.2) | $F_2(2, 51) = 1.09$ | .34 |
| Fam. Frequency | 123.2 (29) | 158.3 (28) | 158.1 (31) | $F_2(2, 51) = 0.47$ | .63 |
| Mannheim | 126.3 (26) | 130.6 (27) | 134.4 (28) | $F_2(2, 51) = 0.02$ | .98 |
| Mann. Written | 118.0 (25) | 123.5 (26) | 124.1 (26) | $F_2(2, 51) = 0.02$ | .98 |
| Orth. Length | 4.9 (0.2) | 5.3 (0.1) | 4.9 (0.3) | $F_2(2, 51) = 0.82$ | .45 |

Note. Associated neutral primes for the Adj, Noun, and Verb subsets were matched as closely as possible on four frequency measures and orthographic length as listed in the CELEX lexical database (Baayen et al., 1995). Separate items ANOVAs were performed using the respective measures as dependent variables and Subset as a between-group factor. Numbers for Subset indicate mean values. Numbers in parentheses indicate standard errors.

In an effort to keep the presentation procedure constant throughout the experiment, primes were created for the filler items as well. For the nonsense verbs in *ver-* and *ker-*, the invented root-like elements were employed. In the case of the existing bisyllabic non-prefixed adjective, noun, and verb targets, and also the nonsense targets derived from them, primes were mere duplicates of the first syllable of these items as shown in Table 3.5. below.

Table 3.4. shows the numerical organization of the final stimulus set, which consisted of a total of 216 items. As can be seen, a numeric balance was achieved both between existing words *vs.* non-words (108 items each), and between stimuli with *ver-* *vs.* stimuli without *ver-* (108 items each).

Table 3.4. Breakdown of the number and types of items in the stimulus set in Expt. 1

| Expected Answer | Root Type | Items with *ver-* | Items without *ver-* |
|---|---|---|---|
| "Yes" | Adj | 18 | 9 |
| | Noun | 18 | 9 |
| | Verb | 18 | 18 |
| | Bound | 18 | --- |
| "No" | *ver-/ker-*Nonse | 36 | 36 |
| | Other Nonse | --- | 36 |

Note. Numbers stand for prime-target pairs. Participants shared all stimuli except the ones in the gray cells, which differed for the root and neutral priming conditions (Lists 1 and 2). All items without *ver-* were bisyllabic, yet non-prefixed. A total of 216 stimuli was presented to each participant.

Table 3.5. shows the structural organization of the final stimulus set using examples that will henceforth be used for illustrative purposes.

Table 3.5. Structural organization of the stimulus set with examples in Experiment 1

| Expect. Answer | Root Type | Priming Conditions for Items with *ver-*: Root | Neutral | *ver-* Target | Items without *ver-* |
|---|---|---|---|---|---|
| "Yes" | Adj | BITTER<br>--- | ---<br>SAUBER | VERBITTERN | HEI/HEIKEL |
| | Noun | KLEID<br>--- | ---<br>KREUZ | VERKLEIDEN | SAL/SALBE |
| | Verb | STOPF<br>--- | ---<br>KRATZ | VERSTOPFEN | WAR/WARTEN |
| | Bound | GEUD<br>--- | ---<br>RAPS | VERGEUDEN | --- |
| "No" | *ver-/ker-* Nonsense Items | KRENG | --- | VERKRENGEN | KRENG/ KERKRENGEN |
| | Other Nonsense Items | --- | --- | --- | DEI/DEIKEL<br>RAL/RALBE<br>NAR/NARTEN |

Note. Participants shared all stimuli except the ones in the gray cells, which differed for the root and neutral priming conditions (Lists 1 and 2). Participants saw a *ver*-target in only one of these conditions. For nonsense and filler items without *ver-*, the string to the left of the slash (/) indicates the "prime", and the string to the right of the slash indicates the target. A total of 216 stimuli was presented to each participant.

### *3.1.3. Design and procedure*

Two counterbalanced lists of stimuli (List 1 and List 2) were constructed such that 36 critical *ver*-verb targets were associated with a root prime in List 1 and a neutral prime in List 2; for another 36 critical *ver*-verb targets the opposite was true. Hence, each list comprised all of the 72 critical stimuli. This procedure was employed to avoid accidental intra-list priming of critical targets, i.e., the priming of a target by the presentation of that very target earlier in the list. Furthermore, participants were randomly assigned to either List 1 or List 2. Taken together, these measures insured that, on the one hand, each critical target would occur only once for each participant during the course of the experiment, and, on the other hand, that, over the whole pool of participants, each critical target would be tested under each of the conditions. Prime-target pairs for filler items and the nonsense *ver*-verbs and *ker*-verbs were identical in both lists (see Table 3.5. above).

Participants received brief instructions and completed a practice phase before the start of the actual experiment. In the instructions participants were told that they would be presented with two sequences of letters on the computer screen and that they were expected to indicate whether or not they thought the second sequence was an existing word in German by pressing specified "Yes" or "No" keys on the keyboard using their right and left index fingers, respectively. Participants were encouraged to make their decision as quickly as possible, while at the same time insuring reasonable accuracy of their responses.

Participants were then presented with the 216 test items in a sequence that was randomized for each individual. Each trial involved the display of a focal point (*) for 500 milliseconds (ms); 100 ms after the focal point disappeared, the prime was presented in uppercase letters for 100 ms. This was then immediately followed by the presentation of the target in uppercase bold letters, which stayed on the screen until participants pressed either of the specified "Yes" or "No" keys.[11] Response times (RTs) were automatically scored as the time that elapsed between the moment the target appeared on the computer screen and the moment participants pressed one of the specified keys. The focal point immediately reappeared after each key press to initiate the next trial.

[11] In order to prevent participants from determining the lexical class of some of the primes and fillers from the capitalization convention used for German nouns, both the primes and the target words were presented in upper case letters throughout. (In standard orthography, a noun like *Tausch* 'exchange' is always written with an initial capital letter, while such verb forms as *tausch* 'Exchange! Swap!' are not.)

This experiment took each participant approximately eight minutes to complete. It was carried out using a Macintosh iBook laptop computer, running PsyScope 1.2.5., a graphic-oriented environment for designing psycholinguistic experiments (Cohen, MacWhinney, Flatt, & Provost, 1993).

## 3.2. Results

In this experiment participants generated 15,984 RT observations (74 participants x 216 stimuli). Two of these involved RTs below 300 ms; these were recoded to 300 ms. Likewise, 903 RT observations were above 1,500 ms; these were recoded to 1,500 ms. Thus, about 5.7% of the overall data in this experiment (i.e., including both critical stimuli and fillers) were replaced with a cutoff value. The data of one participant were accidentally eliminated from the data set. This meant that the response data of 73 participants were preserved for analysis. Given the exploratory nature of this study, all omnibus main effects, interactions, and planned comparisons are reported. (The same applies to all subsequent studies which are presented in this dissertation.)

First, in an effort to insure the comparability of the data from the participants from Freiburg and Zurich, ANOVAs were run on the accuracy and RT scores of the two groups, as they related to the existing *ver*-verbs. In this context, accuracy was defined as the percentage of (correct) "Yes" responses to the 72 existing *ver*-verbs; RT scores included correct responses only. In both analyses Location (Freiburg *vs.* Zurich) was treated as a between-group factor, whereas Priming (neutral *vs.* root) and Root Type (Adj *vs.* Noun *vs.* Verb *vs.* Bound) were treated as within-group factors. The analysis of accuracy did not produce a significant main effect of Location, $F_1(1, 71) = 1.15, p = .29$. The analysis of RT scores revealed a similar result, $F_1(1, 71) = 0.75, p = .39$. There were also no significant interactions involving Location in either analysis (both *p*-values > .14). Thus, it can be reasonably assumed that both location groups provided comparable results, and, consequently, the data from both groups were merged in all subsequent RT analyses.

Next, two ANOVAs were performed to investigate the occurrence of any priming effects across the four root types of *ver*-verbs. One analysis treated participants as a random effect ($F_1$), whereas the other treated items as a random effect ($F_2$).

In the analysis by participants, Priming (neutral *vs.* root) and Root Type (Adj *vs.* Noun *vs.* Verb *vs.* Bound) were treated as within-group factors; there were no between-group factors. This analysis revealed a main effect of both Priming, $F_1(1,72) = 75.56, p < .0001$, and Root Type, $F_1(3, 216) = 6.07, p < .001$, as well as an interaction between these two, $F_1(3, 216) = 7.13, p = .0001$.

In the analysis by items, Priming (neutral *vs.* root) was treated as a within-group factor and Root Type (Adj *vs.* Noun *vs.* Verb *vs.* Bound) as a between-group factor. This analysis revealed a main effect of Priming, $F_2(1, 68) = 44.63$, $p < .0001$, but no significant main effect of Root Type, $F_2(3, 68) = 0.63, p = .60$. There was, however, a significant interaction between these two factors, $F_2(3, 68) = 4.45, p < .01$.

Table 3.6. shows the mean RTs for *each* of the root types under each of the priming conditions in the analysis by items, as well as the resulting priming effects. In order to find out whether the priming effects for each root type subset were statistically significant, ANOVAs were performed treating items as a random factor and Priming

(neutral *vs*. root) as a within-group factor. The analysis for the Adj subset revealed that its priming effect was highly significant, $F_2(1, 17) = 27.16, p < .0001$; the analysis for the Noun subset showed a similar result, $F_2(1, 17) = 32.28, p < .0001$. In the case of the Verb subset, results were only approaching statistical significance, $F_2(1, 17) = 3.67, p = .07$. The results for the Bound subset, finally, clearly did not reach statistical significance, $F_2(1, 17) = 1.60, p = .22$.

Table 3.6. Mean RTs and priming effects (ms) in the analysis by items in Experiment 1

| | Priming Condition | | |
|---|---|---|---|
| Root Type | Neutral | Root | Priming Effect |
| Adj | 924 (28) | 827 (18) | *97 (19) |
| Noun | 882 (15) | 817 (13) | *65 (11) |
| Verb | 856 (25) | 822 (20) | 35 (18) |
| Bound | 864 (24) | 844 (20) | 20 (16) |

Note. Asterisks (*) indicate statistically significant priming effects. Numbers in parentheses indicate standard errors.

The mean values shown in Table 3.6. indicate that the root priming condition yielded lower RTs across the four different root types. However, differences between the mean RTs for the neutral and root conditions were not evenly distributed, which means that there were differential priming effects across the four root types. The priming effects from Table 3.6. are also shown graphically in Figure 3.2..

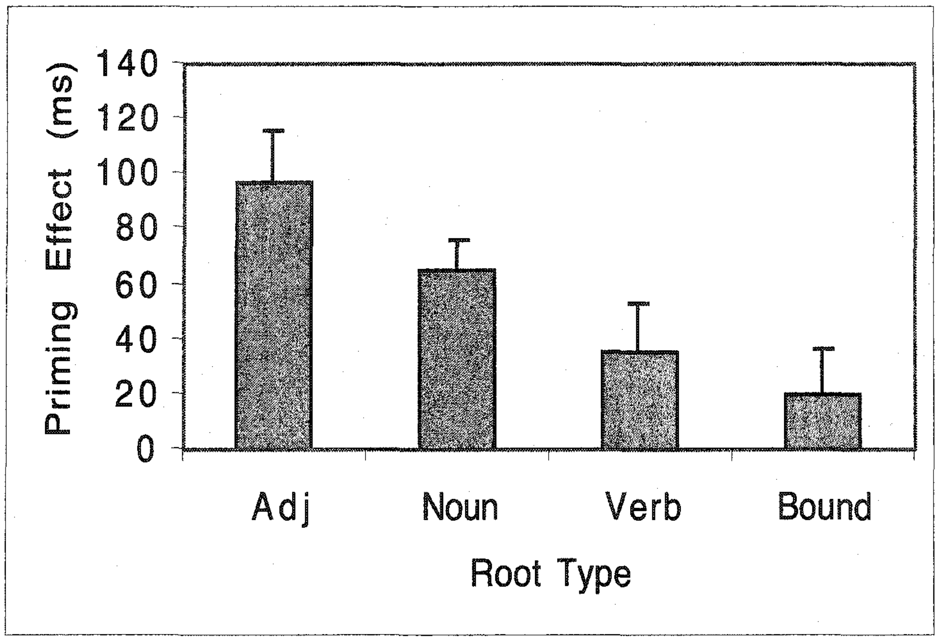



Figure 3.2. Mean priming effects (ms) and standard errors as a function of root type in the analysis by items in Experiment 1

In order to find out whether the priming effects *between* the various root type subsets were statistically significant, a series of unpaired two-tailed $t$ tests was completed using the items data set. Results showed that not all of the differences in priming effects between root type subsets were statistically significant: Adj and Noun, $t(34) = 1.45, p = .16$; Verb and Bound, $t(34) = 0.62, p = .54$; Noun and Verb, $t(34) = 1.43, p = .16$. Yet, some differences did reach statistical significance: Adj and Verb $t(34) = 2.40, p = .02$; Adj and Bound, $t(34) = 3.16, p < .01$; finally, Noun and Bound, $t(34) = 2.33, p = .03$.

### 3.3. Discussion

The purpose of this experiment had been to test whether the template [*ver*[ROOT]*(e)n*] plays a role in the subconscious processing of *ver*-verbs that had either an adjectival, nominal, verbal, or bound root constituent. On a micro scale, the goal of the experiment had been to investigate the potential occurrence of priming effects for *ver*-verbs. On a macro scale, the goal of the experiment had been to investigate the potential involvement of morphology and morpheme salience. The results of the experiment show a pattern of graded priming effects and thus that these factors seem to play a role in processing. In the context of mental representations and their organization this pattern of priming effects suggests the existence of links between the representations of the full forms of *ver*-verbs and their constituents but also differences in the salience of these links. Whereas the patterns for *ver*-verbs belonging to the Adj, Noun, and Bound subsets can be easily explained, understanding the pattern for the items belonging to the Verb subset appears to require additional experimentation.

As can be seen in Figure 3.2. above, there is, basically, a two-group distinction as far as priming effects are concerned. On the one hand, the Adj and Noun subsets pattern together by virtue of yielding relatively large priming effects. On the other hand, the Verb and Bound subsets form a group by virtue of yielding relatively small priming effects.

On a micro scale, the large and highly significant priming effects for *ver*-verbs with Adj and Noun roots both in the analysis by participants and in the analysis by items suggest that the template [*ver*[ROOT]*(e)n*] plays a major role in the subconscious processing of *ver*-verbs belonging to the Adj and Noun subsets. On a macro scale, this phenomenon suggests the involvement of morphology. Furthermore, these priming effects seem to indicate a high degree of salience for the mental representations for Adj and Noun roots during lexical processing. It is, therefore, reasonable to assume that, during processing, *ver*-verbs such as *verbittern* and *verkleiden* are subconsciously perceived as having the structure [*ver*[BITTER]$_{ADJ}$*n*] and [*ver*[KLEID]$_{NOUN}$*en*], respectively.

On a micro scale, the clear absence of statistically significant priming effects for *ver*-verbs with Bound roots suggests that the morphological template [*ver*[ROOT]*(e)n*] does not play a role in the subconscious processing of *ver*-verbs belonging to the Bound subset. This phenomenon seems to be reflective of the obscure morphological structure of the items in this particular group: from a descriptive point of view, there are no synchronically attestable roots for them. On a macro scale, the lack of significant priming effects suggests that morphology does not seem to play a role. Basically, *ver*-verbs belonging to the Bound subset such as *vergeuden* seem to be subconsciously perceived as having the structure [VERGEUDEN] rather than [*ver*[GEUD]$_{BOUND}$*en*].

So far, results are congruent with the reasonable expectation to find a lexicality effect in the priming patterns: Adj and Noun roots constitute existing words of the German language and the activation of their mental representations leads to priming effects in processing; by contrast, such effects are minimal in the case of Bound roots, since these items do not constitute existing words in German, which makes the existence of representations that could be activated questionable. More precisely, this lexicality effect is reflected in the statistically significant difference in the priming effects between the Adj and Bound subsets on the one hand, and between the Noun and Bound subsets on the other hand.

However, the fact that the priming effects for *ver*-verbs belonging to the Verb subset (a) only approached but did not quite reach statistical significance, and (b) were not statistically different from those obtained for the Bound subset constitutes a severe challenge for an explanation based on lexicality effects alone. On a micro scale, the morphological template [*ver*[ROOT]*(e)n*] appears to play only a limited role in the processing of *ver*-verbs belonging to the Verb subset, although Verb roots such as *stopf* (in the case of *verstopfen*) are existing words in German. Thus, on a macro scale, the level of morpheme salience seems to be rather low. One reason for this phenomenon could be that, from a descriptive point of view, a root such as *stopf* does not correspond to the citation form (here: *stopfen*), but rather the imperative form. Although it can be reasonably assumed that the imperative form has an independent mental representation, it appears to be less salient than that of the citation form (infinitive). It is, therefore, conceivable that during the lexical processing of *ver*-verbs such as *verstopfen* the mental representation of the citation form (here: *stopfen*) plays a much more prominent role than that of the imperative. Thus, it is reasonable to assume that *ver*-verbs belonging to the Verb subset might subconsciously be perceived as having the structure [*ver*$[\text{STOPFEN}]_{\text{VERB}}$] rather than [*ver*$[\text{STOPF}]_{\text{VERB}}$*en*].

Testing the hypothesis that the template [*ver*[ROOT*(e)n*]] rather than [*ver*[ROOT]*(e)n*] plays a role in the subconscious processing of *ver*-verbs, especially of those belonging to the Verb subset, was, therefore, the motivation behind Experiment 2.

# CHAPTER 4

# EXPERIMENT 2: MORPHOLOGICAL ROOT+(E)N PRIMING

## 4.0. Introduction

In Experiment 1 a lexical decision task with morphological root priming was employed in order to investigate the role of the template [*ver*[ROOT]*(e)n*] in the subconscious processing of *ver*-verbs belonging to the Adj, Noun, Verb, and Bound subsets. Results indicated that in the Adj and Noun subsets the prior presentation of root primes such as BITTER and KLEID led to statistically significant facilitation in the processing of their corresponding *ver*-verb targets (here: VERBITTERN and VERKLEIDEN) as compared to unrelated controls. This was interpreted as evidence in favor of the hypothesis that the template [*ver*[ROOT]*(e)n*] plays an important role in the subconscious processing of these items due to the salience of the mental representations of these roots. Likewise, the lack of priming effects for prime-target pairs such as GEUD-VERGEUDEN in the Bound subset was seen as evidence against the existence of full-fledged mental representations for these items. In short, the existence of significant priming effects in this paradigm was interpreted to be linked to the factor *lexicality*, i.e., whether or not the roots serving as primes were existing words in German.

Surprisingly, however, results indicated a lack of statistically significant priming effects for prime-target pairs in the Verb subset such as STOPF-VERSTOPFEN. Moreover, the priming effects obtained for that subset did not differ significantly from those obtained for the Bound subset. The fact that a root such as *stopf* is an existing word in

German, namely, the imperative form of the infinitive *stopfen*, considerably weakens the hypothesis that priming effects in this paradigm are exclusively linked to the factor *lexicality*. At the same time this raised the question whether an infinitive such as *stopfen* rather than a root such as *stopf* would be a more efficient prime, which would mean that the factor *morphological structure* might play a role in the processing of *ver*-verbs, especially of those belonging to the Verb subset.

In the present experiment, therefore, a lexical decision task with morphological "root+(e)n" priming was employed in order to investigate the potential role of the template [*ver*[ROOT*(e)n*]] in the subconscious processing of *ver*-verbs (rather than [*ver*[ROOT]*(e)n*] as in Experiment 1). On a micro scale, the rationale behind the experiment was that if the template [*ver*[ROOT*(e)n*]] plays a role in the subconscious morphological processing of *ver*-verbs, the prior presentation of a morphological "root+(e)n" prime such as STOPFEN should, on average, lead to a priming effect (processing time advantage) for a whole *ver*-verb target such as VERSTOPFEN, as compared to the prior presentation of a morphologically unrelated prime such as KRATZEN 'to scratch'. On a macro scale, this would suggest the involvement of morphology and the existence of mental representations based on the format [ROOT*(e)n*].

Figure 4.1. and Figure 4.2. serve to illustrate the slight differences in the rationale underlying Experiment 1 and that underlying the present experiment.

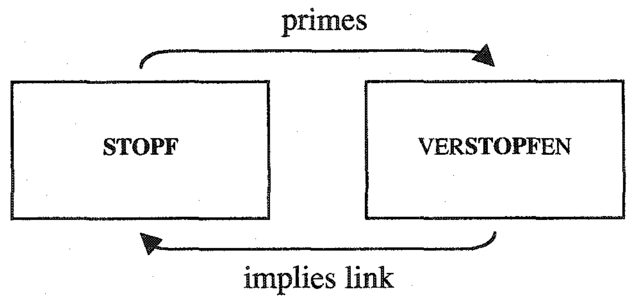



Figure 4.1. Conceptualization of the rationale underlying root-to-whole-word priming in Experiment 1

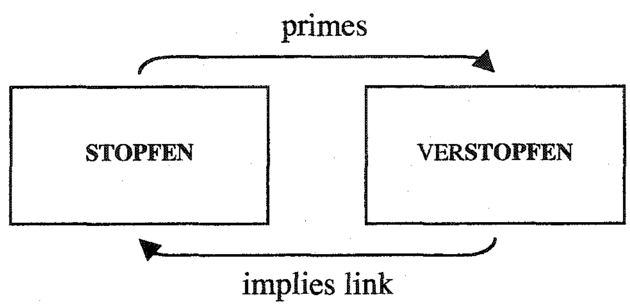



Figure 4.2. Conceptualization of the rationale underlying base-to-whole-word priming in Experiment 2

## 4.1. Method

### *4.1.1. Participants*

A total of 52 native speakers of German volunteered to participate. Twenty-three of these were enrolled in undergraduate Philology courses at Albert-Ludwigs-Universität in Freiburg im Breisgau, Germany. Another 17 were enrolled in undergraduate German courses at Pädagogische Hochschule (University of Education) in the same city. The remaining 12 participants were professionals living in the same general area. None of the 52 participants in this study had taken part in Experiment 1 [ARM-VERARMEN].

*4.1.2. Materials*

The critical stimuli consisted of the same 72 *ver*-verb targets already used in Experiment 1, i.e., 18 each of the Adj, Noun, Verb, and Bound subsets (see Section 3.1.2. above). In the present experiment, however, rather than having the simple structure [ROOT], both morphological and neutral primes had the structure [ROOT*(e)n*]. Thus, whereas, for example, the simple root BITTER 'bitter' served as morphological prime for the target VERBITTERN 'to embitter' in Experiment 1 [ARM-VERARMEN], in the present experiment [ARMEN-VERARMEN] the base BITTERN served as morphological prime for that same target. Sometimes this procedure involved the addition of an *Umlaut*, as, for example, in the case of the neutral prime for VERBITTERN, which was SAUBER 'clean' in Experiment 1 and SÄUBERN 'to clean' in the present experiment (see Appendix for details).

In an effort to maintain homogeneity among the existing *ver*-verb stimuli and the nonsense *ver-/ker*-stimuli, which served as one type of filler items, analogous changes were made to the latter. Hence, the prime for the nonsense target KERKRENGEN, for example, was changed from KRENG, which was used in Experiment 1, to KRENGEN in the present experiment. Other filler items such as HEI (prime) and HEIKEL 'delicate' (target) were exempt from this procedure. Table 4.1. shows the structural organization of the final stimulus set which consisted of a total of 216 items.

Table 4.1. Structural organization of the stimulus set with examples in Experiment 2

| | | Priming Conditions for Items with *ver-* | | | |
|---|---|---|---|---|---|
| Expect. Answer | Root+*en* Type | Root+*en* | Neutral | *ver-* Target | Items without *ver-* |
| "Yes" | Adj | BITTERN | --- | VERBITTERN | HEI/HEIKEL |
| | | --- | SÄUBERN | | |
| | Noun | KLEIDEN | --- | VERKLEIDEN | SAL/SALBE |
| | | --- | KREUZEN | | |
| | Verb | STOPFEN | --- | VERSTOPFEN | WAR/WARTEN |
| | | --- | KRATZEN | | |
| | Bound | GEUDEN | --- | VERGEUDEN | --- |
| | | --- | RAPSEN | | |
| "No" | *ver-/ker-* Nonsense Items | KRENGEN | --- | VERKRENGEN | KRENG/ KERKRENGEN |
| | Other Nonsense Items | --- | --- | --- | DEI/DEIKEL RAL/RALBE NAR/NARTEN |

Note. Participants shared all stimuli except the ones in the gray cells, which differed for the root+en and neutral priming conditions (Lists 1 and 2). Participants saw a *ver*-target in only one of these conditions. For nonsense and filler items without *ver-*, the string to the left of the slash (/) indicates the "prime", and the string to the right of the slash indicates the target. A total of 216 stimuli was presented to each participant.

### *4.1.3. Design and procedure*

The design and procedure employed in this experiment were identical to that of Experiment 1 (see Section 3.1.3. above).

## 4.2. Results

In this experiment participants generated 11,232 RT observations (52 participants x 216 stimuli). None of these involved RTs below 300 ms. However, 1,528 RT observations were above 1,500 ms; these were recoded to 1,500 ms. Thus, about 13.6% of the overall data in this experiment (i.e., including both critical stimuli and fillers) were replaced with a cutoff value. This procedure was employed in order to maintain the same range adopted for Experiment 1 [ARM-VERARMEN], and, thus, to keep basic parameters of the overall investigation constant.

First, in an effort to insure the comparability of the data from the participants with the status of university student, education student, and professional, respectively, ANOVAs were run on the RT scores of these three groups, as they related to the existing *ver*-verbs. RT scores included correct responses only. In this analysis Status (university student *vs*. education student *vs*. professional) was treated as a between-group factor, whereas Priming (neutral *vs*. base) and Base Type (Adj *vs*. Noun *vs*. Verb *vs*. Bound) were treated as within-group factors. The analysis of RT scores did not produce a significant main effect, $F_1(2, 49) = 0.96$, $p = .39$. There were also no significant interactions involving Status (all *p*-values > .53). Thus, it can be reasonably assumed that the three status groups provided comparable results, and, consequently, the data from these groups were merged in all subsequent RT analyses.

Next, two ANOVAs were performed to investigate the occurrence of any priming effects across the four base types of *ver*-verbs. One analysis treated participants as a random effect ($F_1$), whereas the other treated items as a random effect ($F_2$).

In the analysis by participants, Priming (neutral *vs*. base) and Base Type (Adj *vs*. Noun *vs*. Verb *vs*. Bound) were treated as within-group factors; there were no between-group factors. This analysis revealed a main effect of both Priming, $F_1(1, 51) = 78.72$, $p < .0001$, and Base Type, $F_1(3, 153) = 9.59$, $p < .0001$. The interaction between these two was not significant, $F_1(3, 153) = 0.19$, $p = .90$.

In the analysis by items, Priming (neutral *vs*. base) was treated as a within-group factor and Base Type (Adj *vs*. Noun *vs*. Verb *vs*. Bound) as a between-group factor. This analysis revealed a main effect of Priming, $F_2(1, 68) = 59.37$, $p < .0001$, but no significant main effect of Base Type, $F_2(3, 68) = 1.16$, $p = .33$. There was also no significant interaction between these two factors, $F_2(3, 68) = 0.16$, $p = .93$.

The mean values shown in Table 4.2. indicate that the base priming condition yielded lower RTs across the four different base types. Differences between the mean RTs for the neutral and base conditions, and thus priming effects, were almost evenly distributed.

In order to find out whether the priming effects for each base type subset were statistically significant, ANOVAs were performed treating items as a random factor and Priming (neutral *vs*. base) as a within-group factor. The analyses for the respective subsets revealed highly significant priming effects: for the Adj subset, $F_2(1, 17) = 16.52$, $p < .001$; for the Noun subset, $F_2(1, 17) = 15.34$, $p = .001$; for the Verb subset, $F_2(1, 17) = 20.03$, $p < .001$; finally, for the Bound subset, $F_2(1, 17) = 10.49$, $p < .01$.

Table 4.2. Mean RTs and priming effects (ms) in the analysis by items in Experiment 2

| | Priming Condition | | |
|---|---|---|---|
| Root+*en* Type | Neutral | Root+*en* | Priming Effect |
| Adj | 1032 (31) | 954 (24) | *77 (19) |
| Noun | 991 (18) | 923 (14) | *68 (17) |
| Verb | 970 (20) | 907 (19) | *63 (14) |
| Bound | 983 (33) | 921 (22) | *62 (19) |

Note. Asterisks (*) indicate statistically significant priming effects. Numbers in parentheses indicate standard errors.

In order to find out whether the priming effects *between* the various base type subsets were statistically significant, a series of unpaired two-tailed *t* tests was completed. Results showed that none of the differences in priming effects between base type subsets were statistically significant: Adj and Noun, $t(34) = 0.37, p = .72$; Adj and Verb, $t(34) = 0.62, p = .54$; Adj and Bound, $t(34) = 0.54, p = .59$; Noun and Verb, $t(34) = 0.23, p = .82$; Noun and Bound, $t(34) = 0.20, p = .84$; Verb and Bound, $t(34) = 0.01, p = .99$. This state of affairs is also graphically represented in Figure 4.3. below. Furthermore, Figure 4.4. provides a graphic comparison of the results of the present experiment with those of Experiment 1.

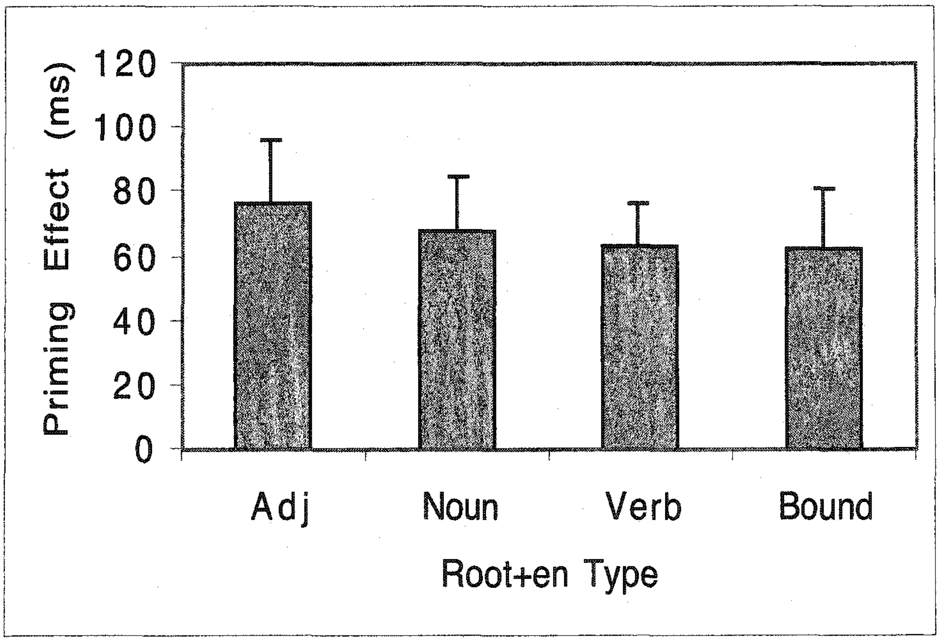



Figure 4.3. Mean priming effects (ms) and standard errors as a function of root+en type in the analysis by items in Experiment 2

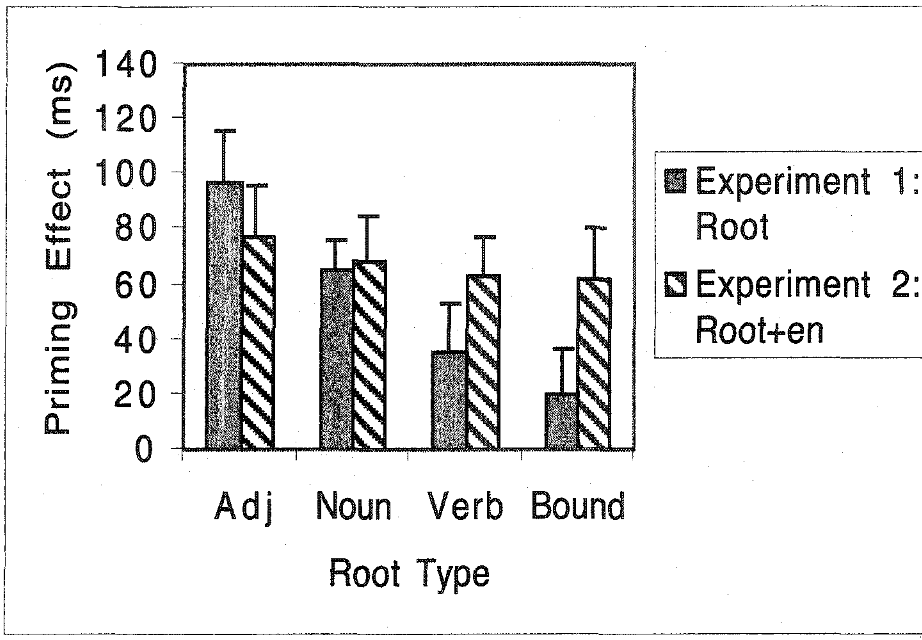



Figure 4.4. Comparison of mean priming effects (ms) and standard errors as a function of root type and root+*en* type, respectively, in the analysis by items in Experiment 1 and Experiment 2

**4.3. Discussion**

The purpose of this experiment had been to test whether the template [*ver*[ROOT*(e)n*]] rather than the template [*ver*[ROOT]*(e)n*] plays a role in the subconscious processing of *ver*-verbs, especially of those belonging to the Verb subset. On a micro scale, the goal of the experiment had been to investigate the occurrence of priming effects for *ver*-verbs. On a macro scale, the goal of the experiment had been to investigate the potential involvement of morphology. The results of the experiments show a pattern of priming effects distributed evenly across the four base types. In the context of mental representations and their organization this pattern of priming effects suggests the existence of links between the representations of "root+(e)n" constituents and full forms of *ver*-verbs which seem to possess an equal degree of salience across the four base types. Viewed from the perspective of the present experiment only, this could be seen as problematic as far as the items belonging to the Bound subset are concerned. Viewed in the context of Experiment 1 (see Section 3.2. above), the results of the present experiment are more easily explained, as will be discussed below.

As can be seen in Table 4.2. and Figure 4.3. above, priming effects are evenly distributed across the four different base types. Although the effects are slightly higher for items belonging to the Adj and Noun subsets than for those belonging to the Verb and Bound subsets, these differences are not statistically significant.

On a micro scale, the large and highly significant priming effects for *ver*-verbs with Adj, Noun, and Verb bases both in the analysis by participants and in the analysis by items suggest that the template [*ver*[ROOT*(e)n*]] plays a major role in the subconscious processing of *ver*-verbs belonging to these subsets. On a macro scale, this phenomenon suggests the involvement of morphology. Furthermore, these priming effects seem to indicate a high degree of salience for the mental representations for Adj, Noun, and Verb bases during lexical processing. It is, therefore, reasonable to assume that during processing *ver*-verbs such as *verbittern*, *verkleiden*, and *verstopfen* are subconsciously perceived as having the structure [*ver*[BITTERN]], [*ver*[KLEIDEN]], and [*ver*[STOPFEN]], respectively.

So far, results are congruent with the reasonable expectation that *morphological structure* and *lexicality* should play a role in the processing of *ver*-verbs: the "root+(e)n" items belonging to the Adj, Noun, and Verb subsets are morphologically well-formed existing words in German and the activation of their mental representations leads to priming effects in processing.[12]

However, the fact that the priming effects for *ver*-verbs belonging to the Bound subset were not statistically different from those obtained for the Adj, Noun, and Verb subsets constitutes a severe challenge to the idea that the factor *lexicality* is involved in the "root+(e)n" priming paradigm. Items in the Bound subset neither have synchronically attestable descriptive roots, nor is there evidence for the existence of salient mental representations for their root-like elements. By extension, there should also not be any salient mental representations for the "base" forms of *ver*-verbs belonging to the Bound subset.

Seen in the context of the present experiment only, the evenly distributed priming effects of the present experiment appear to indicate that the template [*ver*[ROOT*(e)n*]] is equally important in the subconscious processing of *ver*-verbs belonging to the Bound subset, as in the case of the other three. Since the priming effects for the items belonging to the Bound subset are both statistically significant and do not differ significantly from those obtained for items belonging to any of the other "lexical" subsets, one could therefore argue that the representations *subconsciously* activated in the "root+(e)n" priming paradigm are merely form-based in this case, i.e., not morphological.

If one compares the results of the present experiment and those of Experiment 1 [ARM-VERARMEN], however, a more complicated picture of the processing of *ver*-verbs starts to emerge. Again, Figure 4.4. serves to illustrate this comparison. Although the

[12] Although four of the Adj root+en forms are non-words, they are sufficiently close to existing forms if one applies epenthesis or metathesis (see also Section 9.3. below).

magnitude of priming effects for each subset is almost identical in the present experiment, there are considerable changes if one takes the results of Experiment 1 as a reference point.

As already pointed out above, these patterns cannot be explained by a mere recourse to the factor *lexicality*, given the results for the items belonging to the Bound subset. Rather, it appears that the factor *morphological structure* plays a major role. More precisely, it seems that there are *preferred* morphological structures for *ver*-verbs belonging to the various subsets. Thus, the preferred morphological structure for *ver*-verbs belonging to the Adj subset seems to be captured in the morphological template [*ver*[ROOT]*(e)n*] rather than [*ver*[ROOT*(e)n*]]; this argumentation is supported by the diminished magnitude of the priming effects for this subset when comparing the results of the present experiment (that employed the template [*ver*[ROOT*(e)n*]]) with those of Experiment 1 (that employed the template [*ver*[ROOT]*(e)n*]). By contrast, the preferred morphological structure for items belonging to the Verb and Bound subsets seems to be captured in the template [*ver*[ROOT*(e)n*]] rather than [*ver*[ROOT]*(e)n*], as witnessed in the dramatically increased magnitude of the priming effects for *ver*-verbs in these two subsets. In the case of *ver*-verbs belonging to the Noun subset there does not appear to be a preference for either of these two morphological templates, as indicated by the rather stable magnitude of priming effects for items in this particular subset.

In summary, whereas both the root priming paradigm employed in Experiment 1 and the "root+(e)n" priming paradigm employed in the present experiment allowed for a detailed investigation of the *subconscious* processing of *ver*-verbs belonging to the Adj, Noun, Verb, and Bound subsets, there are still some questions that remain to be answered in a satisfactory way. These concern the status of root forms in the Verb subset and "root+(e)n" forms in the Bound subset. Furthermore, claims about the existence of preferred morphological structures need to be backed up by independent evidence. Given that the evidence gathered in the first two experiments was based on the examination the subconscious processing of *ver*-verbs, it is reasonable to assume that independent evidence is best based on the investigation of data gained from a paradigm relying on conscious language processing. Conscious meta-linguistic judgments of *ver*-verbs by native speakers of German that center around the perceived internal structure of these items could constitute one type of such evidence, helping to reduce the risk of postulating claims that might be based on experimental artifacts. Therefore, the focus in Experiment 3 is on judgments concerning the presumed *roots* of *ver*-verbs. Experiment 4 (see Chapter 6 below) investigates the perceived status of "root+(e)n" forms.

# CHAPTER 5

# EXPERIMENT 3: MORPHOLOGICAL ROOT AWARENESS

## 5.0. Introduction

In Experiments 1 and 2 lexical decision tasks with priming components were employed in order to investigate the *subconscious* processing of *ver*-verbs belonging to the Adj, Noun, Verb, and Bound subsets. Results for Experiment 1 [ARM-VERARMEN] indicated that the template [*ver*[ROOT]*(e)n*] seemed to play an important role in the processing of these items, as witnessed in priming effects for prime-target pairs such as BITTER-VERBITTERN. Such priming effects were also taken as support for (a) the involvement of morphology during the subconscious processing of *ver*-verbs, and (b) the existence of mental representations for roots of *ver*-verbs linked to the full form of these items. However, results also indicated a broad two-way distinction between the priming effects obtained for the different subsets such that items in the Adj and Noun subsets yielded relatively large priming effects, whereas items in the Verb and Bound subsets yielded relatively small priming effects. This phenomenon was interpreted in terms of differences in morpheme salience, more precisely, in terms of differential salience of the links between the mental representations of the constituent morphemes and the full forms of *ver*-verbs. Yet, in light of the apparently similar priming efficiency of supposedly lexical Verb roots and supposedly non-lexical Bound "roots", this interpretation was not completely satisfactory.

In Experiment 2, therefore, the focus of the investigation was on the role of the template [*ver*[ROOT*(e)n*]] (rather than [*ver*[ROOT]*(e)n*]) during the subconscious processing of *ver*-verbs. The rationale was that prime-target pairs such as STOPFEN-VERSTOPFEN (rather than STOPF-VERSTOPFEN) might help to distinguish between the Verb and Bound subsets. However, results for Experiment 2 [ARMEN-VERARMEN] indicated evenly distributed priming effects across all four different base types. Seen in the context of Experiment 2 alone, this phenomenon could have been interpreted in terms of "root+(e)n" primes yielding form-based priming. Yet, seen in the context of the results of Experiment 1, the results of Experiment 2 indicated dramatic changes concerning the magnitude of the priming effects obtained for the four different base types that were interpreted in terms of the existence of preferred morphological structures for *ver*-verbs belonging to the Adj, Noun, Verb, and Bound subsets.

While the root priming and "root+(e)n" priming paradigms employed in Experiment 1 and Experiment 2, respectively, provided valuable insight into aspects of the *subconscious* processing of *ver*-verbs, issues such as the perceived status of root primes in the Verb subset (Experiment 1) and claims such as the one concerning the existence of preferred morphological structures for different subsets (Experiment 2) need to be substantiated with further evidence.

This way of thinking is in line with an argument made in recent literature overviews, namely, that research should be guided by the principle of ecological validity and, thus, should include a wide variety of tasks (Frost & Grainger, 2000; Libben & Jarema, 2002). Derwing (1997) also emphasized the importance of task variation, arguing that one of the weaknesses of controlled laboratory experiments was that, by default, they involve manipulations that are artificial from the perspective of normal language behavior. In order to avoid experimental artifacts, Derwing recommended approaching the phenomenon of interest from different perspectives to insure results are independent of the nature of any particular experimental task, in other words, to insure cross-methodological validation.

In the context of the present dissertation, this approach is called for not only to validate results across tasks, but also to compensate for the limits of certain tasks when it comes to tapping certain phenomena. Hence, while priming experiments are a useful tool in the examination of *subconscious* language processing, they are not too revealing when it comes to gathering information on speakers' overt perceptions. One approach that has been used in an effort to investigate the *conscious* processing of complex words is to elicit meta-linguistic judgments by native speakers. Such judgments of the relationship between *ver*-verbs and their presumed components by native speakers of German could provide both evidence concerning the *conscious* processing of these items and answers to some of the questions that could not be settled by the priming experiments alone.

Berko's (1958) study constitutes an early attempt to investigate speakers' overt judgment of the morphological relationships between words and their descriptive constituents, and thus, the conscious processing of morphologically complex items. That author tried to determine children's knowledge of the morphological constituents of English compounds such as *Thanksgiving* by simply asking these youngsters why they thought these words were so named. Berko's probe, however, turned out to be too loosely drafted to provide a satisfactory proportion of the targeted morphologically-based responses of the type "Thanksgiving is called *Thanksgiving* because the pilgrims gave thanks".

Unsatisfied with the results that Berko's procedure gave in a replication with adults, Derwing (1976) introduced a new procedure that required participants to rate whether or not a given derived word had "come from" its presumed root (e.g., "Does the word *quietly* come from the word *quiet*"?). Responses were scored on a 0-4 confidence scale. The results of this "comes from" test yielded consistently high ratings for morphologically transparent word pairs such as *quietly-quiet* (mean rating: 3.97) and consistently low ratings for morphologically opaque word pairs such as *bashful-bash* (mean rating: 0.75). Such responses enhanced the prospect that this probe might provide valid and reliable measures of speakers' overt awareness of morphological structure in morphologically complex words.

For the purposes of the present dissertation, however, Derwing's original (1976) probe was supplemented with two other questions. The purpose of this was a methodological cross-check in itself, by biasing the test question in ways that might yield separate measures for speakers' etymological, morphological, and semantic awareness of the structure of German *ver*-verbs. Using the English word pair *quietly-quiet* for illustrative purposes here, the resulting three probes are outlined below: (a) The (original) probe "Does the word *quietly* come from the word *quiet*"? was designed to investigate speakers' degree of awareness of potential *etymological* links between the members of a word pair; (b) the probe "Does the word *quietly* contain a form of the word *quiet*?" was designed to investigate speakers' degree of awareness of perceived *morphological* links between the members of a word pair; (c) the probe "Does the word *quietly* contain the meaning of the word *quiet*?" was designed to investigate speakers' degree of awareness of perceived *semantic* links between the members of a word pair.

In the present experiment, therefore, a morpheme awareness task consisting of these three probes (adapted to German) was employed to investigate the degree of etymological, morphological, and semantic awareness of native speakers of German concerning links between *ver*-verbs and their presumed roots. The purpose of this experiment had been to test whether or not native speakers of German *consciously* perceive *ver*-verbs to have the morphological structure [*ver*[ROOT]*(e)n*] in word pairs such as VERBITTERN-BITTER. The rationale behind this experiment was the following: (a) If speakers were aware of the structure [*ver*[ROOT]*(e)n*], this would both indicate a certain measure of psychological validity for this structure and provide corroborative evidence for the claim of links between the mental representations of *ver*-verbs and their constituents made in Experiment 1 [ARM-VERARMEN] (see Section 3.3. above); (b) differential ratings across the four different root types would provide corroborative evidence for another claim made in Experiment 1 [ARM-VERARMEN], namely, that the links between the mental representations of the constituent morphemes and the full forms of *ver*-verbs are of variable salience or strength; (c) differential ratings across the three probes would indicate a certain measure of independence of the factors *etymology*, *morphology*, and *semantics* in conscious language processing, whereas a common set of responses would suggest that all three versions of the test question were meaning essentially the same thing.

## 5.1. Method

### *5.1.1. Participants*

A total of 74 native speakers of German volunteered to participate. These were the same individuals who had already completed Experiment 1 [ARM-VERARMEN], one of whom was excluded from the analysis for reasons already given. None of the 74 participants in this study had taken part in Experiment 2 [ARMEN-VERARMEN].

### *5.1.2. Materials*

The stimuli consisted of the same 72 *ver*-verb targets already used in Experiment 1 [ARM-VERARMEN], i.e., 18 each of the Adj, Noun, Verb, and Bound subsets (see Section 3.1.2. above). In the present experiment, however, these targets were supplemented with their presumed roots (that correspond to the root primes in Experiment 1), such that the final stimulus list consisted of 72 *ver*-verb-root *pairs* (e.g., VERBITTERN-BITTER). No filler items were employed.

### *5.1.3. Design and procedure*

The main task in this experiment consisted of rating the potential etymological, morphological, and semantic links between the members of *ver*-verb-root pairs such as VERBITTERN-BITTER in an expanded version of Derwing's (1976) "comes from" test. The templates for the three German probes are shown below using the word pair ERZÄHLEN-

ZAHL as the model throughout, and with English translations provided here for the sake of clarity:

(a) "Wurde das Wort *erzählen* vom Wort *Zahl* abgeleitet?" ("Does the word *to tell* come from the word *number*?").

This probe was designed to provide a measure of speakers' etymological awareness and will henceforth be referred to as the "comes from" (CF) task.

(b) "Enthält das Wort *erzählen* eine Form des Wortes *Zahl*?" ("Does the word *to tell* contain a form of the word *number*?").

This probe was designed to provide a measure of speakers' morphological awareness and will henceforth be referred to as the "contains" (CON) task.

(c) "Enthält das Wort *erzählen* die Bedeutung des Wortes *Zahl*?" ("Does the word *to tell* contain the meaning of the word *number*?").

This probe was designed to provide a measure of speakers' semantic awareness and will henceforth be referred to as the "meaning" (MNG) task.

Three lists of stimuli (List A, List B, and List C) were constructed such that six word pairs of each subset (Adj, Noun, Verb, and Bound) were randomly assigned to each of these lists; hence, each list comprised 24 stimuli. Each of the lists was then randomly associated with one of the three tasks (CF, CON, and MNG). This procedure insured, on the one hand, that each word pair would occur only once for each participant during the course of the experiment; on the other hand, it also insured that, over the whole pool of participants, each word pair would be tested under each of the tasks. Crucially, the CF, CON, and MNG tasks were administered in separate blocks, with the order of these randomized for each participant. Within these blocks, the order of the 24 word pairs was also randomized anew for each individual. Participants were assigned to lists A, B, and C in the order in which they appeared for the testing session.

Participants received extensive instructions and completed a practice phase before the start of the actual experiment. In the instructions participants were told that they would be presented with three types of questions (probes) concerning specific word pairs on a computer screen. For the purpose of illustration, they were shown the three sample questions illustrated above. Participants were then given the following rating scale, adapted from Derwing (1976), which, they were told, should be the basis for their answers:

4 - Zweifelsohne ja (No doubt about it)

3 - Wahrscheinlich (Probably)

2 - Bin mir nicht schlüssig (Can't decide)

1 - Wahrscheinlich nicht (Probably not)

0 - Keinesfalls (No way)

Participants were then instructed to indicate their ratings (answers) by pressing either of the specified "4", "3", "2", "1", or "0" keys at the bottom center of the keyboard (these numbers had been pasted over the regular M, N, B, V, and C keys, respectively). A copy of the rating scale was placed to the left of the computer for the purpose of convenience. Participants were also told that they could take as much time as they wanted to rate each word pair.

Each trial involved the display of a probe on the upper half of the computer screen and the simultaneous presentation of a word pair in uppercase letters at the center of the screen. When participants pressed any of the specified number keys to indicate their rating, the response was recorded and a new trial was initiated. Before the start of each block (CF, CON, and MNG), the specific instructions for that block re-appeared on the screen.

This experiment took each participant approximately 15 minutes to complete. It was carried out using the same computer and program used in Experiments 1 and 2.

**5.2. Results**

Since the present experiment did not involve measuring any RTs, there was no need for any data trimming (in contrast to Experiment 1 and Experiment 2).

First, in an effort to insure the comparability of the data from the participants from Freiburg and Zurich, an ANOVA was run on the rating scores of the two groups. In this analysis Location (Freiburg *vs.* Zurich) was treated as a between-group factor, whereas Root Type (Adj *vs.* Noun *vs.* Verb *vs.* Bound) and Task (CF *vs.* CON *vs.* MNG) were treated as within-group factors. This analysis did not produce a significant main effect of Location, $F_1(1, 71) = 1.48, p = .23$. There were also no significant interactions involving Location (both $p$-values > .67). Thus, it can be reasonably assumed that both location groups provided comparable results, and, consequently, the data from both groups were merged in all subsequent rating analyses.

Next, two ANOVAs were performed to investigate the ratings that resulted from the CF, CON, and MNG tasks across the four root types. One analysis treated participants as a random effect ($F_1$), whereas the other treated items as a random effect ($F_2$).

In the analysis by participants, Root Type (Adj *vs.* Noun *vs.* Verb *vs.* Bound) and Task (CF *vs.* CON *vs.* MNG) were treated as within-group factors; there were no between-group factors. This analysis revealed a main effect of both Root Type, $F_1(3, 216) = 707.40$, $p < .0001$, and Task, $F_1(2, 144) = 33.75$, $p < .0001$, as well as an interaction between these two, $F_1(6, 432) = 10.55$, $p < .0001$.

In the analysis by items, Task (CF *vs.* CON *vs.* MNG) was treated as a within-group factor and Root Type (Adj *vs.* Noun *vs.* Verb *vs.* Bound) as a between-group factor. This analysis revealed a main effect of both Task, $F_2(2, 136) = 70.66$, $p < .0001$, and Root Type, $F_2(3, 68) = 82.82$, $p < .0001$, as well as an interaction between these two, $F_2(6, 136) = 12.65$, $p < .0001$.

Table 5.1. shows the mean ratings obtained for word pairs belonging to the four different root types in each of the three tasks (CF, CON, and MNG).

Table 5.1. Mean rating scores across four root types and three tasks in the analysis by items in Experiment 3

| | Task | | |
|---|---|---|---|
| Root Type | CF | CON | MNG |
| Adj | 339 (13) | 349 (9) | 334 (15) |
| Noun | 355 (10) | 363 (8) | 346 (11) |
| Verb | 174 (24) | 254 (16) | 190 (21) |
| Bound | 65 (11) | 146 (13) | 75 (11) |

Note. Original ratings based on a 0-4 confidence scale were converted to scores by multiplying them by 100. Numbers in parentheses indicate standard errors.

The same results are also displayed graphically in Figure 5.1..

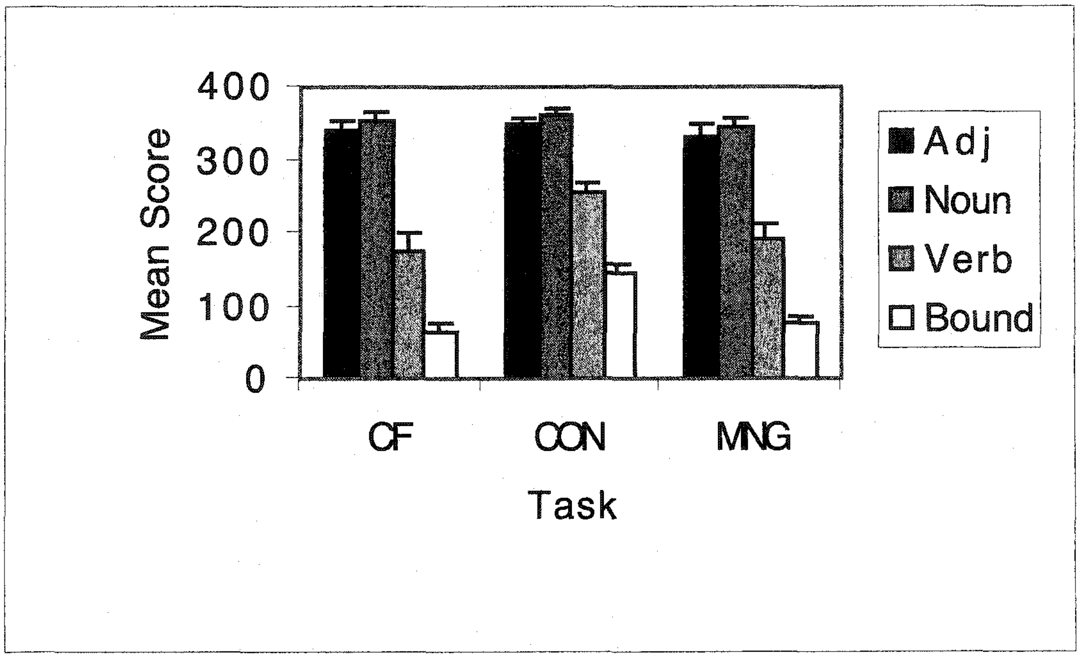



Figure 5.1. Mean rating scores and standard errors as a function of root type and task in the analysis by items in Experiment 3

In order to find out whether mean rating scores for *each* subset differed significantly *across* all three probes, ANOVAs were performed treating items as a random factor and Task (CF *vs*. CON *vs*. MNG) as a within-group factor. The analysis for the Adj subset did not yield a significant main effect, $F_2(2, 34) = 2.21, p = .13$. By contrast, the analysis for the Noun subset did reveal a small but significant main effect, $F_2(2, 34) = 4.01, p = .03$. In the case of the Verb subset, the analysis revealed a highly significant main effect, $F_2(2, 34) = 30.16$, $p < .0001$; the analysis for the Bound subset showed a similar result, $F_2(2, 34) = 54.43$, $p < .0001$.

In order to find out whether mean rating scores for *each* subset differed significantly between the CON and MNG probes in particular, another series of ANOVAs was performed treating items as a random factor and Task-2 (CON *vs.* MNG) as a within-group factor. The analysis for the Adj subset did not yield a significant main effect, $F_2(1, 17) = 2.81$, $p = .11$. By contrast, the analysis for the Noun subset did again reveal a significant main effect, $F_2(1, 17) = 10.61$, $p < .01$. In the case of the Verb subset, the analysis revealed a highly significant main effect, $F_2(1, 17) = 38.23$, $p < .0001$; the analysis for the Bound subset showed, again, a similar result, $F_2(1, 17) = 52.27$, $p < .0001$.

In order to find out whether mean ratings differed significantly *between* the various subsets *within* each probe, a series of unpaired two-tailed *t* tests was completed. The analysis of the CF probe revealed that the difference between the Adj and Noun subset was not statistically significant, $t(34) = 0.95$, $p = .35$. By contrast, all other differences were highly significant: Adj and Verb, $t(34) = 6.01$, $p < .0001$; Adj and Bound, $t(34) = 15.99$, $p < .0001$; Noun and Verb, $t(34) = 6.97$, $p < .0001$; Noun and Bound, $t(34) = 19.85$, $p < .0001$; Verb and Bound, $t(34) = 4.16$, $p < .001$. The analysis of the CON probe revealed a similar picture. The difference between the Adj and Noun subset was not statistically significant, $t(34) = 1.13$, $p = .27$. By contrast, all other differences were statistically significant: Adj and Verb, $t(34) = 5.17$, $p < .0001$; Adj and Bound, $t(34) = 12.74$, $p < .0001$; Noun and Verb, $t(34) = 6.03$, $p < .0001$; Noun and Bound, $t(34) = 13.96$, $p < .0001$; Verb and Bound, $t(34) = 5.19$, $p < .0001$. The overall picture also does not change in the analysis of the MNG probe. The difference between the Adj and Noun subset once more did not reach statistical significance, $t(34) = 0.63, p = .54$, whereas all the other differences were highly significant: Adj and Verb, $t(34) = 5.54, p < .0001$; Adj and Bound, $t(34) = 13.97, p < .0001$; Noun and Verb, $t(34) = 6.54, p < .0001$; Noun and Bound, $t(34) = 17.63, p < .0001$; Verb and Bound, $t(34) = 4.87, p < .0001$.

## 5.3. Discussion

The purpose of this experiment had been to test whether native speakers of German *consciously* perceive *ver*-verbs to have the morphological structure [*ver*[ROOT]*(e)n*]. More precisely, the purpose had been to investigate the degree of awareness of etymological, morphological, and semantic links between *ver*-verbs and their presumed roots in word pairs such as VERBITTERN-BITTER, as reflected in the mean ratings for these items in separate probes, each of which focused on one of these three factors. Furthermore, the goal of this experiment had been to clarify and complement the findings of Experiment 1 [ARM-VERARMEN]. The results of the present experiment show a broadly similar pattern of mean ratings across the three different probes on the one hand, but also marked differences between the mean ratings for *ver*-verbs belonging to the four subsets within each probe. In the context of mental representations and their organization, these rating patterns suggests the existence of links between the representations of *ver*-verbs and their roots and that the salience of these links depends both on the root type and the probe. Viewed in the context of Experiment 1 [ARM-VERARMEN], the results of the present experiment provide valuable evidence to confirm and complement the priming patterns of that experiment.

Figure 5.1. above illustrates the general picture of this experiment as it results from the analysis by items. Basically, the mean ratings for each root type across the CF and MNG tasks were similar, with *ver*-verbs belonging to the Adj and Noun subsets yielding relatively high ratings, *ver*-verbs belonging to the Bound subset yielding relatively low ratings, and *ver*-verbs belonging to the Verb subset yielding intermediate ratings. This basic pattern also manifests itself in the results for the CON task, although the mean ratings for each root type were higher, especially for the Bound and Verb subsets.

Given this general picture, it is reasonable to assume that the template [*ver*[ROOT]*(e)n*] has a certain measure of psychological validity as far as the conscious processing of *ver*-verbs is concerned. Taking the 0-4 rating scale used in this experiment as a point of reference, the high mean ratings for *ver*-verbs belonging to the Adj and Noun subsets of more than 3.00 in all three tasks indicate that participants judged etymological, morphological, and semantic links between *ver*-verbs and corresponding roots such as VERBITTERN-BITTER and VERKLEIDEN-KLEID to be highly “probable”. On the other hand, the low mean ratings for *ver*-verbs belonging to the Bound subset of less than 1.50 in all three tasks suggest that participants judged these three kinds of links as being “probably not” existent in cases such as VERGEUDEN-GEUD. Between these two extremes the intermediate mean ratings for *ver*-verbs belonging to the Verb subset, ranging from about 1.75 to 2.50, indicate that participants were “uncertain” about the existence of etymological, morphological, or semantic links in cases such as VERSTOPFEN-STOPF.

These general observations on what the average rating values actually mean in terms of participants' judgements are helpful for a preliminary understanding of the details concerning the perceived structure of *ver*-verbs as they relate to both the significant effects for Task and Task-2 and the significant interaction of Root Type and Task.

As to the task effects for each subset across the CF, CON, and MNG tasks, the lack of statistical significance in the case of the items belonging to the Adj subset suggests that the factors *etymology*, *morphology*, and *semantics* do not have an independent role in the conscious processing of word pairs such as VERBITTERN-BITTER. In other words, speakers' awareness of the structure [*ver*[ROOT]*(e)n*] for this root type does not seem to depend on any of the three probes (CF, CON, and MNG) in particular, and, thus, that all three probes tap knowledge of the same general factor "morpheme awareness". In the case of items belonging to the Noun subset, however, there is a small but significant task effect that can be attributed to higher mean ratings in the CON task. This suggests that it may be somewhat easier for speakers to see a formal morphological link between members of *ver*-verb-root pairs such as VERKLEIDEN-KLEID than it is to see either an etymological or a semantic link between them. In the case of both *ver*-verbs belonging to the Verb subset and the Bound subset there is a highly significant task effect because of clearly elevated mean ratings in the CON task. This suggests that speakers' awareness of the structure [*ver*[ROOT]*(e)n*] in the context of word pairs such as VERSTOPFEN-STOPF and VERGEUDEN-GEUD is mainly based on orthographic grounds.

As to the task effects for each subset across the CON and MNG tasks alone (i.e., Task-2), the lack of significance in the case of the items belonging to the Adj subset suggests that the factors *morphology* and *semantics* do not play an independent role in the conscious processing of these items. In other words, the respective impact of the factors *form* and *meaning* cannot be separated for word pairs such as VERBITTERN-BITTER. The case of *ver*-verbs belonging to the Noun subset is different because the mean ratings for the MNG task are significantly lower than those for the CON task. Thus this phenomenon allows for the separation of the respective impact of *form* and *meaning* for word pairs such as VERKLEIDEN-KLEID. Furthermore, the lack of congruency between these two factors could be interpreted in terms of semantic transparency: the occurrence of mean MNG ratings that are lower in comparison to their CON counterparts would indicate a lower level of semantic transparency. In the case of both *ver*-verbs belonging to the Verb and Bound subsets the differences between mean CON ratings and mean MNG ratings are even more pronounced, which, by extension, could also be interpreted as a widening of the semantic transparency effect for word pairs such as VERSTOPFEN-STOPF and VERGEUDEN-GEUD.

The interaction between Root Type and Task is revealing not only in the context of the present experiment, but also in relation to Experiment 1 [ARM-VERARMEN]. In the context of the present experiment, the results of the analyses for each of the three tasks corroborate the general picture outlined in Experiment 1, namely, that *ver*-verbs belonging to the Adj and Noun subsets group together at the top of the rating scale, items belonging to the Bound subset are situated at the bottom, and items belonging to the Verb subset are in an intermediate position. This state of affairs is reflected in the lack of statistical significance between the mean ratings for items belonging to the Adj and Noun subsets in each of the tasks on the one hand, and the existence of statistical differences between all the other subsets in each of the tasks on the other hand. Most importantly, the differences between the mean ratings for items belonging to the Verb and Bound subsets, respectively, are highly significant in each of the tasks. This is a crucial finding because it allows for the clarification of the priming patterns for items belonging to these two root types obtained in Experiment 1 [ARM-VERARMEN]: The analysis of those patterns had indicated a lack of a significant difference between the two subsets which presented a challenge as to the interpretation of the status of the representations of verbal roots in the mental lexicon. The results of the present experiment suggest that while speakers' awareness of etymological, morphological, and semantic links between the mental representations of *ver*-verbs and their corresponding roots in the Verb subset is significantly weaker than that for items in both the Adj and Noun subsets, they are also significantly stronger than those for items in the Bound subset. Hence, *lexicality,* i.e., whether or not a root is perceived as an existing word, does seem to play a role in the *conscious* processing of these items.

In summary, the rating patterns of the present experiment corroborate and complement the priming patterns obtained in Experiment 1 [ARM-VERARMEN]. As far as the structure of *ver*-verbs is concerned, the high ratings for the Adj and Noun subsets in the CF and CON tasks indicate that *ver*-verbs such as *verbittern* and *verkleiden* are clearly perceived as having the structure [*ver*[BITTER]$_{\text{ADJ}}$*n*] and [*ver*[KLEID]$_{\text{NOUN}}$*en*], respectively. For speakers, this seems to be apparent from a synchronic perspective (CON task) and appears to be well motivated from a diachronic perspective (CF task) as well. Furthermore, the high MNG ratings indicate that seeing links between these subsets of *ver*-verbs "makes sense". On the other hand, the low ratings for the Bound subset indicate that *ver*-verbs such as *vergeuden* are overtly perceived as having the structure [VERGEUDEN] rather than [*ver*[GEUD]$_{\text{BOUND}}$*en*]. For speakers, the lack of internal structure for these items from a synchronic perspective (CON task) also seems to be based on a lack of diachronic motivation for such a structure (CF task). Furthermore, the low MNG ratings suggest that bound roots such as *-geud* are not perceived to be meaningful components at all. All these rating patterns corroborate the priming patterns found in Experiment 1, if one sees a parallel between the level of mean ratings and the magnitude of priming effects.

Still, the *ver*-verbs belonging to the Verb subset remain an interesting case. The intermediate ratings for these items indicate a certain indecisiveness on the part of speakers: although they saw some motivation for links between roots such as *stopf* and *ver*-verbs such as *verstopfen* on diachronic grounds (CF task), they did not manage to rate such links as "probable" from a synchronic morphological perspective (CON task), maybe due to a lack of semantic transparency (MNG task). While the analysis revealed significantly higher ratings for items belonging to the Verb subset than for those belonging to the Bound subsets and, thus, clarified one of the questions that remained unsettled in Experiment 1, the possibility that *ver*-verbs belonging to the Verb subset are consciously perceived as having the structure [*ver*[ROOT*(e)n*]] rather than [*ver*[ROOT]*(e)n*] can still not be ruled out. Thus, *verstopfen*, for example, could be perceived as [*ver*[STOPFEN]$_{\text{VERB}}$] rather than [*ver*[STOPF]$_{\text{VERB}}$en]. Testing the hypothesis that the template [*ver*[ROOT*(e)n*]] rather than [*ver*[ROOT]*(e)n*] affects the conscious processing of *ver*-verbs, especially of those belonging to the Verb subset, was, thus, at the heart of Experiment 4.

# CHAPTER 6

# EXPERIMENT 4: MORPHOLOGICAL ROOT+(E)N AWARENESS

## 6.0. Introduction

In Experiment 3 [ARM IN VERARMEN] a morpheme awareness task was employed to investigate whether native speakers of German *consciously* perceive *ver*-verbs as having the structure [*ver*[ROOT]*(e)n*] (see Chapter 5 above). More precisely, the task consisted of three different probes (CF, CON, MNG) designed to explore the degree of etymological, morphological, and semantic awareness of native speakers of German concerning links between *ver*-verbs and their presumed roots in word pairs such as VERBITTERN-BITTER. Results indicated that (a) word pairs belonging to the Adj and Noun subsets yielded the highest mean ratings within and across the different probes, (b) word pairs belonging to the Bound subset produced the lowest mean ratings, an (c) word pairs belonging to the Verb subset yielded intermediate mean ratings. Thus, the rating patterns of Experiment 3, reflecting native speakers' conscious processing of *ver*-verbs, corroborated, in general, the priming patterns of Experiment 1 [ARM-VERARMEN], reflecting the subconscious processing of these items. Crucially, however, the results of Experiment 3 revealed that in all three probes the mean ratings for word pairs belonging to the Verb subset were significantly higher than those for the Bound subset, thus settling an unresolved question from Experiment 1 (see Section 3.3. above). The combined results of Experiment 3 were interpreted as evidence in favor of the hypothesis that *ver*-verbs belonging to the Adj, Noun, and Verb subsets such as *verbittern*, *verkleiden*, and *verstopfen* are consciously perceived as having the structure [*ver*[BITTER]$_{ADJ}$*n*], [*ver*[KLEID]$_{NOUN}$*en*], and [*ver*[STOPF]$_{VERB}$*en*], respectively, whereas *ver*-verbs belonging to the Bound subset such as *vergeuden* are perceived as [VERGEUDEN].

Still, several questions related to *ver*-verbs remain unresolved. Viewed in isolation, the relatively flat pattern of priming effects across the different subsets (Adj, Noun, Verb, and Bound) obtained for Experiment 2 [ARMEN-VERARMEN] (see Section 4.2. above) could be interpreted such that the prior presentation of primes conforming to the structure [ROOT*(e)n*] leads to form-based effects that are independent of the factor lexicality. This would explain the similar magnitude of priming effects for prime-target pairs such as BITTERN-VERBITTERN (Adj subset) and GEUDEN-VERGEUDEN (Bound subset). On the other hand, if seen in the context of the priming patterns obtained for Experiment 1, in which prime-target pairs such as BITTER-VERBITTERN were used (see Section 3.1.2. above), the priming patterns obtained for Experiment 2 could be interpreted such that *ver*-verbs belonging to different subsets have preferred morphological structures, namely, either [*ver*[ROOT]*(e)n*] or [*ver*[ROOT*(e)n*]]. This would explain why, in comparison, the priming effects for *ver*-verbs belonging to the Adj subset were reduced, those for the Noun subset remained stable, and those for the Bound subset and especially the Verb subset increased. While all these claims have their merits, they do require substantiation with further independent evidence.

In the present experiment, therefore, another version of the morpheme awareness task already familiar from Experiment 3 [ARM IN VERARMEN] was employed to investigate the degree of etymological, morphological, and semantic awareness of native speakers of German concerning links between *ver*-verbs and the root+*en* element they contain (rather than their presumed root only). The purpose of this experiment had been to test whether or not native speakers of German *consciously* perceive *ver*-verbs to have the morphological structure [*ver*[ROOT*(e)n*]] (rather than [*ver*[ROOT]*(e)n*]) in word pairs such as VERBITTERN-BITTERN. The rationale behind this experiment was the following: (a) If speakers were aware of the structure [*ver*[ROOT*(e)n*]], this would both indicate a certain measure of psychological validity for this structure and provide corroborative evidence for the claim of links between the mental representations of *ver*-verbs and their constituents made in Experiment 2 [ARMEN-VERARMEN] (see Section 4.3. above); (b) differential ratings across the four root+*en* types would provide corroborative evidence for another claim made in Experiment 2, namely, that there are preferred morphological structures for different subsets; (c) differential ratings across the three probes would indicate a certain measure of independence of the factors *etymology*, *morphology*, and *semantics* in conscious language processing.

## 6.1. Method

### *6.1.1. Participants*

A total of 55 native speakers of German volunteered to participate. Thirty of these were enrolled in undergraduate Philology courses at Albert-Ludwigs-Universität in Freiburg im Breisgau, Germany. Another 15 were enrolled in undergraduate German courses at Pädagogische Hochschule (University of Education) in the same city. The remaining 10 participants were professionals living in the same general area. The 55 participants in this study had neither taken part in Experiment 1 [ARM-VERARMEN] nor in

Experiment 3 [ARM IN VERARMEN]. Twenty-five of them, however, had taken part in Experiment 2 [ARMEN-VERARMEN]. The remaining participants had taken part in experiments that will be discussed in more detail later.

*6.1.2. Materials*

The stimuli consisted of the same 72 *ver*-verb targets already used in Experiment 3, i.e., 18 each of the Adj, Noun, Verb, and Bound subsets. In the present experiment, however, these targets were supplemented with the root+*en* elements they contain (corresponding to the root+*en* primes in Experiment 2), such that the final stimulus list consisted of 72 *ver*-verb-root-*en pairs* (e.g., VERBITTERN-BITTERN). No filler items were employed.

*6.1.3. Design and procedure*

The design and procedure in this experiment differed from that of Experiment 3 in the following respects.[13]

First, the templates for the three German probes had to be altered in order to reflect the fact that *ver*-verb-root-*en* pairs such as VERBITTERN-BITTERN were used as stimuli rather than *ver*-verb-root pairs such as VERBITTERN-BITTER. Thus, in the present experiment the templates for the CF, CON, and MNG probes, respectively, were as

[13] These changes in procedure were necessitated by practical limits on both the length of the testing period in Germany and the availability of travel funds.

shown below, with English translations provided here for the sake of clarity and the probes employed in Experiment 3 in parentheses for comparison:

(a) "Wurde das Wort *erzählen* vom Wort *zählen* abgeleitet?"/"Does the word *to tell* come from the word *to count*?".

(In Experiment 3 the probe had been "Wurde das Wort *erzählen* vom Wort *Zahl* abgeleitet?"/"Does the word *to tell* come from the word *number*?".)

(b) "Enthält das Wort *erzählen* eine Form des Wortes *zählen*?"/"Does the word *to tell* contain a form of the word *to count*?".

(In Experiment 3 the probe had been "Enthält das Wort *erzählen* eine Form des Wortes *Zahl*?"/"Does the word *to tell* come from the word *number*?".)

(c) "Enthält das Wort *erzählen* die Bedeutung des Wortes *zählen*?"/"Does the word *to tell* contain the meaning of the word *to count*?".

(In Experiment 3 the probe had been "Enthält das Wort *erzählen* die Bedeutung des Wortes *Zahl*?"/"Does the word *to tell* contain the meaning of the word *number*?".)

Second, data were collected by e-mail rather than by direct computer elicitation. This meant that (a) participants had to be randomly pre-assigned to three lists (List A, List B, and List C); and (b) a practical limit had to be imposed on the number of written questionnaires sent out to prospective participants. Thus, three lists (List A, List B, and List C) were constructed such that each of them consisted of three blocks (CF, CON, and MNG) that comprised 24 word pairs each, bringing the total number of word pairs in each list to 72. Each block consisted of six groups of four words, where each word belonged to either the Adj, Noun, Verb, or Bound subsets. In List A, the CF block came first, followed by the CON block, and, finally the MNG block. In List B, the CON block preceded the MNG block, which, in turn, preceded the CF block. Finally, in List C the MNG block came first, followed by the CF block and the CON block, respectively. Across lists, both the selection and the order of the first group of four stimuli in each block were fixed such that the same four stimuli belonging to the Bound, Adj, Noun, and Verb subsets, respectively, were used. For the remaining five groups of four stimuli within each block, the selection of stimuli was semi-randomized across Lists A, B, and C: a different stimulus belonging to the Bound subset was always used first and then followed by different stimuli belonging to either of the Adj, Noun, or Verb subsets, whereby the order of these subsets was fixed within each list but differed across lists.

One version of the resulting questionnaires, i.e., either List A, List B, or List C, was then sent out as a Microsoft Word e-mail attachment to each of 95 individuals who had already volunteered to participate in other experiments (see Section 6.1.1. above), keeping the numbers of each version in rough balance. In the instructions, recipients were told that the questionnaire dealt with three types of questions concerning specific word pairs, and that they were kindly asked to fill in that questionnaire on-line. For the purpose of illustration, the cover page of the questionnaire contained the sample questions mentioned above. Recipients were also given the 0-4 rating scale already employed in Experiment 3 (see Section 5.1.3. above), which, they were told, should be the basis for their answers. Recipients were then instructed to indicate their answers (ratings) by typing the appropriate number into the box to the left of each question. Before each block (CF, CON, and MNG), the specific instructions for that block were reproduced.

Furthermore, the rating scale was repeated below each question. Finally, recipients were instructed to take their time completing the questionnaire and then send it back, again as a Microsoft Word e-mail attachment. As already mentioned, a total of 55 recipients responded to the request and provided data.

### 6.2. Results

Since the present experiment did not involve measuring any RTs, there was no need for any data trimming (analogous to Experiment 3).

First, in an effort to insure the comparability of the data from the participants with the status of university student, education student, and professional, respectively, ANOVAs were run on the rating scores of these three groups. In this analysis Status (university student *vs.* education student *vs.* professional) was treated as a between-group factor, whereas Base Type (Adj *vs.* Noun *vs.* Verb *vs.* Bound) and Task (CF *vs.* CON *vs.* MNG) were treated as within-group factors. This analysis produced a significant main effect of Status, $F_1(2, 52) = 4.49$, $p < .02$, and a significant interaction between Base Type and Status, $F_1(6, 156) = 2.42$, $p < .03$. Both of these effects were based on the professional group's lower mean ratings. Given this state of affairs, the same type of ANOVA was performed again, this time excluding the data from the professional group. This new analysis did not produce a significant main effect of Status, $F_1(1, 43) = 0.07$, $p = .79$; however, it produced again a significant interaction between Base Type and Status, $F_1(3, 129) = 4.47$, $p < .01$, that was based on the education student's higher mean rating for items belonging to the Bound subset. Crucially, however, both analyses produced a similar overall pattern with significant main effects of Task and Base Type but no significant interaction between these two factors. Thus, it can be reasonably assumed that the three status groups did provide comparable results after all, and, consequently, the data from these three groups were merged in all subsequent rating analyses.

Next, two ANOVAs were performed to investigate the ratings that resulted from the CF, CON, and MNG tasks across the four base types. One analysis treated participants as a random effect ($F_1$), whereas the other treated items as a random effect ($F_2$).

In the analysis by participants, Base Type (Adj *vs.* Noun *vs.* Verb *vs.* Bound) and Task (CF *vs.* CON *vs.* MNG) were treated as within-group factors; there were no between-group factors. This analysis revealed a main effect of both Base Type, $F_1(3, 162) = 318.47, p < .0001$, and Task, $F_1(2, 108) = 9.02, p < .001$. The interaction between these two factors, however, did not reach statistical significance, $F_1(6, 324) = 1.56, p = .16$.

In the analysis by items, Task (CF *vs.* CON *vs.* MNG) was treated as a within-group factor and Base Type (Adj *vs.* Noun *vs.* Verb *vs.* Bound) as a between-group factor. This analysis revealed a main effect of both Task, $F_2(2, 136) = 12.25, p < .0001$, and Base Type, $F_2(3, 68) = 31.90, p < .0001$, as well as an interaction between these two, $F_2(6, 136) = 2.23, p < .05$.

Table 6.1. shows the mean ratings obtained for word pairs belonging to the four different root+*en* types in each of the three tasks (CF, CON, and MNG).

Table 6.1. Mean rating scores across four root+en types and three tasks in the analysis by items in Experiment 4

| | Task | | |
|---|---|---|---|
| Root+*en* Type | CF | CON | MNG |
| Adj | 235 (25) | 255 (28) | 245 (24) |
| Noun | 264 (23) | 274 (22) | 250 (16) |
| Verb | 329 (14) | 347 (10) | 291 (18) |
| Bound | 92 (11) | 98 (10) | 78 (11) |

Note. Original ratings based on a 0-4 confidence scale were converted to scores by multiplying them by 100. Numbers in parentheses indicate standard errors.

The same results are also graphically represented in Figure 6.1..

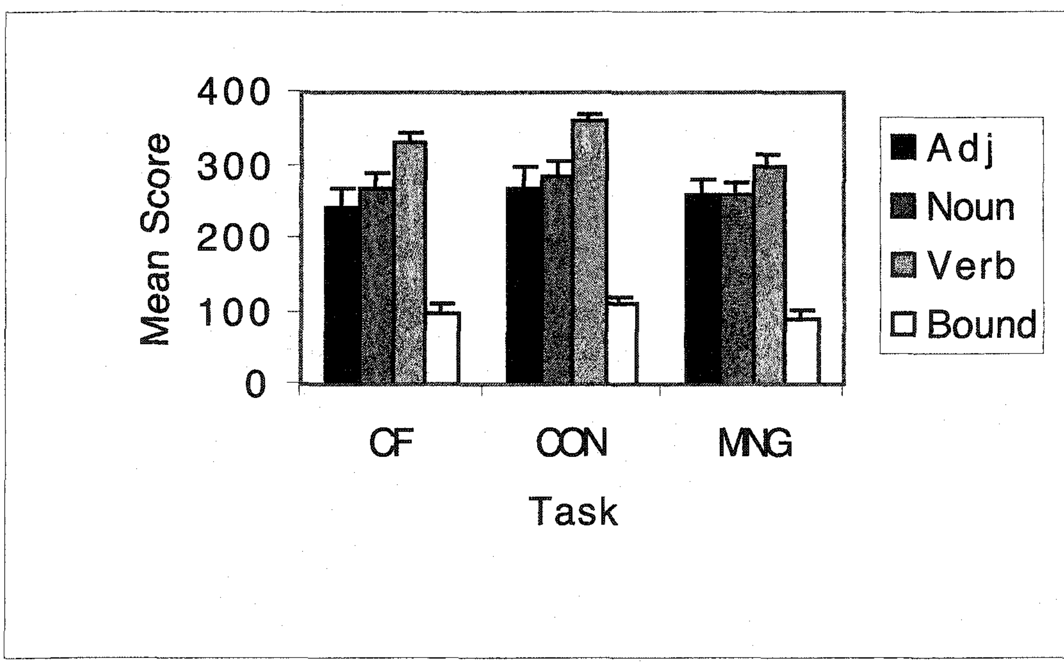



Figure 6.1. Mean rating scores and standard errors as a function of root+en type and task in the analysis by items in Experiment 4

In order to find out whether mean rating scores for each subset differed significantly across all three probes, ANOVAs were performed treating items as a random factor and

Task (CF *vs*. CON *vs*. MNG) as a within-group factor. The analyses for the Adj and Noun subsets did not yield a significant main effect, $F_2(2, 34) = 1.75, p = .19$, and $F_2(2, 34) = 1.61, p = .21$, respectively. By contrast, the analysis for the Verb subset revealed a highly significant main effect, $F_2(2, 34) = 12.69, p < .0001$. The analysis for the Bound subset, finally, showed that mean rating scores were approaching statistical significance, $F_2(2, 34) = 2.67, p = .08$.

In order to find out whether mean rating scores for each subset differed significantly between the CON and MNG probes in particular, another series of ANOVAs was performed treating items as a random factor and Task-2 (CON *vs*. MNG) as a within-group factor. The analyses for the Adj and Noun subsets did not yield a significant main effect, $F_2(1, 17) = 1.09$, $p = .31$, and $F_2(1, 17) = 2.72$, $p = .12$, respectively. By contrast, the analysis for the Verb subset did again reveal a highly significant main effect, $F_2(1, 17) = 18.06, p < .001$. The analysis for the Bound subset yielded a significant main effect as well, $F_2(1, 17) = 10.97, p < .01$.

In order to find out whether mean ratings differed significantly between the various subsets within each probe, a series of unpaired two-tailed $t$ tests was completed. The analysis of the CF probe revealed that the difference between the Adj and Noun subsets was not statistically significant, $t(34) = 0.85$, $p = .39$. By contrast, all other differences were statistically significant: Adj and Verb, $t(34) = 3.28, p < .01$; Adj and Bound, $t(34) = 5.26, p < .0001$; Noun and Verb, $t(34) = 2.44, p = .02$; Noun and Bound, $t(34) = 6.82$, $p < .0001$; Verb and Bound, $t(34) = 13.47, p < .0001$. The analysis of the CON probe revealed a similar picture. The difference between the Adj and Noun subsets was not statistically significant, $t(34) = 0.53, p = .59$. By contrast, all other differences were statistically significant: Adj and Verb, $t(34) = 3.05, p < .01$; Adj and Bound, $t(34) = 5.16, p < .0001$; Noun and Verb, $t(34) = 3.05, p < .01$; Noun and Bound, $t(34) = 7.29, p < .0001$; Verb and Bound, $t(34) = 17.25, p < .0001$. As far as the analysis of the MNG probe is concerned, the overall picture changes slightly. Here, not only the difference between the Adj and Noun subsets did not reach statistical significance ($t(34) = 0.19, p = .85$), but also the differences between the Adj and Verb subsets ($t(34) = 1.53, p = .14$) and the Noun and Verb subsets ($t(34) = 1.69, p = .09$), respectively. By contrast, all other differences, i.e., those involving the Bound subset, were highly significant: Adj and Bound, $t(34) = 6.33, p < .0001$; Noun and Bound, $t(34) = 9.06, p < .0001$; Verb and Bound, $t(34) = 10.31, p < .0001$.

### 6.3. Discussion

The purpose of this experiment had been to test whether native speakers of German consciously perceive *ver*-verbs to have the morphological structure [*ver*[ROOT*(e)n*]]. More precisely, the purpose had been to investigate the degree of awareness of etymological, morphological, and semantic links between *ver*-verbs and the root+*en* elements they contain in word pairs such as VERBITTERN-BITTERN, as reflected in the mean ratings for these items in separate probes, each of which focused on one of these three factors. Furthermore, the goal of this experiment had been to clarify and complement the findings of Experiment 2 [ARMEN-VERARMEN] and Experiment 3 [ARM IN VERARMEN]. The results of the present experiment show a broadly similar pattern of mean ratings across the three different probes, but also marked differences between the mean ratings for *ver*-verbs belonging to the four subsets within each probe. In the context of mental representations and their organization, these rating patterns suggest the existence of links between the representations of *ver*-verbs and the root+*en* elements they contain and that the salience of these links depends on both the root+*en* type and the probe. Viewed in the context of Experiment 2 [ARMEN-VERARMEN], the results of the present experiment provide valuable evidence to confirm and complement the priming patterns of that experiment. Furthermore, in the context of Experiment 3 [ARM IN VERARMEN], the results of the present experiment allow for a more comprehensive understanding of the role of morphological structure in the conscious processing of *ver*-verbs.

Figure 6.1. illustrates the general picture of this experiment as it results from the analysis by items. Basically, the pattern of mean ratings across the three tasks is similar, with *ver*-verbs belonging to the Adj, Noun, and Verb subsets yielding relatively high ratings, and *ver*-verbs belonging to the Bound subset yielding relatively low ratings. Two striking characteristics are (a) the elevated ratings for all subsets in the CON task, and (b) the clearly elevated ratings for *ver*-verbs belonging to the Verb subset across the three tasks.

Given this general picture, it is reasonable to assume that the template [*ver*[ROOT*(e)n*]] has a certain measure of psychological validity as far as the conscious processing of *ver*-verbs is concerned. Taking the 0-4 rating scale used in this experiment as a point of reference, the mean ratings of around 2.50 across tasks for *ver*-verbs belonging to the Adj subset and around 2.60 for those belonging to the Noun subset indicates that participants were "uncertain" concerning etymological, morphological, and semantic links between *ver*-verbs and the root+*en* elements in word pairs such as VERBITTERN-BITTERN and VERKLEIDEN-KLEIDEN, although there seemed to be a tendency towards seeing such links as being marginally "probable". On the other hand, participants judged any such links as being "probably not" existent in the case of word pairs belonging to the Bound subset such as VERGEUDEN-GEUDEN, since mean ratings for this subset were below 1.00 across the three tasks. In contrast to the situation for these three subsets above, participants judged etymological, morphological, and semantic links between *ver*-verbs and root+*en* elements as clearly "probable" in the case of the Verb subset, i.e., for word pairs such as VERSTOPFEN-STOPFEN, the respective mean ratings ranging between 3.30 and 2.90. This state of affairs represents a change from Experiment 3 [ARM IN VERARMEN], where *ver*-verbs belonging to the Adj and Noun subsets, respectively, received the highest ratings and items belonging to the Verb subset only received intermediate ratings.

These general observations are helpful for a preliminary understanding of the details concerning the perceived structure of *ver*-verbs as they relate to both the significant effects for Task and Task-2 and the significant interaction of Base Type and Task.

As to the task effects for each subset across the CF, CON, and MNG tasks, the lack of statistical significance in the case of the items belonging to the Adj, Noun, and Bound subsets suggests that the factors *etymology*, *morphology*, and *semantics* do not have an independent role in the conscious processing of word pairs such as VERBITTERN-BITTERN, VERKLEIDEN-KLEIDEN, and VERGEUDEN-GEUDEN. In other words, speakers' awareness of the structure [*ver*[ROOT*(e)n*]] for these subsets does not seem to depend on any of the three probes (CF, CON, and MNG) in particular. This represents a slight change in comparison to Experiment 3 [ARM IN VERARMEN], where there had been elevated mean ratings for items belonging to the Noun and Bound subsets in the CON task. In the case of items belonging to the Verb subset, there is a significant task effect in both experiments. However, whereas in Experiment 3 this effect was based on elevated mean ratings in the CON task only, suggesting an increased awareness of morphological links between *ver*-verbs and their roots, in the present experiment this effect is based on both elevated mean ratings in the CON task and lower mean ratings in the MNG task (as compared to the ratings for the CF task). This indicates a heightened awareness of the factors *morphological structure* and *semantic transparency* among participants for *ver*-verbs belonging to this particular subset such as VERSTOPFEN-STOPFEN.

As to the task effects for each subset across the CON and MNG tasks alone, i.e., Task-2, the lack of statistical significance in the case of the items belonging to the Adj and Noun subsets suggests that the factors *morphology* and *semantics* do not play an independent role in the conscious processing of these items. In other words, the respective impact of the factors *form* and *meaning* cannot be separated for word pairs such as VERBITTERN-BITTERN and VERKLEIDEN-KLEIDEN. This represents a slight change in comparison to Experiment 3 [ARM IN VERARMEN], where there had been a significant difference in the mean ratings for these two tasks for items belonging to the Noun subset, resulting in a semantic transparency effect. On the other hand, this transparency effect is still at work for *ver*-verbs belonging to the Verb and Bound subsets. Thus, in the present experiment it seemed to be easier for participants to see a morphological link between the members of word pairs such as VERSTOPFEN-STOPFEN and VERGEUDEN-GEUDEN than to see either an etymological or a semantic link between them.

The interaction between Base Type and Task is revealing not only in the context of the present experiment, but also in relation to Experiment 2 [ARMEN-VERARMEN] and Experiment 3 [ARM IN VERARMEN]. In the context of the present experiment, the results for the analyses of the CF and CON tasks corroborate the general picture outlined above, namely, that *ver*-verbs belonging to the Verb subset are at the top of the rating scale, *ver*-verbs belonging to the Adj and Noun subsets are lower but still very high, and *ver*-verbs belonging to the Bound subset are at the very bottom. This state of affairs is reflected in the existence of statistically significant differences between (a) the mean ratings for items belonging to the Verb subset and the items belonging to all the other subsets, and (b) the mean ratings for *ver*-verbs belonging to the Adj and Noun subsets on the one hand and the Bound subset on the other hand. Furthermore, there is a lack of statistical significance between the mean ratings for *ver*-verbs belonging to the Adj and Noun subsets. As far as the MNG task is concerned, there is a two-way distinction between *ver*-verbs belonging to the Adj, Noun, and Verb subsets, on the one hand, all of which yield high mean ratings, and items belonging to the Bound subset that yield very low ratings. This state of affairs is reflected in (a) the lack of statistical significance between the mean ratings for items belonging to the Adj, Noun, and Verb subsets, respectively, and (b) significantly higher mean ratings for *ver*-verbs belonging to these subsets than for those belonging to the Bound subset.

The above results are crucial for a better understanding of several issues that have arisen from previous experiments. The occurrence of flat priming effects across the four different base types in Experiment 2 [ARMEN-VERARMEN], viewed in isolation, could have been interpreted such that these effects are merely based on *form* and independent of the factor lexicality. However, the existence of statistically significant differences across the three tasks in the present experiment between the mean ratings for *ver*-verbs belonging to the Adj, Noun and Verb subsets, on the one hand, and those belonging to the Bound subset, on the other hand, do not corroborate this interpretation. Hence, viewed from the combined perspective of these two experiments, the factor lexicality does seem to play a role in the processing of *ver*-verbs. Furthermore, the occurrence of statistically significant differences between the mean ratings for items belonging to the Adj and Noun subsets, on the one hand, and the Verb subset, on the other hand, in both the CF and MNG tasks, as well as the lack of such differences in the MNG task in the present experiment corroborate an important claim made in Experiment 2, namely, that of preferred structures for the different subsets of *ver*-verbs. This claim had been based on the comparison of the magnitude of priming effects for items belonging to the four different subsets obtained in Experiment 1 [ARM-VERARMEN] and those obtained in Experiment 2 [ARMEN-VERARMEN] which revealed a weakening of the priming effect for items belonging to the Adj subset, an increase of the priming effect for items belonging to the Verb and Bound subsets, and a stabilization in the case of items belonging to the Noun subset (see Section 4.3. above). This state of affairs was claimed to be indicative of certain preferences concerning the internal structure of *ver*-verbs: the Adj and Bound subsets were said to be based on the template [*ver*[ROOT]*(e)n*], whereas the Verb and Bound subsets were said to be based on the template [*ver*[ROOT*(e)n*]]. Thus, the occurrence of statistically significant higher mean ratings for *ver*-verbs belonging to the

Verb subset as compared to items belonging to both the Adj and Noun subsets in the present experiment, especially in the CON task, and the lack of statistical significant differences between the mean ratings for items belonging to the Adj and Noun subsets, respectively, provide corroborative evidence for the claim of preferred morphological structures for different subsets of *ver*-verbs. (In this context, the consistently low mean ratings for items belonging to the Bound subset indicate that priming effects for these items were based only on *form*.) Additional supportive evidence for the claim of preferred morphological structures for different subsets of *ver*-verbs comes from the comparison of the mean rating scores obtained in Experiment 3 [ARM IN VERARMEN] and those obtained in the present experiment: whereas ratings for items belonging to the Verb subset go up across the three tasks, those for items belonging to the Adj and Noun subsets, respectively, go down.

In summary, while Experiment 1 [ARM-VERARMEN] and Experiment 2 [ARMEN-VERARMEN] have provided a coherent account of the *subconscious* processing of *ver*-verbs, Experiment 3 [ARM IN VERARMEN] and Experiment 4 [ARMEN IN VERARMEN] have provided a sensible account of the *conscious* processing of these items by native speakers of German. Still, the account of the processing of *ver*-verbs is not complete yet. The priming studies mentioned above have focused on only one kind of priming, namely, constituent-to-whole-word priming, establishing that the prior presentation of both constituents such as BITTER and BITTERN facilitates the processing of a target such as VERBITTERN. So far, it is, however, not clear whether whole-word-to-constituent priming could also occur such that, for example, primes such as VERBITTERN facilitate the processing of targets such as BITTER and BITTERN. In that case priming would not be unidirectional but bi-directional, suggesting the existence of an intricate mental network in which the representations of full forms are linked to the representations of their constituents and vice versa.

Investigating the possibility of bi-directional priming is, therefore, at the center of Experiment 5a [VERARMEN-ARM] and Experiment 5b [VERARMEN-ARMEN], which represent reversals of Experiment 1 and Experiment 2, respectively.

# CHAPTER 7

# EXPERIMENTS 5A AND 5B: WHOLE-WORD PRIMING

## 7.0. Introduction

In Experiment 1 a lexical decision task with morphological root priming had been employed in order to investigate the role of the template [*ver*[ROOT]*(e)n*] in the subconscious processing of *ver*-verbs belonging to the Adj, Noun, Verb, and Bound subsets. Results indicated that in the Adj and Noun subsets the prior presentation of root primes such as BITTER and KLEID led to statistically significant facilitation in the processing of the *ver*-targets in which they are embedded (here: VERBITTERN and VERKLEIDEN) as compared to unrelated controls. By contrast, the prior presentation of Bound root primes such as GEUD did not lead to facilitation in the processing of the corresponding whole-word target (here: VERGEUDEN). Surprisingly, there was also a lack of statistically significant priming effects for prime-target pairs in the Verb subset such as STOPF-VERSTOPFEN (see Section 3.2. above).

This state of affairs raised questions concerning the status of verbal roots in the processing of the *ver*-verbs in which they are embedded: in a morphological priming paradigm the lexical roots belonging to the Verb subset appeared to be less effective primes for *ver*-verbs than the lexical roots belonging to both the Adj and Noun subsets. Thus, the mental representations for roots belonging to the Verb subset seemed to be less salient in the process of accessing the *ver*-verbs in which they are embedded than those belonging to the Adj and Noun subsets. Seen from the point of view of the organization of representations in the mental lexicon, this would suggest the existence of reasonably strong links between the representations of *ver*-verbs and the representations of their roots in the case of items belonging to the Adj and Noun subsets, and weaker links of that kind in the case of items belonging to the Verb subset. Hence, the results of Experiment 1 suggest that, for example, VERBITTERN seems to have strong links to BITTER, just as VERKLEIDEN appears to have strong connections to KLEID. On the other hand, VERSTOPFEN seems to have only comparatively weak links to STOPF. Whereas these results endorse the claim of root-to-whole-word priming, it remains unclear whether whole-word-to-root priming could also occur.

The conceptual difference between these two types of priming in the context of the organization of mental representations is illustrated in Figure 7.1. (root-to-whole-word priming) and Figure 7.2. (whole-word-to-root priming). According to the present line of argumentation, either type of priming can be seen as indicating a circular relationship between two mental representations such that the fact that representation A primes representation B implies the existence of a link between representation B and representation A; furthermore, the magnitude of any priming effects can be seen as a measure of the salience of this link.

Figure 7.1. illustrates this way of argumentation for Experiment 1 (thus reproducing Figure 3.1.).

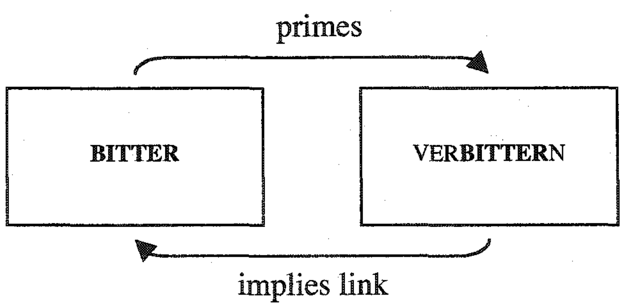



Figure 7.1. Conceptualization of root-to-whole-word priming in terms of the relationships between the mental representations of whole *ver*-verbs and their (presumed) roots

The fact that in that experiment a root such as BITTER primed VERBITTERN, i.e., the fact that root-to-whole-word priming occurred, implies the existence of a link between the mental representation of the full form VERBITTERN and the root BITTER. Essentially, this conceptualization is a more elaborate way of arguing for a prominent role of the template [*ver*[ROOT]*(e)n*] in the processing of these items, and, thus, for items such as VERBITTERN to be perceived as [*ver*[BITTER]*n*]. Differential priming effects obtained for the four root types in Experiment 1 indicate differences in the salience of the links between the mental representations of full forms and roots.

Figure 7.2. illustrates the argumentation for the reverse case, namely, whole-word-to-root priming.

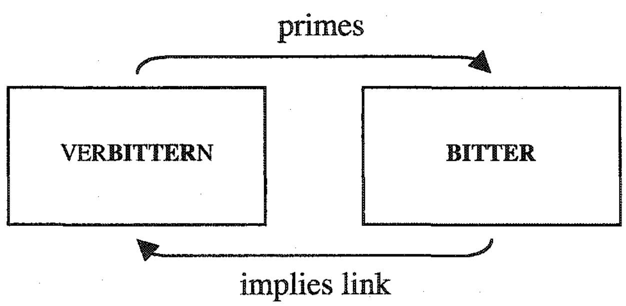



Figure 7.2. Conceptualization of whole-word-to-root priming in terms of the relationships between the mental representations of roots and the whole *ver*-verbs in which they are embedded

If a full form such as VERBITTERN primed its corresponding root BITTER, this would imply the existence of a link between the mental representation of the root BITTER and the full form VERBITTERN.

In the present experiment, therefore, a lexical decision task with a priming component was employed to investigate whether the mental representations of adjective, noun and verb roots have links to the mental representations of the *ver*-verbs in which they are embedded. The rationale behind the experiment was that if such links exist, the prior presentation of *ver*-verb primes should lead to facilitatory processing for corresponding root targets, as compared to unrelated controls. Thus, the prior presentation of a prime such as VERBITTERN should lead to a priming effect for the target root BITTER. The occurrence of differential priming effects across target root types would be indicative of variation in the strength of links between the representations of root targets and whole-word primes.

## 7.1. Method

### *7.1.1. Participants*

A total of 40 native speakers of German volunteered to participate. Twenty-two of these were enrolled in undergraduate Philology courses at Albert-Ludwigs-Universität in Freiburg im Breisgau, Germany. Another eight were enrolled in undergraduate German courses at Pädagogische Hochschule (University of Education) in the same city. The remaining ten participants were professionals living in the same general area. The 40 participants in this study had neither taken part in any of the previous priming studies (Experiment 1 [ARM-VERARMEN]; Experiment 2 [ARMEN-VERARMEN]) nor in the morpheme awareness task that employed *ver*-verb-root pairs (Experiment 3 [ARM IN VERARMEN]). Twenty-one of them, however, subsequently volunteered to take part in the morpheme awareness task that employed *ver*-verb-root-*en* pairs (Experiment 4).

### *7.1.2. Materials*

The critical *target* stimuli consisted of the roots of 54 of the *ver*-verbs that had been used as *primes* in Experiment 1 [ARM-VERARMEN], i.e., 18 simple adjectives, nouns, and verbs. Since, in contrast to these, the expected answer for the 18 bound roots in this lexical decision task was "No" rather than "Yes", this meant that (a) bound roots were not employed as critical targets in the present experiment, and (b) the numerical balance of "Yes" and "No" answers in the stimulus set established for Experiment 1 could no longer be upheld. Therefore, in the present experiment 18 of the filler items employed in Experiment 1 that had required a "No" response were replaced by using 18 of the filler items that required a "Yes" response twice. The whole *ver*-verbs in which the simple adjectives, nouns, verbs, and bound elements, respectively, were embedded served as primes. Filler items included items such as HEI (prime) and HEIKEL (target). Table 7.1. shows the numerical organization of the final stimulus set that consisted of 216 items, just as in Experiment 1.

Table 7.1. Breakdown of the number and types of items in the stimulus set in Expt. 5a

| Expected Answer | Target Root Type | Items with *ver-* | Items without *ver-* |
|---|---|---|---|
| "Yes" | Adj | 18 | 18 |
| | Noun | 18 | 18 |
| | Verb | 18 | 18 |
| "No" | Bound | 18 | --- |
| | *ver-/ker-*Nonsense | 36 | 36 |
| | Other Nonsense | --- | 18 |

Note. Numbers stand for prime-target pairs. Participants shared all target stimuli except the ones in the gray cells, which differed for the root and neutral target priming conditions (Lists 1 and 2). All items without *ver-* were bisyllabic, yet non-prefixed. A total of 216 stimuli was presented to each participant.

### *7.1.3. Design and procedure*

The design and procedure employed in this experiment [VERARMEN-ARM] constituted a simple reversal of that of Experiment 1 [ARM-VERARMEN]. In other words, items that had been primes in Experiment 1 were targets in the present experiment and vice versa. For example, rather than having prime-target sequences such as BITTER-VERBITTERN (as in Experiment 1), prime-target sequences such as VERBITTERN-BITTER were used in the present study. This reversal applied to both the critical root target stimuli and also the nonsense *ver-/ker-*stimuli, which served as one type of filler items. Other filler items such as HEI (syllabic nonsense prime) and HEIKEL (real target) were exempt from this procedure in order to keep the number of expected "Yes" and "No" answers in balance. Table 7.2. shows the structural organization of the final stimulus set, reflecting the design of the present experiment.

Table 7.2. Structural organization of the stimulus set with examples in Experiment 5a

| | | | Priming Conditions for Items with *ver-* | | |
|---|---|---|---|---|---|
| Expect. Answer | Target Root Type | *ver*-Prime | Root | Neutral | Items without *ver-* |
| "Yes" | Adj | VERBITTERN | BITTER<br>--- | ---<br>SAUBER | HEI/HEIKEL |
| | Noun | VERKLEIDEN | KLEID<br>--- | ---<br>KREUZ | SAL/SALBE |
| | Verb | VERSTOPFEN | STOPF<br>--- | ---<br>KRATZ | WAR/WARTEN |
| "No" | Bound | VERGEUDEN | GEUD<br>--- | ---<br>RAPS | --- |
| | *ver-/ker-* Nonsense Items | VERKRENGEN | KRENG | --- | KERKRENGEN/ KRENG |
| | Other Nonsense Items | --- | --- | --- | DEI/DEIKEL<br>RAL/RALBE<br>NAR/NARTEN |

Note. Participants shared all target stimuli except the ones in the gray cells, which differed for the root and neutral target priming conditions (Lists 1 and 2). Participants saw a root target in only one of these conditions. For nonsense and filler items without *ver-*, the string to the left of the slash (/) indicates the "prime", and the string to the right of the slash indicates the target. A total of 216 stimuli was presented to each participant.

## 7.2. Results

In this experiment participants generated 8,640 RT observations (40 participants x 216 stimuli). None of these involved RTs below 300 ms. However, 244 RT observations were above 1,500 ms; these were recoded to 1,500 ms. Thus, about 2.8% of the overall data in this experiment (i.e., including both critical stimuli and fillers) were replaced with a cutoff value. This procedure was employed in order to maintain the same range adopted for Experiment 1 [ARM-VERARMEN] and Experiment 2 [ARMEN-VERARMEN], and, thus, to keep basic parameters of the overall investigation constant.

First, in an effort to insure the comparability of the data from the participants with the status of university student, education student, and professional, ANOVAs were run on the accuracy and RT scores of these three groups, as they related to the adjective, noun, and verb root target stimuli. In this context, accuracy was defined as the percentage of (correct) “Yes” responses to the 54 existing target roots; RT scores included correct responses only. (The 18 bound root targets, which called for “No” responses, were not analyzed.) In both analyses Status (university student *vs.* education student *vs.* professional) was treated as a between-group factor, whereas Priming (neutral *vs.* root) and Root Type (adjective *vs.* noun *vs.* verb) were treated as within-group factors. The analysis of accuracy did not produce a significant main effect of Status, $F_1(2, 37) = 0.30$, $p = .74$; there were also no significant interactions involving that factor (all $p$-values > .68). Based on this analysis, it is reasonable to assume that the three groups provided comparable results. The analysis of RT scores, however, did reveal a marginally significant main effect of Status, $F_1(2, 37) = 3.39, p = .045$, that was based on elevated response latencies for the professional group. There were no significant interactions involving Status (all $p$-values > .68). Given this state of affairs, the same type of ANOVA was performed again, this time excluding the data from the professional group. This new analysis did not produce a significant main effect of Status, $F_1(1, 28) = 0.07, p = .79$.; there were also no significant interactions involving this factor (all $p$-values > .57).

Interestingly, whereas in the first experiment there had been a significant main effect of Priming, $F_1(1, 37) = 5.01, p < .04$, this effect disappeared in this new analysis, $F_1(1, 28) = 2.07, p = .16$. At the same time, however, the power of the analysis, i.e., the probability to detect a potential effect (Cohen, 1992), decreased from a medium value of .58 to a low value of .27. For this reason, and also because there was no significant interaction of Priming and Status in either analysis ($F_1(2, 37) = 0.38, p = .68$, and $F_1(1, 28) = 0.33, p = .57$, respectively) it was decided to keep the data provided by the professional group, and, consequently, the data from all three groups were merged in all subsequent RT analyses.

Next, two ANOVAs were performed to investigate the occurrence of priming effects across the three target root types in detail. One analysis treated participants as a random effect ($F_1$), whereas the other treated items as a random effect ($F_2$).

In the analysis by participants, Priming (neutral *vs.* root) and Root Type (adjective *vs.* noun *vs.* verb) were treated as within-group factors; there were no between-group factors. This analysis revealed a main effect of both Priming, $F_1(1, 39) = 6.73, p = .01$, and Root Type, $F_1(2, 78) = 60.29, p < .0001$, whereas the interaction between these two factors only approached statistical significance, $F_1(2, 78) = 2.74, p = .07$.

In the analysis by items, Priming (neutral *vs.* root) was treated as a within-group factor and Root Type (adjective *vs.* noun *vs.* verb) as a between-group factor. This analysis revealed a main effect of both Priming, $F_2(1, 51) = 5.89, p = .02$, and Root Type, $F_2(2, 51) = 24.21, p < .0001$. There was no significant interaction between these two factors, $F_2(2, 51) = 2.36, p = .10$.

Table 7.3. shows the mean RTs for each of the target root types under each of the priming conditions in the analysis by items, as well as the resulting priming effects. In

order to find out whether the priming effects for each target root type were statistically significant, ANOVAs were performed treating items as a random factor and Priming (neutral *vs*. root) as a within-group factor. The results for the adjective root targets did not reach statistical significance, $F_2(1, 17) = 0.38, p = .55$. Likewise, the analysis of the noun root targets did not produce a significant priming effect, $F_2(1, 17) = 0.71, p = .41$. By contrast, the analysis of the verb root targets did reveal a significant priming effect, $F_2(1, 17) = 5.26, p = .04$.

Table 7.3. Mean RTs and priming effects (ms) in the analysis by items in Experiment 5a

| | Priming Condition | | |
|---|---|---|---|
| Root Target Type | Neutral | Root | Priming Effect |
| Adj | 760 (19) | 747 (16) | 13 (22) |
| Noun | 715 (11) | 702 (13) | 13 (16) |
| Verb | 922 (32) | 840 (33) | *81 (35) |

Note. Asterisks (*) indicate statistically significant priming effects. Numbers in parentheses indicate standard errors.

The mean values shown in Table 7.3 indicate that the root priming condition yielded lower RTs than the neutral priming condition. Whereas the difference is minimal in the case of adjective and noun root targets, there is a more pronounced contrast in the case of the verb root targets. These priming effects are also graphically represented in Figure 7.3. below.

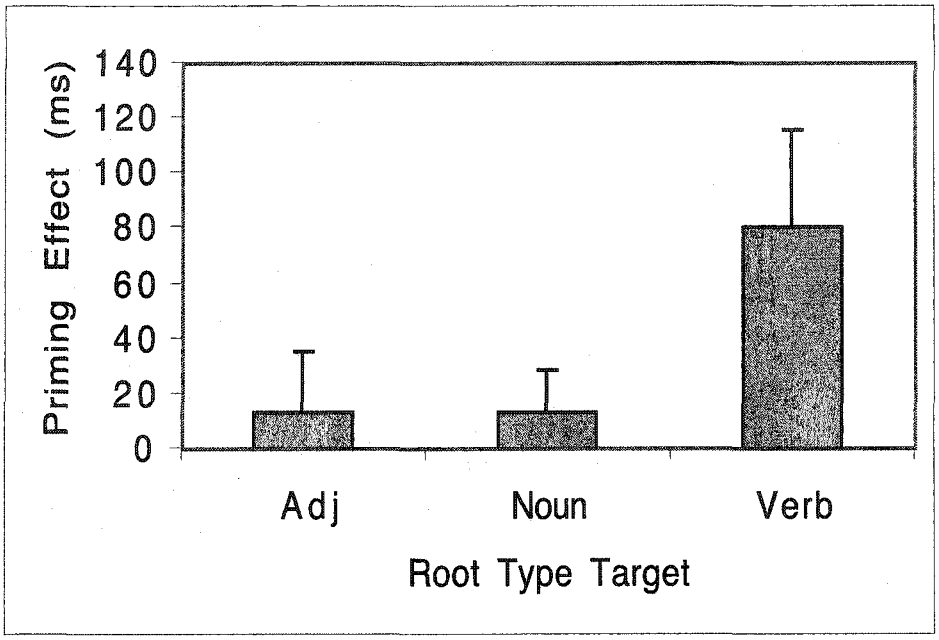



Figure 7.3. Mean priming effects (ms) and standard errors as a function of root type target in the analysis by items in Experiment 5a

In order to find out whether the priming effects between the three root type targets were statistically significant, a series of unpaired two-tailed *t* tests was completed. Results showed a lack of statistical significance in all the comparisons: adjective and noun, $t(34) = 0.006$, $p = .99$; adjective and verb, $t(34) = 1.64$, $p = .11$; noun and verb, $t(34) = 1.76$, $p = .09$.

**7.3. Preliminary discussion**

The purpose of this experiment had been to test whether the mental representations of roots have links to the mental representations of the *ver*-verbs in which they are embedded. More specifically, the goal had been to investigate whether there are any differences in the strength of links between the representations of adjective, noun, and verb roots, and the representations of their corresponding *ver*-verbs. The results of the experiment show a pattern of differential priming effects for the three target root types that mirrors the pattern of mean RT scores for these items. In the context of mental representations and their organization the pattern for the priming effects suggests that not all target root types have salient links to the *ver*-verbs in which they are embedded. In the context of the results of Experiment 1 [ARM-VERARMEN], the results of the present experiment suggest the existence of differential weights for whole-word-to-root links and root-to-whole-word links.

As can be seen in Figure 7.3. above, there is a two-way distinction as far as priming effects are concerned. On the one hand, adjective and noun root targets pattern together by virtue of yielding very small priming effects. On the other hand, verb root targets yield much larger priming effects. Table 7.3. above illustrates a similar picture for the mean RT scores for these different targets.

In this context, the large and highly significant effect of Root Type obtained for RT scores both in the analysis by participants and in the analysis by items clearly indicates that accessing the mental representations of verb root targets such as STOPF involves a much higher processing cost than accessing either adjective root targets such as BITTER or noun root targets such as KLEID. This phenomenon suggests that the mental representations of verb root targets such as STOPF are less salient than those of adjective root targets and noun root targets, respectively. Such an argumentation would be in line with the results obtained in Experiment 1 [ARM-VERARMEN] (see Section 3.2. above) and Experiment 3 [ARM IN VERARMEN] (see Section 5.2. above): in Experiment, 1 verb roots had proven to be the least efficient primes among the three root types in question; in Experiment 3, verb roots yielded only intermediate ratings, whereas adjective and noun roots yielded high ratings. Both of these phenomena were interpreted in terms of a lower level of salience for the mental representations of verb roots, as compared to their adjective and noun counterparts.

Whereas the existence of a root type effect had been anticipated, the analysis of the interaction of Priming and Root Type revealed a surprise. Contrary to expectations, there was only minimal and statistically insignificant facilitation in the case of both the adjective root targets and the noun root targets, whereas there was significant facilitation in the case of the verb root targets. In other words, whereas there was whole-word-to-root priming for Verb prime-target pairs such as VERSTOPFEN-STOPF, there was a lack of whole-word-to-root priming for Noun prime-target pairs such as VERKLEIDEN-KLEID and for Adj prime-target pairs such as VERBITTERN-BITTER.

One interpretation of this state of affairs is that reasonably strong links connect the representations of verb root targets and the representations of the *ver*-verbs in which they are embedded, whereas only very weak links of that kind connect the representations of the adjective root targets and noun root targets and the representations of their corresponding *ver*-verbs. At first glance, this claim seems to contradict the results of Experiment 1 [ARM-VERARMEN], where items belonging to the Adj and Noun subsets enjoyed the largest priming effects. However, if one assumes the existence of links that have different weights for different directions (whole-word-to-root in Experiment 1 *vs.* root-to-whole-word in the present experiment), the above claim becomes more plausible (see also Figure 7.1. and Figure 7.2.). The rationale for such an organization could be found in the differences concerning the salience of the representations of the three target root types: both the representations of adjective root targets and noun root targets are very salient since items such as *bleich* and *Kleid* are free morphemes; on the other hand, the representations of verb root targets are less salient since items such as *stopf* can be interpreted only as either the free but rather infrequent imperative form, or as a more frequent but bound constituent in prefixed words. Thus, having a link between the representation of such verb root targets and the representation of their corresponding *ver-*verb would appear to be helpful in terms of making sense of these otherwise obscure roots: this link would point towards the fact that the verb roots in question are used as bound constituents in prefixed constructions much more often than they are used as free imperatives, leading to a reduction in processing cost. In the case of the free adjective root targets and noun root targets such a link would be far less helpful given the reasonably high salience of the representations of these items. Hence, in the case of the verb root targets the high RT scores in the neutral condition are significantly reduced in the root condition, whereas in the case of the adjective root targets and noun root targets the much lower RT scores in the neutral condition are only slightly reduced in the root condition.

An alternative explanation for the lack of significant priming effects for the adjective root targets and the noun root targets could be the simple existence of a floor effect based on task demands. According to this line of argumentation, lexical access to these items happens already so fast in the neutral condition that it is extremely difficult for participants to be even faster in the primed condition. Again, as in the explanation based on differently-weighted links given above, the high degree of salience of the mental representations of adjective root targets and noun root targets would be the basis for this phenomenon.

Although these two explanations are not mutually exclusive, there is a simple way of testing the validity of the claim that there might be a floor effect. As the comparison of the results of Experiment 1 [ARM-VERARMEN] (root-to-whole-word priming) and Experiment 2 [ARMEN-VERARMEN] (base-to-whole-word priming) has shown (see Section 4.2. above), the magnitude of priming effects was much larger for verb bases such as STOPFEN than for verb roots such as STOPF. Similarly, the comparison of the results of the rating tasks in Experiment 3 [ARM IN VERARMEN] and Experiment 4 [ARMEN IN VERARMEN] (see Section 6.2. above) has shown that participants rated word pairs such as VERSTOPFEN-STOPFEN much higher than word pairs such as VERSTOPFEN-STOPF. Thus, the distinction between root and base in the case of items belonging to the Verb subset seems to be crucial. As a consequence, it would be reasonable to expect a different priming pattern for items belonging to the Verb subset, if a whole-word-to-base priming paradigm instead of whole-word-to-root priming paradigm were employed. Investigating this possibility was, therefore, at the center of a pilot study in which prime-target pairs such as VERSTOPFEN-STOPFEN were employed. Figure 7.4. represents the conceptualization of this paradigm graphically.

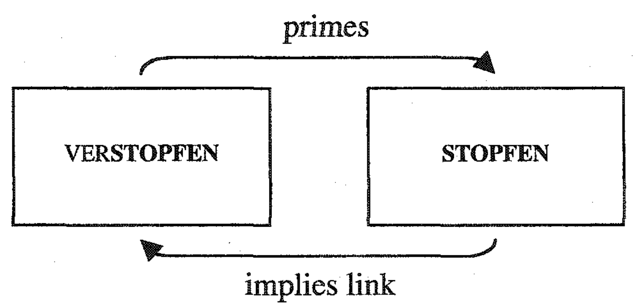



Figure 7.4. Conceptualization of whole-word-to-base priming in terms of the relationships between the mental representations of bases and the whole *ver*-verbs in which they are embedded

## 7.4. Pilot study: Whole-word-to-base priming [VERSTOPFEN-STOPFEN]

### *7.4.1. Method*

#### 7.4.1.1. Participants

A total of 12 native speakers of German volunteered to participate. All of them were enrolled in undergraduate Philology courses at Albert-Ludwigs-Universität in Freiburg im Breisgau, Germany. The 12 participants in this study had neither taken part in any of the previous priming studies (Experiment 1 [ARM-VERARMEN]; Experiment 2 [ARMEN-VERARMEN]; Experiment 5a [VERARMEN-ARM]), nor in the morpheme awareness task that employed *ver*-verb-root pairs (Experiment 3 [ARM IN VERARMEN]). Five of them, however, subsequently volunteered to take part in the morpheme awareness task that employed *ver*-verb-root-*en* pairs (Experiment 4) [ARMEN IN VERARMEN].

7.4.1.2. Materials

The stimulus set in the present experiment was almost identical to that employed in Experiment 5a [VERARMEN-ARM]. However, whereas in Experiment 5a the 18 critical verb target stimuli had the structure [ROOT], these had the structure [ROOT*(e)n*] in the present experiment. In other words, whereas simple verb roots such as STOPF served as targets in Experiment 5a, verb bases such as STOPFEN served as targets in the present experiment. Analogous changes were made to the bound targets and to the root-like nonsense elements associated with the *ver-/ker*-fillers: bound elements such as GEUD were changed to GEUDEN and nonsense elements such as KRENG were changed to KRENGEN. Other filler items such as HEI (prime) and HEIKEL (target) were exempt from this procedure. The adjective and noun targets were not subjected to this procedure since, *a priori*, it was not always clear whether participants would interpret the resulting [ROOT*(e)n*] items as existing words or nonsense words (e.g. BITTER 'bitter' *vs.* BITTERN '?'; see also the results of Experiment 4 [ARMEN IN VERARMEN], Section 6.2. above, that revealed participants' uncertainty concerning the status of root+*en* items belonging to the Adj and Noun subsets). Thus, it would not have been possible to establish an accurate balance of expected "Yes" and "No" answers in the stimulus set. Except for the last type of filler items, full *ver*-verbs or *ver-/ker-* nonsense verbs served as primes. As in Experiment 5a, the final stimulus set consisted of 216 items.

7.4.1.3. Design and procedure

The design and procedure employed in this experiment were identical to that of Experiment 5a [VERARMEN-ARM]. As far as the targets with the structure [ROOT*(e)n*] are concerned, the present design and procedure constituted the reversal of that of Experiment 2 [ARMEN-VERARMEN]. Table 7.4. shows the structural organization of the final stimulus set, reflecting the design of the present experiment.

Table 7.4. Structural organization of the stimulus set with examples in Experiment 5b

| | | | Priming Conditions for Items with *ver-* | | |
|---|---|---|---|---|---|
| Expect. Answer | Target Root/Base Type | *ver*-Prime | Root/Base | Neutral | Items without *ver-* |
| "Yes" | Adj | VERBITTERN | BITTER<br>--- | ---<br>SAUBER | HEI/HEIKEL |
| | Noun | VERKLEIDEN | KLEID<br>--- | ---<br>KREUZ | SAL/SALBE |
| | *Verb* | *VERSTOPFEN* | *STOPFEN*<br>--- | ---<br>*KRATZEN* | WAR/WARTEN |
| "No" | Bound | VERGEUDEN | GEUDEN<br>--- | ---<br>RAPSEN | --- |
| | *ver-/ker-*<br>Nonsense Items | VERKRENGEN | KRENGEN | --- | KERKRENGEN/<br>KRENGEN |
| | Other Nonsense Items | --- | --- | --- | DEI/DEIKEL<br>RAL/RALBE<br>NAR/NARTEN |

Note. Participants shared all target stimuli except the ones in the gray cells, which differed for the root/base and neutral target priming conditions (Lists 1 and 2). Participants saw a target (i.e., a root in the case of the Adj and Noun subsets, and a base in the case of the Verb subset) in only one of these conditions. For nonsense and filler items without *ver-*, the string to the left of the slash (/) indicates the "prime", and the string to the right of the slash indicates the target. A total of 216 stimuli was presented to each participant.

*7.4.2. Results*

In this experiment participants generated 2,592 RT observations (12 participants x 216 stimuli). None of these involved RTs below 300 ms. However, 58 RT observations were above 1,500 ms; these were recoded to 1,500 ms. Thus, about 2.2% of the overall data in this experiment (i.e., including both critical stimuli and fillers) were replaced with a cutoff value. This procedure was employed in order to maintain the same range adopted for Experiment 1 [ARM-VERARMEN] (see Section 3.2. above), Experiment 2 [ARMEN-VERARMEN] (see Section 4.2. above), and Experiment 5a [VERARMEN-ARM] (see Section 7.2. above), and, thus, to keep basic parameters of the overall investigation constant.

In contrast to the previous experiments, all of the 12 participants were university students enrolled in undergraduate Philology courses, and, thus, from a single reasonably homogeneous group. Therefore, there was no need to check the comparability of the data they provided. Furthermore, following the rationale behind this pilot study outlined in Section 7.3., the focus on the analysis was on the RTs for the verb base targets only.

Table 7.5. shows the descriptive mean RTs obtained for the verb base targets under each of the priming conditions in the analysis by items as well as the resulting priming effects.

Table 7.5. Mean RTs and priming effects (ms) in the analysis by items in Experiment 5b

| | Priming Condition | | |
|---|---|---|---|
| Base Target Type | Neutral | Base | Priming Effect |
| Verb | 740 (24) | 784 (24) | -43 (38) |

Note. Numbers in parentheses indicate standard errors.

Surprisingly, the mean values shown in Table 7.5. indicate that the base priming condition yielded higher RTs than the neutral priming condition, which suggests the occurrence of inhibition rather than facilitation.

In order to find out whether this inhibition effect was statistically significant, an ANOVA was performed treating items as a random factor and Priming (neutral *vs.* base) as a within-group factor. This analysis did not to produce a significant main effect, $F_2(1, 17) = 1.30, p = .27$ (power: .18).

For the purpose of comparison, Figure 7.5. below graphically represents the priming effects for the adjective root, noun root, and verb root targets obtained in Experiment 5a [VERARMEN-ARM] (see Section 7.2. above) on the one hand, and the inhibition effect obtained for the verb base targets in the present pilot study (Experiment 5b) on the other hand.

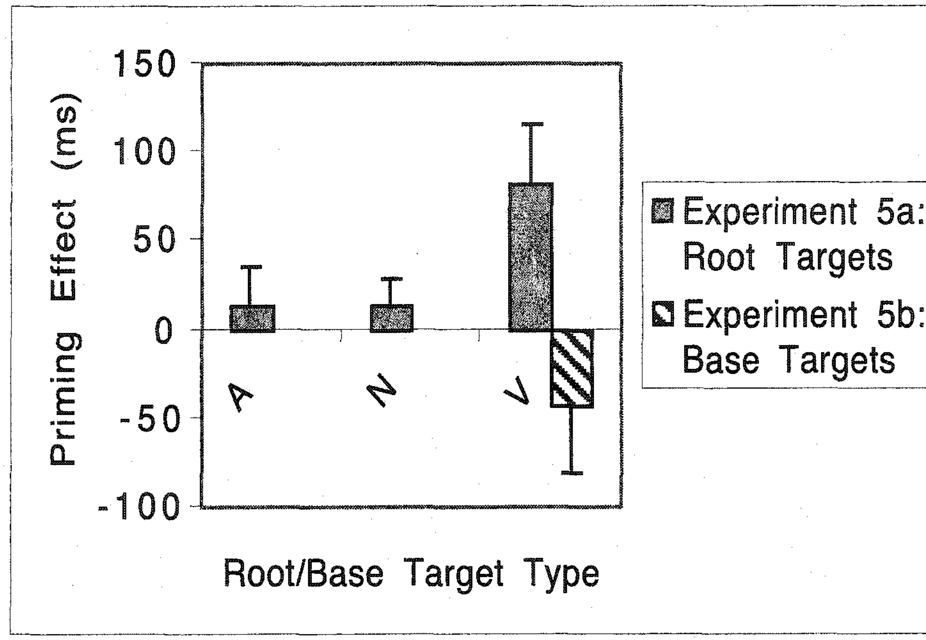



Figure 7.5. Comparison of mean priming effects (ms) and standard errors as a function of root target type and base target type, respectively, in the analysis by items in Experiment 5a (solid bars) and Experiment 5b (striped bar)

### 7.5. General discussion

The purpose of this pilot study had been to test whether the mental representations of verb bases have links to the mental representations of the *ver*-verbs in which they are embedded. The results of the experiment show that the prior presentation of *ver*-verbs such as VERSTOPFEN may lead to inhibitory processing of verb bases such as STOPFEN. In the context of mental representations and their organization this suggests the existence of inhibitory links between verb bases and their corresponding *ver*-verbs (base-to-whole-word links). Together with the results from Experiment 5a [VERARMEN-ARM] (see Section 7.2. above) the results of the present pilot study suggest the existence of an intricate system of root-to-whole-word and verb-base-to-whole-word links between the representations of adjective, noun, and verb roots and verb bases, on the one hand, and the representations of the *ver*-verbs in which they are embedded on the other hand. Seen in the context of the results of Experiment 1 [ARM-VERARMEN] and Experiment 2 [ARMEN-VERARMEN], directionality appears to influence the strength and nature of links between mental representations.

Although the analysis of the inhibition effect obtained in the present pilot study revealed that it is not statistically significant, there are several indications that the observed occurrence of inhibition might be more than a mere random incidence. First, since the power of the analysis was extremely low with a value of just .18, the probability of failing to notice an effect is extremely high (namely, .82); in other words, with an increase in power the observed effect may very well have stabilized, if it had been possible to increase power by testing more speakers.[14] Furthermore, a look at the mean RT scores for the verb bases in both the neutral condition and the base condition revealed that 11 out of the 18 verb bases employed in the present experiment (61%) showed negative priming, i.e., inhibition.

Concerning the organization of root-to-whole-word and verb-base-to-whole-word links between representations in the mental lexicon, the combined results of Experiment 5a [VERARMEN-ARM], see Section 7.2. above) and the present pilot study suggest the existence of different links as far as verb roots and verb bases are concerned. On the one hand, the large and statistically significant priming effects obtained for prime-target pairs such as VERSTOPFEN-STOPF suggest the existence of reasonably strong facilitatory links between the representations of these roots and their corresponding *ver*-verbs. On the other hand, the preliminary results for prime-target pairs such as VERSTOPFEN-STOPFEN indicate the possibility of the existence of inhibitory links between the representations of verb bases and the representations of the *ver*-verbs in which they are embedded.

In summary, the results of Experiment 5a [VERARMEN-ARM] (see Section 7.2. above) and the present experiment both corroborate and complement the results of Experiment 1 [ARM-VERARMEN] (see Section 3.2. above) and Experiment 2 [ARMEN-VERARMEN] (see Section 4.2. above), although they might seem at first to contradict each other. In Experiment 1 and Experiment 5a adjective roots and noun roots were said to have highly salient mental representations. However, whereas in Experiment 1 this claim was based on large priming effects for these items, a similar claim was based on the absence of significant priming effects in Experiment 5a. This state of affairs was interpreted in terms of (a) a distinction between whole-word-to-root links and root-to-whole-word links, and (b) different weights for each direction. In the case of verb roots, the same rationale was used, although the magnitude of priming effects for these items was the reverse of that of adjective and noun roots. The case of verb bases, however, seems to be the most intriguing one: in both Experiment 2 and the present pilot study the representations of verb bases were said to have a high degree of salience; yet, whereas this phenomenon led to large priming effects in Experiment 2, it led to inhibition in the present pilot study. Thus, whole-word-to-base links (Experiment 2) and base-to-whole-word links (pilot study) appear to be of a fundamentally different nature. In order to corroborate this claim, though, the testing of more speakers would be necessary. Independent support for the claim of the occurrence of inhibition could be found in the

[14] There were practical limits on both the length of the testing period in Germany and the availability of participants.

results of the CON and MNG tasks employed in Experiment 4 [ARMEN IN VERARMEN] (see Section 6.2. above). The comparison of the mean ratings of word pairs such as VERSTOPFEN-STOPFEN in these tasks had revealed the existence of significantly lower ratings for these items in the MNG task, which was interpreted as an issue of semantic transparency. In the context of the results of the present pilot study this might account for the levels of inhibition seen for the verb base targets for the following reasons. First, both verb bases and the *ver*-verbs in which they are embedded can be interpreted as lexical items of their own. Second, in contrast to the verb bases, the meaning structure of the *ver*-verbs is necessarily a composite structure, since it is determined not only by the meaning of the verb base, but also by the meaning of the prefix *ver*- (see also Belz, 1997, Section 2.2.2. above). Thus, in the paradigm employed in the present pilot study, the representations of verb bases such as STOPFEN appear to have an inhibitory link to the representations of *ver*-verbs such as VERSTOPFEN, reflecting the semantic difference between them.

So far, the fundamental issues of what the roles of morphology, morpheme salience, and task effects might be in the lexical processing of *ver*-verbs have been dealt with in detail. In Experiment 6 ([CAPS]) below, yet another task is introduced, namely, the lexical decision paradigm with stimulus alteration rather than priming. The focus of this experiment, however, is the investigation of stimulus effects.

# CHAPTER 8

# EXPERIMENT 6: LEXICAL DECISION WITH CAPITALIZATION

## 8.0. Introduction

So far, a number of different paradigms have been employed to investigate the access and representation of *ver*-verbs, namely, on-line techniques such as priming (examining subconscious processing) and off-line techniques such as rating tasks (examining conscious processing). To be more precise, a number of priming paradigms have been employed: root-to-whole-word priming (Experiment 1, [ARM-VERARMEN]), base-to-whole-word priming (Experiment 2, [ARMEN-VERARMEN]), whole-word-to-root priming (Experiment 5a, [VERARMEN-arm]), and whole-word-to-base priming (Experiment 5b, [VERSTOPFEN-STOPFEN]). As for the rating tasks, the critical stimuli consisted of either *ver*-verb-root pairs (Experiment 3, [ARM IN VERARMEN]) or *ver*-verb-root-*en* pairs (Experiment 4, [ARMEN IN VERARMEN]). While it is reasonable to assume that this task variety already provides a satisfactory level of cross-methodological validation, adding the (unprimed) simple lexical decision paradigm (Rubenstein, Garfield, & Millikan, 1970) to this array could even increase that level.

Crucially, however, in all of the previous on-line experiments the critical stimuli had consisted of existing *ver*-verbs. While this characteristic is of paramount importance given that the main goal of the present dissertation is to investigate the lexical access and representation of these items, it is a well documented fact that the examination of nonsense words that feature existing components or that constitute an unattested combination of existing components can sometimes reveal more details about morphological processing than the examination of existing words (e.g., Caramazza et al., 1988; Taft & Forster, 1975; but see Henderson, 1989, for a critique of this practice).

In the present experiment, therefore, a simple lexical decision task was employed in order to investigate the morphological processing of both existing *ver*-verb targets and novel *ver*-verb targets that consisted of the unattested combination of the prefix *ver*- and an existing item. Crucially, these targets were presented in four different "capitalization styles", intended to bias participants towards different internal structures.[15] Thus, items such as *verbittern* were presented as "verbittern" (control condition), on the one hand, and "VERBITTERn", "verBITTERn", and "verBITTERN", on the other hand. The rationale behind the experiment was the following. If morphological structure plays a role in the processing of *ver*-verbs in the lexical decision paradigm, (a) *ver*-verbs belonging to the four different subsets might show differential RT patterns, and (b) the application of different capitalization styles might not affect all subsets in the same way. Furthermore, the present paradigm would allow for a direct comparison of the processing of existing *ver*-verbs and similarly structured novel *ver*-verbs.

[15] Beauvillain (1994) employed a contrast display procedure to emphasize the morphological components of composite words in French (e.g., REVOIR *vs*. REVOIR *vs*. **REVOIR** 'to see again').

## 8.1. Method

### *8.1.1. Participants*

A total of 116 native speakers of German volunteered to participate. Sixty-four of these were enrolled in undergraduate Philology courses at Albert-Ludwigs-Universität in Freiburg im Breisgau, Germany. Another 30 were enrolled in undergraduate German courses at Pädagogische Hochschule (University of Education) in the same city. The remaining 22 participants were professionals living in the same general area. The 116 participants in this study had neither taken part in Experiment 1 [ARM-VERARMEN] (see Chapter 3 above) nor in Experiment 3 [ARM IN VERARMEN] (see Chapter 5 above). Fifty-two of them, however, had taken part in Experiment 2 [ARMEN-VERARMEN] (see Chapter 4 above), 40 of them had taken part in Experiment 5a [VERARMEN-ARM] (see Chapter 7 above), and 12 had taken part in Experiment 5b [VERSTOPFEN-STOPFEN] (see Chapter 7 above). Another 12 had taken part in an experiment not reported on so far. Fifty of them subsequently volunteered to take part in Experiment 4 [ARMEN IN VERARMEN] (see Chapter 6 above).

### *8.1.2. Materials*

The critical stimuli consisted of 72 existing *ver*-verb targets and 72 nonsense verb targets involving the prefix *ver*-. The critical 72 existing *ver*-verb targets were identical to those first introduced in Experiment 1 [ARM-VERARMEN] (see Section 3.1.2. above), i.e., 18 containing monomorphemic adjective roots (Adj subset), 18 containing monomorphemic noun roots (Noun subset), 18 containing monomorphemic verb roots

(Verb subset), and 18 containing bound roots (Bound subset). With the exception of the Bound items (see Section 1.3.2. above) both the whole verb subsets and the root subsets, respectively, were matched as closely as possible on the factors of orthographic length, Mannheim frequency per six million (i.e., 5.4 million on written language and 0.6 million on spoken language), and Mannheim frequency per 5.4 million (written language only). Furthermore, the root subsets were also balanced as closely as possible for family size and family frequency. All these frequency and length counts were taken from the CELEX lexical database (Baayen et al., 1995), more precisely from the CELEX German lemma lexicon; since this lexicon lists types, all the frequency counts constitute summations over inflectional variants. For the purposes of the present experiment, an additional frequency cross-check was performed for those items in the Adj and Noun subsets that had both meaningful roots and meaningful bases such as in *verbleichen* 'to fade away', where the root *bleich* 'pale' was a well-formed adjective and the base *bleichen* 'to bleach' was a well-formed simple verb (see details in Section 8.1.3. on design and procedure below). The results of these additional ANOVAs using the indicated control factors as a dependent variable and Subset as a between-group factor did not reveal any significant differences between roots and bases (all $p$-values > .32).

The 72 critical nonsense verb targets consisted of the morphologically unattested combination of the prefix *ver-* and an existing four-letter German root having either the structure CVCC or CVVC. More precisely, the structure of these nonsense stimuli was as follows: 18 targets consisted of the unattested combination of *ver-* and a simple adjective root such as **verbunten* (*ver-* plus *bunt* 'colored'), henceforth called the *Adj subset; 18 targets consisted of the unattested combination of *ver-* and a simple noun root such as

**verlieden* (*ver-* plus *Lied* 'song'), henceforth called the *Noun subset; 18 targets consisted of the unattested combination of *ver-* and a simple verb root such as **verfühlen* (*ver-* plus *fühl* 'feel'), henceforth called the *Verb subset; finally, 18 targets consisted of the combination of *ver-* and a nonsense root having either the structure CVCC or CVVC such as **verdeisen* (*ver-* plus **deis*), henceforth called the *Bound subset. Crucially, whereas the bases of the targets in the *Adj and *Noun subsets, for example **bunten* and **lieden* do not exist in German, the bases of the targets in the *Verb subset do (e.g., *fühlen* 'to feel'). With the exception of the *Bound subset, root subsets were matched as closely as possible on the same frequency counts on which the roots of the existing *ver-*verbs had been matched (see above), namely, Mannheim frequency per six million (i.e., 5.4 million on written language and 0.6 million on spoken language), Mannheim frequency per 5.4 million (written language only), family size and family frequency. A balance was achieved by performing the same type of ANOVAs mentioned above. Table 8.1. below shows the results of these analyses for the roots used in the critical novel *ver-*verb targets. Since, in contrast to the roots in the existing *ver-*verb targets, the orthographic length of the roots in the novel *ver-*verb targets was fixed to four letters, this factor was excluded. Again, all the frequency counts were taken from the CELEX German lemma lexicon (Baayen et al., 1995), and, consequently, they constitute summations over inflectional variants.

Table 8.1. Results of the statistical matching procedures for the roots of novel *ver*-verbs

| | Subset | | | | |
|---|---|---|---|---|---|
| Measure | *Adj | *Noun | *Verb | *F*-Value | *p*-Value |
| Family Size | 6.6 (2.4) | 6.4 (1.2) | 5.9 (2.3) | $F_2(2, 51) = 0.03$ | .97 |
| Fam. Frequency | 76.8 (27) | 74.9 (17) | 112.2 (63) | $F_2(2, 51) = 0.27$ | .77 |
| Mannheim | 148.5 (41) | 150.1 (32) | 115.9 (50) | $F_2(2, 51) = 0.21$ | .81 |
| Mann. Written | 136.5 (37) | 139.4 (30) | 110.4 (48) | $F_2(2, 51) = 0.17$ | .84 |

Note. Existing roots embedded in novel *ver*-verb targets in the *Adj, *Noun, and *Verb subsets were matched as closely as possible on four frequency measures as listed in the CELEX lexical database (Baayen et al., 1995). Separate items ANOVAs were performed using the respective measures as dependent variables and Subset as a between-group factor. Numbers for Subset indicate mean values. "Roots" in the *Bound subset consisted of invented four-letter strings with either a CVCC or CVVC structure. Since in all subsets the factor orthographic length was fixed to four letters, it was excluded from the analysis. Numbers in parentheses indicate standard errors.

In addition to the critical existing *ver*-verb targets and novel *ver*-verb targets, the stimulus set also contained fillers included both to achieve a balance between existing words and non-words and to minimize the probability of participants developing extraneous test-taking strategies. Thus, 72 real-word fillers were added to the target set that existed of either bisyllabic but non-prefixed adjectives, nouns, or verbs, or bimorphemic noun compounds. Another 72 non-word fillers were created from these by replacing the first letter of each item.

Table 8.2. below shows the numerical organization of the final stimulus set, which consisted of a total of 288 items. As can be seen, a numeric balance was achieved both between existing words *vs*. non-words (144 items each), and between stimuli with *ver*- *vs*. stimuli without *ver*- (144 items each).

Table 8.2. Breakdown of the number and types of items in the stimulus set in Expt. 6

| | | Capitalization Style | | | | |
|---|---|---|---|---|---|---|
| Exp. Answer | Subset | no_cap | pref_root_cap | root_cap | root_suff_cap | *Total* |
| "Yes" | Adj | 4/5 | 4/5 | 4/5 | 4/5 | *18* |
| | Noun | 4/5 | 4/5 | 4/5 | 4/5 | *18* |
| | Verb | 4/5 | 4/5 | 4/5 | 4/5 | *18* |
| | Bound | 4/5 | 4/5 | 4/5 | 4/5 | *18* |
| | Fillers | --- | --- | --- | --- | *72* |
| "No" | *Adj | 4/5 | 4/5 | 4/5 | 4/5 | *18* |
| | *Noun | 4/5 | 4/5 | 4/5 | 4/5 | *18* |
| | *Verb | 4/5 | 4/5 | 4/5 | 4/5 | *18* |
| | *Bound | 4/5 | 4/5 | 4/5 | 4/5 | *18* |
| | *Fillers | --- | --- | --- | --- | *72* |

Note. Numbers stand for targets. Participants saw a given *ver*-target in only one of the four capitalization styles (Lists 1 to 4, gray cells). Over the course of the whole experiment, participants saw *ver*-targets belonging to all of the subsets in all of the capitalization styles ("total" in italics). Due to the chosen system of semi-randomization, capitalization styles occurred either four times or five times in each subset in each list. Since for fillers random capitalization styles or the "no_cap" style were employed, only total numbers for fillers are given. A total of 288 stimuli was presented to each participant.

Table 8.3. shows the structural organization of the final stimulus set using examples that will henceforth be used for illustrative purposes.

Table 8.3. Structural organization of the stimulus set with examples in Experiment 6

| | | Capitalization Style | | | |
|---|---|---|---|---|---|
| Exp. Answer | Subset | no_cap | pref_root_cap | root_cap | root_suff_cap |
| "Yes" | Adj | verbittern | VERBITTERn | verBITTERn | verBITTERN |
| | Noun | verkleiden | VERKLEIDen | verKLEIDen | verKLEIDEN |
| | Verb | verstopfen | VERSTOPFen | verSTOPFen | verSTOPFEN |
| | Bound | vergeuden | VERGEUDen | verGEUDen | verGEUDEN |
| | Fillers | Netzwerk | --- | --- | --- |
| "No" | *Adj | verbunten | VERBUNTen | verBUNTen | verBUNTEN |
| | *Noun | verlieden | VERLIEDen | verLIEDen | verLIEDEN |
| | *Verb | verfühlen | VERFÜHLen | verFÜHLen | verFÜHLEN |
| | *Bound | verdeisen | VERDEISen | verDEISen | verDEISEN |
| | *Fillers | Retzwerk | --- | --- | --- |

Note. Participants saw a given *ver*-target in only one of the four capitalization styles (Lists 1 to 4). Over the course of the whole experiment, participants saw *ver*-targets belonging to all of the subsets in all of the capitalization styles. For fillers random capitalization styles or the "no_cap" style were employed (gray cells). A total of 288 stimuli was presented to each participant.

*8.1.3. Design and procedure*

Four lists of stimuli (List 1, List 2, List 3, and List 4) were constructed such that both each of the critical 72 existing *ver*-verb targets and each of the critical 72 novel *ver*-verb targets appeared once in each of the four lists. Therefore, each list comprised 144 critical targets, which were then supplemented with 144 filler targets to bring the total number of stimuli in each list to 288 items. Crucially, both critical existing targets and critical nonsense targets appeared in one of four different "capitalization styles" in each of the four lists ("root_cap" *vs*. "pref_root_cap", "root_suff_cap" *vs*. "no_cap") according to a semi-randomized pattern.[16] Hence, the target *verbittern*, for example, was shown with capitalized root as "verBITTERn" ("root_cap") in List 1, with capitalized prefix and root as "VERBITTERn" ("pref_root_cap") in List 2, with capitalized root and infinitival suffix as "verBITTERN" ("root_suff_cap") in List 3, and, finally, in its conventional form as "verbittern" ("no_cap") in List 4. Participants were assigned to Lists 1, 2, 3, and 4 in the order in which they appeared for the testing session. Taken together, these measures insured, on the one hand, that each critical target would occur only once for each participant during the course of the experiment, and, on the other hand, that, over the whole pool of participants, each critical target would be tested under each of the capitalization styles. Filler items appeared in the same capitalization styles across lists. In contrast to the capitalization styles for the critical targets, however, capitalization styles for the fillers followed a randomized non-morphemic pattern (e.g., "NeTZWeRK" 'network').

[16] This pattern could not be completely randomized since this would have resulted in the possibility of a specific capitalization style occurring more than once for a specific item.

Participants received brief instructions and completed a practice phase before the start of the actual experiment. In the instructions, participants were told that they would be presented with a string of letters on the computer screen and that they were expected to indicate whether or not they thought that this string was an existing word in German by pressing specified "Yes" and "No" keys on the keyboard using their right and left index fingers, respectively. Participants were encouraged to make their decision as quickly as possible, while at the same time insuring reasonable accuracy of their responses.

Participants were then presented with the 288 test items in a sequence that was randomized for each individual. Each trial involved the display of a focal point (*) for 500 ms; 100 ms after the focal point disappeared, the target was presented in one of four capitalization styles, which stayed on the screen until participants pressed either of the specified "Yes" or "No" keys. Response times were automatically scored as the time that elapsed between the moment the target appeared on the computer screen and the moment participants pressed one of the specified keys. The focal point immediately reappeared after each key press to initiate the next trial.

This experiment took each participants approximately 10 minutes to complete. It was carried out using a Macintosh iBook laptop computer, running PsyScope 1.2.5., a graphic-oriented environment for designing psycholinguistic experiments (Cohen et al., 1993).

## 8.2. Data split: Existing *ver*-verb targets *vs*. novel *ver*-verb targets

In this experiment participants generated 33,408 RT observations (116 participants x 288 stimuli). None of these involved RTs below 300 ms. However, 3,607 RT observations were above 1,500 ms; these were recoded to 1,500 ms. Thus, about 10.8% of the overall data in this experiment (i.e., including both critical stimuli and fillers) were replaced with a cutoff value. This procedure was employed in order to maintain the same range adopted for Experiment 1 [ARM-VERARMEN] (see Chapter 3 above), Experiment 2 [ARMEN-VERARMEN] (see Chapter 4 above), Experiment 5a and 5b [VERARMEN-ARM, VERSTOPFEN-STOPFEN] (see Chapter 7 above), and, thus, to keep basic parameters of the overall investigation constant.

Then, two separate data files were created, one for the critical 72 existing *ver*-verb targets (for the analysis of "Yes" answers), and another one for the critical 72 novel *ver*-verb targets (for the analysis of "No" answers).

### *8.2.1. Existing* ver-*verb targets*

#### 8.2.1.1. Preliminary results

First, in an effort to insure the comparability of the data from the participants with the status of university student, education student, and professional, respectively, ANOVAs were run on the RT scores of these three groups. In this analysis Status (university student *vs*. education student *vs*. professional) was treated as a between-group factor, whereas Subset (Adj *vs*. Noun *vs*. Verb *vs*. Bound) and Capitalization Style ("root_cap" *vs*. "pref_root_cap", "root_suff_cap" *vs*. "no_cap") were treated as within-group factors. This analysis produced a significant main effect of Status, $F_1(2, 113) = 5.18, p < .01$; however, there were no significant interactions involving that factor (all *p*-values > .07). This effect was mainly based on the elevated RT scores for the professional group. Given this state of affairs, the same type of ANOVA was performed again, this time excluding the data from the professional group. This new analysis did not produce a significant main effect of Status, $F_1(1, 92) = 1.03, p = .31$; it also did not produce any significant interactions involving that factor (all *p*-values > .24). Crucially, however, both analyses produced a similar overall pattern with significant main effects of Subset and Capitalization Style but no significant interaction between these two factors. Thus, it can be reasonably assumed that the three status groups did provide comparable results after all, and, consequently, the data from these three groups were merged in all subsequent RT analyses involving existing *ver*-verb targets.

Next, two ANOVAs were performed to investigate the occurrence of any effects of capitalization across the four subsets of targets. One analysis treated participants as a random effect ($F_1$), whereas the other treated items as a random effect ($F_2$).

In the analysis by participants, Capitalization Style ("root_cap" *vs.* "pref_root_cap", "root_suff_cap" *vs.* "no_cap") and Subset (Adj *vs.* Noun *vs.* Verb *vs.* Bound) were treated as within-group factors; there were no between-group factors. This analysis revealed a main effect of both Capitalization Style, $F_1(3, 345) = 116.79, p < .0001$, and Subset, $F_1(3, 345) = 18.43, p < .0001$. There was no significant interaction between these two factors, $F_1(9, 1035) = 1.53, p = .13$.

In the analysis by items, Capitalization Style ("root_cap" *vs.* "pref_root_cap", "root_suff_cap" *vs.* "no_cap") was treated as a within-group factor and Subset (Adj *vs.*

Noun *vs*. Verb *vs*. Bound) as a between-group factor. This analysis revealed a main effect of Capitalization Style, $F_2(3, 204) = 83.79, p < .0001$; however, there was no significant main effect of Subset, $F_2(3, 68) = 1.19, p = .32$. The interaction between these two factors was not significant either, $F_2(9, 204) = 1.17, p = .32$.

Given this lack of a statistically significant interaction between Capitalization Style and Subset in the overall analysis, it was decided to investigate each of the four capitalization styles individually, using the items data base as a point of reference.

In the "pref_root_cap" analysis (e.g., VERBITTERn) Capitalization Style ("no_cap" *vs*. "pref_root_cap") was treated as a within-group factor and Subset (Adj *vs*. Noun *vs*. Verb *vs*. Bound) as a between-group factor. This analysis produced a significant main effect of Capitalization Style, $F_2(1, 68) = 178.57, p < .0001$, but no significant effect of Subset, $F_2(3, 68) = 1.46$, $p = .23$. The interaction between these two factors only approached statistical significance, $F_2(3, 68) = 2.51, p = .07$.

Table 8.4. shows the mean RTs for each of the subsets under both the "no_cap" and "pref_root_cap" capitalization styles in the analysis by items, as well as the resulting "pref_root" capitalization effects. The mean values shown in Table 8.4. indicate that the "no_cap" style yielded the lowest RTs, whereas the "pref_root" capitalization style yielded roughly the same elevated RTs for the Noun, and Bound subsets, slightly higher RTs for the Adj subset, and slightly lower RTs for the Verb subset.

In order to find out whether the "pref_root" capitalization effects for each subset were statistically significant, ANOVAs were performed treating items as a random factor and Capitalization Style ("no_cap" *vs*. "pref_root_cap") as a within-group factor. These analyses revealed highly significant capitalization effects for all four subsets: Adj, $F_2$(1,

17) = 64.37, $p < .0001$; Noun, $F_2(1, 17) = 45.51$, $p < .0001$; Verb, $F_2(1, 17) = 38.05$, $p < .0001$; Bound, $F_2(1, 17) = 33.23$, $p < .0001$.

Table 8.4. Mean RTs and "pref_root" capitalization effects (ms) for existing *ver*-verbs in the analysis by items in Experiment 6

| | Capitalization Style | | |
|---|---|---|---|
| Subset | no_cap | pref_root_cap | Capitalization Effect |
| Adj | 813 (20) | 982 (30) | *-169 (21) |
| Noun | 794 (17) | 924 (14) | *-130 (19) |
| Verb | 788 (18) | 885 (24) | *-97 (16) |
| Bound | 802 (27) | 919 (29) | *-117 (20) |

Note. Asterisks (*) indicate statistically significant capitalization effects. Numbers in parentheses indicate standard errors.

The "pref_root" capitalization effects are also graphically represented in Figure 8.1.

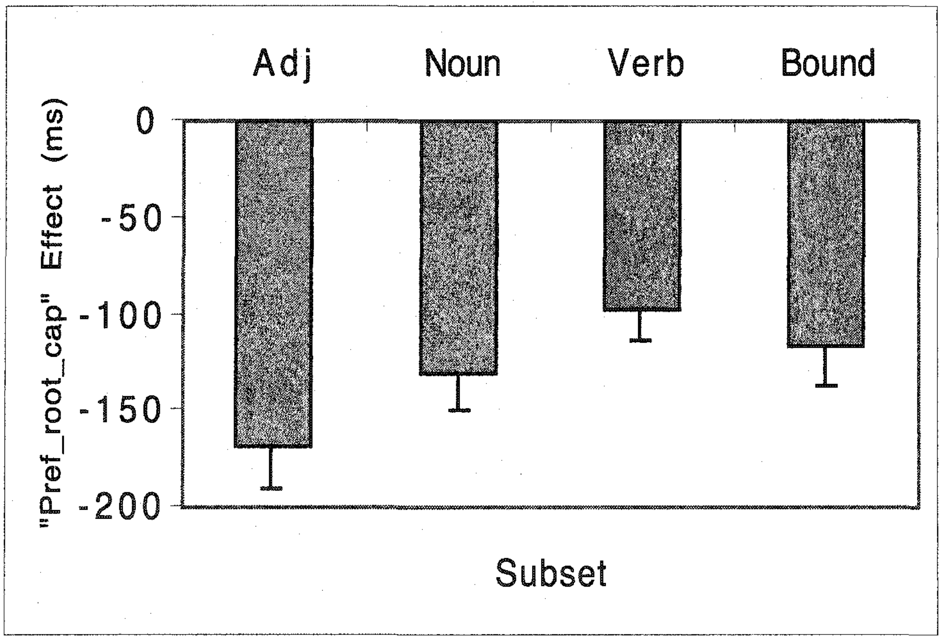



Figure 8.1. Mean "pref_root" capitalization effects (ms) and standard errors as a function of subset for existing *ver*-verbs in the analysis by items in Experiment 6

In the "root_cap" analysis (e.g., verBITTERn) Capitalization Style ("no_cap" *vs.* "root_cap") was treated as a within-group factor and Subset (Adj *vs.* Noun *vs.* Verb *vs.* Bound) as a between-group factor. This analysis produced a significant main effect of Capitalization Style, $F_2(1, 68) = 206.99, p < .0001$, but no significant effect of Subset, $F_2(3, 68) = 0.71, p = .55$. There was no significant interaction between these two factors either, $F_2(3, 68) = 0.79, p = .51$.

Table 8.5. shows the mean RTs for each of the subsets under both the "no_cap" and "root_cap" capitalization styles in the analysis by items, as well as the resulting "root" capitalization effects. The mean values shown in Table 8.5. indicate that the "no_cap" style yielded the lowest RTs, whereas the "root" capitalization style yielded roughly the same elevated RTs across the Noun, Verb, and Bound subsets, and slightly higher RTs for the Adj subset.

In order to find out whether the "root" capitalization effects for each subset were statistically significant, ANOVAs were performed treating items as a random factor and Capitalization Style ("no_cap" *vs.* "root_cap") as a within-group factor. These analyses revealed highly significant capitalization effects for all four subsets: Adj, $F_2(1, 17) = 66.93, p < .0001$; Noun, $F_2(1, 17) = 63.74, p < .0001$; Verb, $F_2(1, 17) = 47.02, p < .0001$; Bound, $F_2(1, 17) = 37.11, p < .0001$.

Table 8.5. Mean RTs and "root" capitalization effects (ms) for existing *ver*-verbs in the analysis by items in Experiment 6

| | Capitalization Style | | |
|---|---|---|---|
| Subset | no_cap | root_cap | Capitalization Effect |
| Adj | 813 (20) | 958 (25) | *-144 (18) |
| Noun | 794 (17) | 907 (16) | *-113 (14) |
| Verb | 788 (18) | 909 (25) | *-121 (18) |
| Bound | 802 (27) | 914 (26) | *-112 (18) |

Note. Asterisks (*) indicate statistically significant capitalization effects. Numbers in parentheses indicate standard errors.

The "root" capitalization effects are also graphically represented in Figure 8.2.

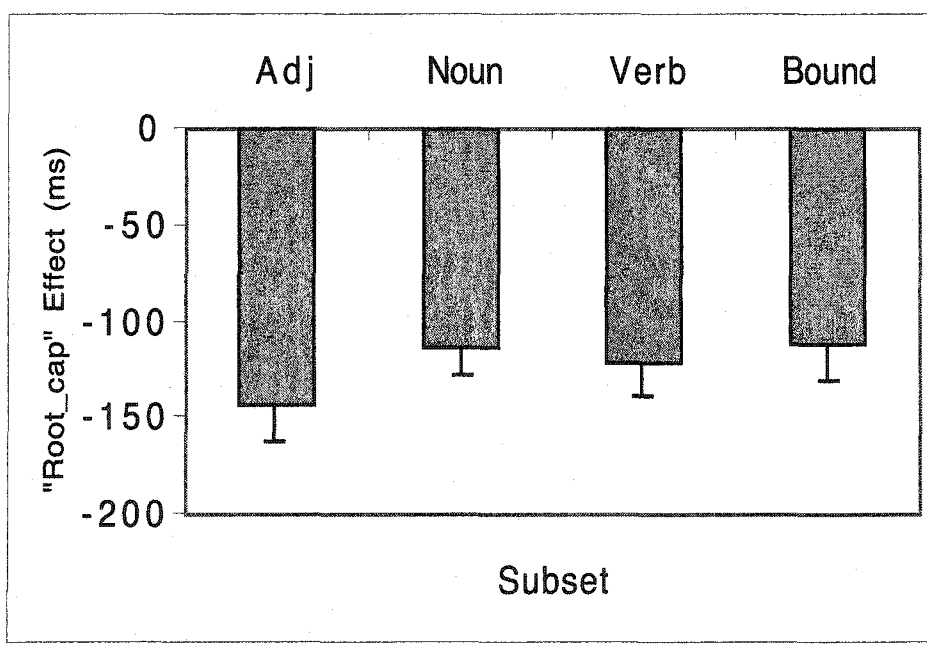



Figure 8.2. Mean "root" capitalization effects (ms) and standard errors as a function of subset for existing *ver*-verbs in the analysis by items in Experiment 6

In the "root_suff_cap" analysis (e.g., verBITTERN) Capitalization Style ("no_cap" *vs.* "root_suff_cap") was treated as a within-group factor and Subset (Adj *vs.*

Noun *vs*. Verb *vs*. Bound) as a between-group factor. This analysis produced a significant main effect of Capitalization Style, $F_2(1, 68) = 104.73, p < .0001$, but no significant effect of Subset, $F_2(3, 68) = 0.56, p = .65$. There was no significant interaction between these two factors either, $F_2(3, 68) = 0.32, p = .81$.

Table 8.6. shows the mean RTs for each of the subsets under both the "no_cap" and "root_suff" capitalization styles in the analysis by items, as well as the resulting "root_suff" capitalization effects. The mean values shown in Table 8.6. indicate that the "no_cap" style yielded the lowest RTs, whereas the "root_suff" capitalization style yielded roughly the same elevated RTs for the Verb and Bound subsets, slightly higher RTs for the Noun subset, and the highest RTs for the Adj subset.

In order to find out whether the "root_suff" capitalization effects for each subset were statistically significant, ANOVAs were performed treating items as a random factor and Capitalization Style ("no_cap" *vs*. "root_suff_cap") as a within-group factor. These analyses revealed highly significant capitalization effects for all four subsets: Adj, $F_2(1, 17) = 34.86, p < .0001$; Noun, $F_2(1, 17) = 14.27, p < .01$; Verb, $F_2(1, 17) = 26.80, p < .0001$; Bound, $F_2(1, 17) = 38.69, p < .0001$.

Table 8.6. Mean RTs and "root_suff" capitalization effects (ms) for existing *ver*-verbs in the analysis by items in Experiment 6

| | Capitalization Style | | |
|---|---|---|---|
| Subset | no_cap | root_suff_cap | Capitalization Effect |
| Adj | 813 (20) | 937 (33) | *-124 (21) |
| Noun | 794 (17) | 891 (25) | *-97 (26) |
| Verb | 788 (18) | 890 (29) | *-102 (20) |
| Bound | 802 (27) | 916 (26) | *-114 (18) |

Note. Asterisks (*) indicate statistically significant capitalization effects. Numbers in parentheses indicate standard errors.

The “root_suff” capitalization effects are also graphically represented in Figure 8.3.

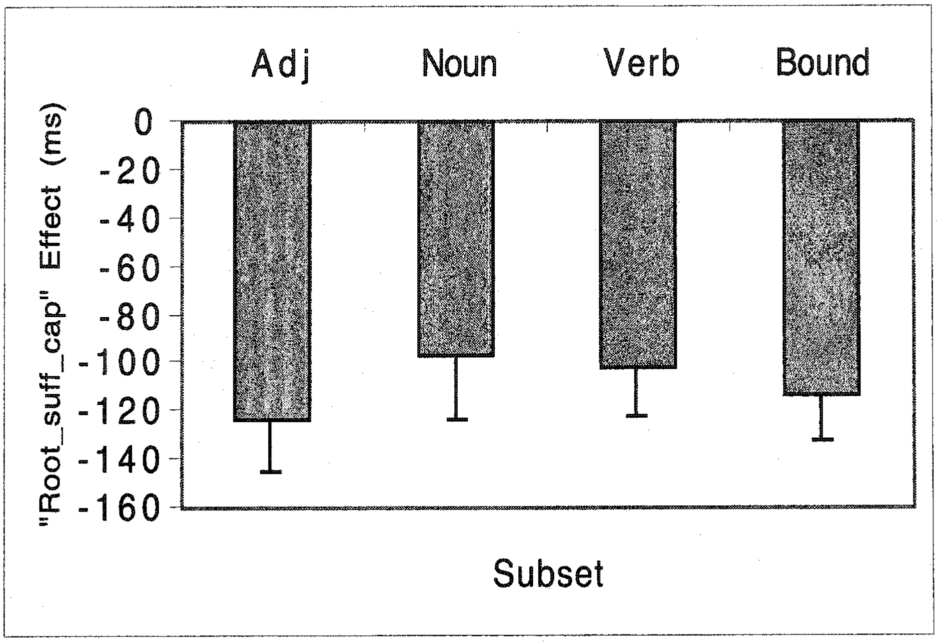



Figure 8.3. Mean “root_suff” capitalization effects (ms) and standard errors as a function of subset for existing *ver*-verbs in the analysis by items in Experiment 6

For the purpose of comparison, all of the capitalization effects are graphically represented in Figure 8.4. below.

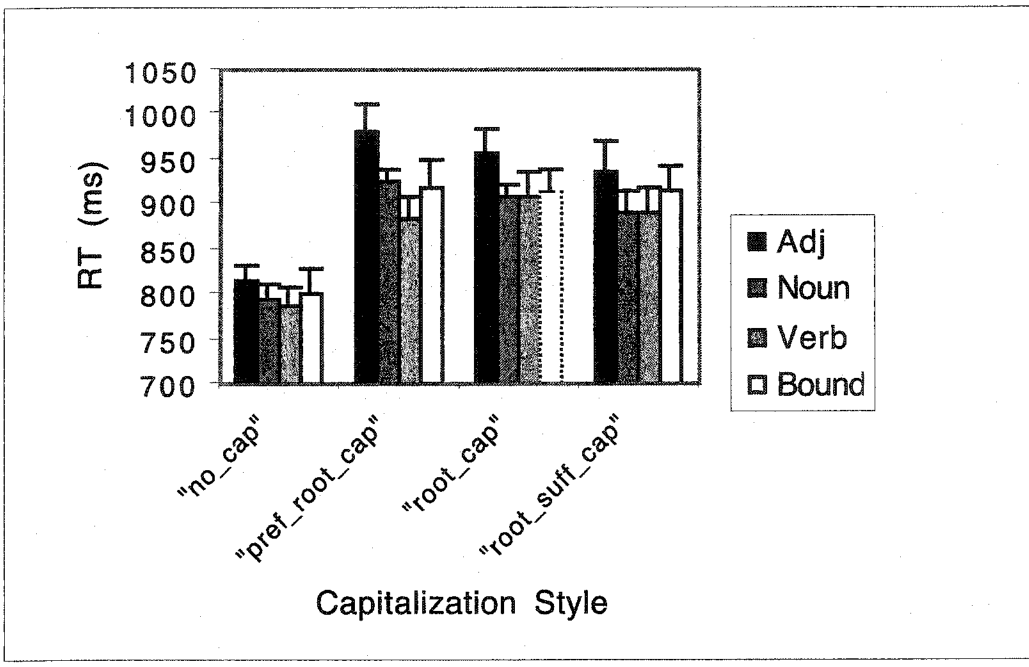



Figure 8.4. Comparison of mean capitalization effects (ms) and standard errors as a function of capitalization style and subset for existing *ver*-verbs in the analysis by items in Experiment 6

8.2.1.2. Preliminary discussion

The purpose of this part of the experiment had been to test whether in a lexical decision paradigm response latencies for existing *ver*-verbs differ as a function of both Subset and "Capitalization style". More specifically, the goal had been to investigate whether the response latencies for existing *ver*-verbs belonging to the Adj, Noun, Verb, and Bound subsets differ depending on whether an item is presented in "no_cap" style (e.g., "verbittern"), "pref_root_cap" style (e.g., "VERBITTERn"), "root_cap" style (e.g, "verBITTERn"), or "root_suff_cap" style (e.g., "verBITTERN"). The results of this part of the experiment indicate the existence of an overall "capitalization effect" but no effect of Subset (in the analysis by items), nor an interaction between these two factors.

As can be seen in Table 8.4., Table 8.5., and Table 8.6. above, existing *ver*-verbs of all subsets yielded statistically significant "pref_root", "root", and "root_suff" capitalization effects, respectively. Crucially, however, rather than leading to facilitatory processing these effects led to inhibitory processing. In other words, the three capitalization styles incurred an additional processing cost during the visual word recognition of these items: it, thus, seems to be easier to process, for example, "verbittern" than either "VERBITTERn", "verBITTERn", or "verBITTERN".

As the lack of a significant interaction of Subset and Capitalization style suggests, the magnitude of the three capitalization effects is approximately the same, a phenomenon that is also graphically represented in Figure 8.4. above. The state of affairs illustrated in this figure allows for the drawing of two basic conclusions: first, taking the mean response latencies obtained for the "no_cap" style as a point of reference, the magnitude of inhibition caused by each of the other three capitalization styles appears to be stable; second, the similar overall patterns of the "pref_root_cap", "root_cap", and "root_suff_cap" styles suggest that the same basic phenomenon is tapped, namely, that "capitalization is costly".

The results obtained for the existing *ver*-verbs, therefore, do not allow for a detailed investigation of subtle differences in the internal structure of these items. The use of different capitalization styles in a lexical decision paradigm for existing *ver*-verbs seems to be less sensitive a tool than either the priming paradigms or the morpheme awareness tasks used in Experiments 1 to 5 b (see Chapters 3 to 7 above).

Since, for example, Caramazza et al. (1988) have claimed that the morphological processing of nonsense words containing existing morphemes can very often reveal more subtle differences than the processing of existing words, in the following section the results for the novel *ver*-verb targets are presented to see whether they present a different picture.

### *8.2.2. Novel* ver-*verb targets*

#### 8.2.2.1. Preliminary results

First, in an effort to insure the comparability of the data from the participants with the status of university student, education student, and professional, respectively, ANOVAs were run on the RT scores of these three groups. In this analysis Status (university student *vs.* education student *vs.* professional) was treated as a between-group factor, whereas Subset (*Adj *vs.* *Noun *vs.* *Verb *vs.* *Bound) and Capitalization Style ("root_cap" *vs.* "pref_root_cap", "root_suff_cap" *vs.* "no_cap") were treated as within-group factors. This analysis produced a significant main effect of Status, $F_1(2, 105) = 6.18, p < .01$;[17] however, there were no significant interactions involving that factor (all *p*-values > .12). This effect was mainly based on the elevated RT scores for the professional group. Given this state of affairs, the same type of ANOVA was performed again, this time excluding the data from the professional group. This new analysis did not

[17] Due to a software error, the data of eight participants obtained for the nonsense *ver*-verb target set were rendered partially unusable for the analyses by participants, and, therefore, had to be excluded. Although this reduced the number of the degrees of freedom slightly, the power of the overall analysis of the factors under investigation was still at ceiling (i.e., 1.0).

produce a significant main effect of Status, $F_1(1, 88) = 2.83$, $p = .10$; it also did not produce any significant interactions involving that factor (all $p$-values > .07). Crucially, however, both analyses produced a similar overall pattern with significant main effects of Subset and Capitalization Style, as well as a significant interaction between these two factors. Thus, it can be reasonably assumed that the three status groups did provide comparable results after all, and, consequently, the data from these three groups were merged in all subsequent RT analyses involving novel *ver*-verb targets.

Next, two ANOVAs were performed to investigate the occurrence of any effects of capitalization across the four subsets of targets. One analysis treated participants as a random effect ($F_1$), whereas the other treated items as a random effect ($F_2$).

In the analysis by participants, Capitalization Style ("root_cap" *vs.* "pref_root_cap", "root_suff_cap" *vs.* "no_cap") and Subset (*Adj *vs.* *Noun *vs.* *Verb *vs.* *Bound) were treated as within-group factors; there were no between-group factors. This analysis revealed a main effect of both Capitalization Style, $F_1(3, 321) = 72.32$, $p < .0001$, and Subset, $F_1(3, 321) = 106.15$, $p < .0001$. The interaction between these two factors was highly significant as well, $F_1(9, 963) = 4.93$, $p < .0001$.

In the analysis by items, Capitalization Style ("root_cap" *vs.* "pref_root_cap", "root_suff_cap" *vs.* "no_cap") was treated as a within-group factor and Subset (*Adj *vs.* *Noun *vs.* *Verb *vs.* *Bound) as a between-group factor. This analysis revealed a main effect of both Capitalization Style, $F_2(3, 204) = 38.05$, $p < .0001$, and Subset, $F_2(3, 68) = 14.83$, $p < .0001$. The interaction between these two factors was highly significant as well, $F_2(9, 204) = 3.97$, $p = .0001$.

In order to keep the analyses of existing *ver*-verb targets and novel *ver*-verb targets comparable, it was again decided to investigate each of the four capitalization styles individually, using the items data base as a point of reference.

In the "pref_root_cap" analysis (e.g., *VERBUNTen) Capitalization Style ("no_cap" *vs.* "pref_root_cap") was treated as a within-group factor and Subset (*Adj *vs.* *Noun *vs.* *Verb *vs.* *Bound) as a between-group factor. This analysis produced a significant main effect of both Capitalization Style, $F_2(1, 68) = 87.40$, $p < .0001$, and Subset, $F_2(3, 68) = 16.57$, $p < .0001$. The interaction between these two factors was highly significant as well, $F_2(3, 68) = 7.76$, $p < .001$.

Table 8.7. shows the mean RTs for each of the subsets under both the "no_cap" and "pref_root_cap" capitalization styles in the analysis by items, as well as the resulting "pref_root" capitalization effects. The mean values shown in Table 8.7. indicate that RTs for the *Adj, *Noun, and *Bound subsets were considerably lower in the "no_cap" style than in the "pref_root" capitalization style. More precisely, in the "no_cap" style the *Adj subset yielded the highest RTs, closely followed by the *Noun subset, and the *Bound subset clearly yielding the lowest RTs. The same stepwise pattern is reproduced in the "pref_root" style, albeit with elevated RTs. By contrast, the *Verb subset yielded the highest RTs in both conditions, with only slightly elevated RTs in the "pref_root" style.

In order to find out whether the "pref_root" capitalization effects for each subset were statistically significant, ANOVAs were performed treating items as a random factor and Capitalization Style ("no_cap" *vs.* "pref_root_cap") as a within-group factor. These analyses revealed highly significant capitalization effects for the *Adj, *Noun, and *Bound subsets (*Adj, $F_2(1, 17) = 17.66$, $p < .001$; *Noun, $F_2(1, 17) = 21.63$, $p < .001$;

*Bound, $F_2(1, 17) = 92.27, p < .0001$). By contrast, the *Verb subset did not produce a significant "pref_root" capitalization effect, $F_2(1, 17) = 1.22, p = .29$.

Table 8.7. Mean RTs and "pref_root" capitalization effects (ms) for novel *ver*-verbs in the analysis by items in Experiment 6

| | Capitalization Style | | |
|---|---|---|---|
| Subset | no_cap | pref_root_cap | Capitalization Effect |
| *Adj | 1042 (26) | 1137 (26) | *-95 (23) |
| *Noun | 998 (19) | 1097 (15) | *-100 (21) |
| *Verb | 1114 (15) | 1133 (19) | -20 (18) |
| *Bound | 888 (14) | 1041 (18) | *-152 (16) |

Note. Asterisks (*) in the right-most column indicate statistically significant capitalization effects. Numbers in parentheses indicate standard errors.

The "pref_root" capitalization effects are also graphically represented in Figure 8.5.

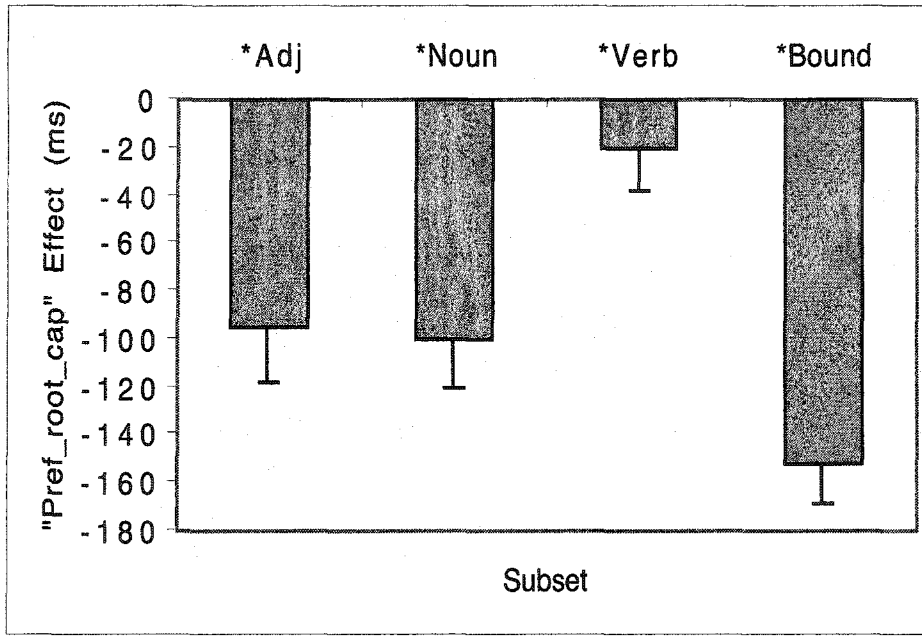



Figure 8.5. Mean "pref_root" capitalization effects (ms) and standard errors as a function of subset for novel *ver*-verbs in the analysis by items in Experiment 6

In order to find out whether the "pref_root" capitalization effects between the various subsets were statistically significant, a series of unpaired two-tailed $t$ tests was completed using the items data set. Results showed that two of the differences in capitalization effects between subsets were not statistically significant: *Adj and *Noun, $t(34) = 0.16, p = .87$; *Noun and *Bound, $t(34) = 1.97, p = .06$. Yet, four differences did reach statistical significance: *Adj and *Bound, $t(34) = 2.09, p = .04$; *Adj and *Verb, $t(34) = 2.61, p = .01$; *Noun and *Verb, $t(34) = 2.88, p < .01$; *Bound and *Verb, $t(34) = 5.57, p < .0001$.

In the "root_cap" analysis (e.g., *verBUNTen) Capitalization Style ("no_cap" *vs.* "root_cap") was treated as a within-group factor and Subset (*Adj *vs.* *Noun *vs.* *Verb *vs.* *Bound) as a between-group factor. This analysis produced a significant main effect of both Capitalization Style, $F_2(1, 68) = 50.31, p < .0001$, and Subset, $F_2(3, 68) = 19.43, p < .0001$. The interaction between these two factors was significant as well, $F_2(3, 68) = 4.87, p < .01$.

Table 8.8. shows the mean RTs for each of the subsets under both the “no_cap” and “root_cap” capitalization styles in the analysis by items, as well as the resulting “root” capitalization effects. The mean values shown in Table 8.8. indicate that RTs for the *Adj, *Noun, and *Bound subsets were considerably lower in the “no_cap” style than in the “root” capitalization style. More precisely, in the “no_cap” style the *Adj subset yielded the highest RTs, closely followed by the *Noun subset, and the *Bound subset clearly yielding the lowest RTs. In the “root” capitalization style, the *Adj and *Noun subsets yielded almost identical elevated RTs, while the *Bound subset still yielded clearly lower RTs. By contrast, the *Verb subset, again, yielded the highest RTs in both conditions, with only slightly elevated RTs in the “root” style.

In order to find out whether the “root” capitalization effects for each subset were statistically significant, ANOVAs were performed treating items as a random factor and Capitalization Style (“no_cap” *vs.* “root_cap”) as a within-group factor. These analyses revealed highly significant capitalization effects for the *Adj, *Noun, and *Bound subsets (*Adj, $F_2(1, 17) = 11.78, p < .01$; *Noun, $F_2(1, 17) = 32.36, p < .0001$; *Bound, $F_2(1, 17) = 27.85, p < .0001$). By contrast, the *Verb subset did not produce a significant “root” capitalization effect, $F_2(1, 17) = 0.39, p = .54$.

Table 8.8. Mean RTs and "root" capitalization effects (ms) for novel *ver*-verbs in the analysis by items in Experiment 6

| | Capitalization Style | | |
|---|---|---|---|
| Subset | no_cap | root_cap | Capitalization Effect |
| *Adj | 1042 (26) | 1093 (26) | *-50 (15) |
| *Noun | 998 (19) | 1095 (21) | *-97 (17) |
| *Verb | 1114 (15) | 1127 (15) | -13 (21) |
| *Bound | 888 (14) | 981 (20) | *-93 (18) |

Note. Asterisks (*) in the right-most column indicate statistically significant capitalization effects. Numbers in parentheses indicate standard errors.

The "root" capitalization effects are also graphically represented in Figure 8.6.

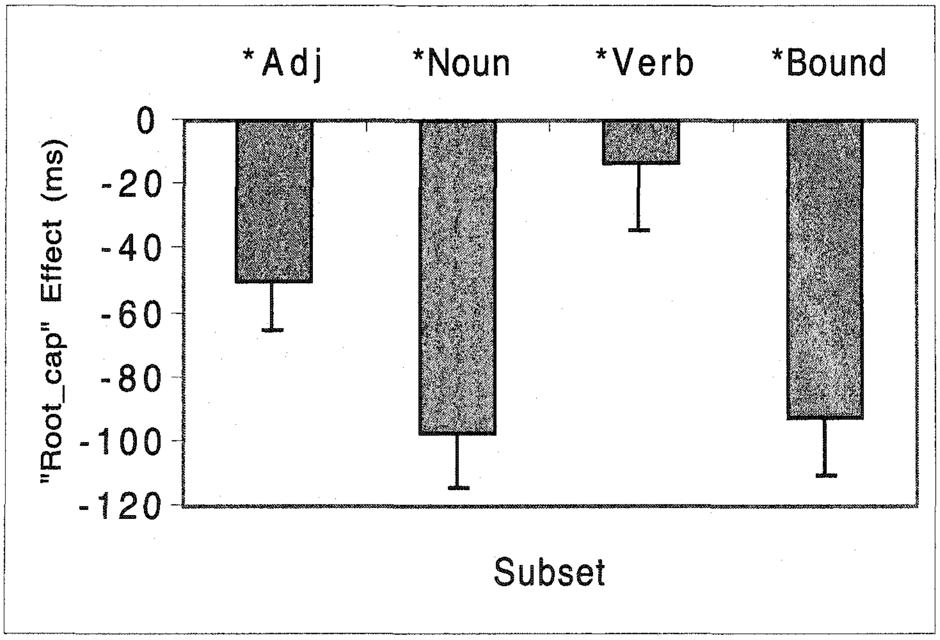



Figure 8.6. Mean "root" capitalization effects (ms) and standard errors as a function of subset for novel *ver*-verbs in the analysis by items in Experiment 6

In order to find out whether the "root" capitalization effects between the various subsets were statistically significant, a series of unpaired two-tailed $t$ tests was completed using the items data set. Results showed that three of the differences in capitalization effects between subsets were not statistically significant: *Adj and *Bound, $t(34) = 1.85$, $p = .07$; *Adj and *Verb, $t(34) = 1.43, p = .16$; *Noun and *Bound, $t(34) = 0.17, p = .87$. Yet, an equal number of differences did reach statistical significance: *Adj and Noun, $t(34) = 2.07, p = .046$; *Noun and *Verb, $t(34) = 3.05, p < .01$; *Bound and *Verb, $t(34) = 2.86, p < .01$.

In the "root_suff_cap" analysis (e.g., *verBUNTEN) Capitalization Style ("no_cap" *vs.* "root_suff_cap") was treated as a within-group factor and Subset (*Adj *vs.* *Noun *vs.* *Verb *vs.* *Bound) as a between-group factor. This analysis produced a significant main effect of both Capitalization Style, $F_2(1, 68) = 61.73, p < .0001$, and Subset, $F_2(3, 68) = 18.51, p < .0001$. The interaction between these two factors was highly significant as well, $F_2(3, 68) = 6.33, p < .001$.

Table 8.9. shows the mean RTs for each of the subsets under both the "no_cap" and "root_suff_cap" capitalization styles in the analysis by items, as well as the resulting "root_suff" capitalization effects. The mean values shown in Table 8.9. indicate that RTs for the *Adj, *Noun, and *Bound subsets were considerably lower in the "no_cap" style than in the "root_suff" capitalization style. More precisely, in the "no_cap" style the *Adj subset yielded the highest RTs, closely followed by the *Noun subset, and the *Bound subset clearly yielding the lowest RTs. In the "root_suff" capitalization style, the *Adj and *Noun subsets yielded almost identical elevated RTs, while the *Bound subset still yielded clearly lower RTs. By contrast, the *Verb subset, again, yielded the highest RTs in both conditions, with only slightly elevated RTs in the "root_suff" style.

In order to find out whether the "root_suff" capitalization effects for each subset were statistically significant, ANOVAs were performed treating items as a random factor and Capitalization Style ("no_cap" *vs*. "root_suff_cap") as a within-group factor. These analyses revealed highly significant capitalization effects for the *Adj, *Noun, and *Bound subsets (*Adj, $F_2(1, 17) = 10.55, p < .01$; *Noun, $F_2(1, 17) = 41.70, p < .0001$; *Bound, $F_2(1, 17) = 33.28, p < .0001$). By contrast, the *Verb subset did not produce a significant "root_suff" capitalization effect, $F_2(1, 17) = 0.33, p = .58$.

Table 8.9. Mean RTs and "root_suff" capitalization effects (ms) for novel *ver*-verbs in the analysis by items in Experiment 6

| | Capitalization Style | | |
|---|---|---|---|
| Subset | no_cap | root_suff_cap | Capitalization Effect |
| *Adj | 1042 (26) | 1105 (27) | *-63 (19) |
| *Noun | 998 (19) | 1095 (16) | *-98 (15) |
| *Verb | 1114 (15) | 1124 (18) | -10 (18) |
| *Bound | 888 (14) | 1000 (15) | *-112 (19) |

Note. Asterisks (*) in the right-most column indicate statistically significant capitalization effects. Numbers in parentheses indicate standard errors.

The "root_suff" capitalization effects are also graphically represented in Figure 8.7.

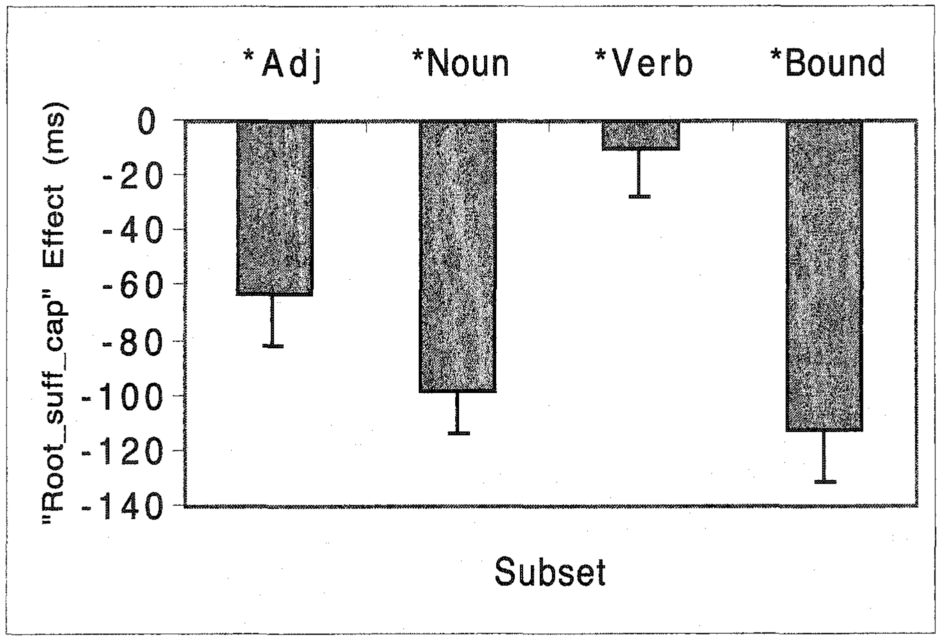



Figure 8.7. Mean "root_suff" capitalization effects (ms) and standard errors as a function of subset for novel *ver*-verbs in the analysis by items in Experiment 6

In order to find out whether the "root_suff" capitalization effects between the various subsets were statistically significant, a series of unpaired two-tailed $t$ tests was completed using the items data set. Results showed that four of the differences in capitalization effects between subsets were not statistically significant: *Adj and *Noun, $t(34) = 1.40, p = .17$; *Adj and *Bound, $t(34) = 1.77, p = .09$; *Adj and *Verb, $t(34) = 2.02, p = .051$; *Noun and *Bound, $t(34) = 0.56, p = .58$. Yet, two differences did reach statistical significance: *Noun and *Verb, $t(34) = 3.77, p < .001$; *Bound and *Verb, $t(34) = 3.88, p < .001$.

For the purpose of comparison, all of the capitalization effects are graphically represented in Figure 8.8. below.

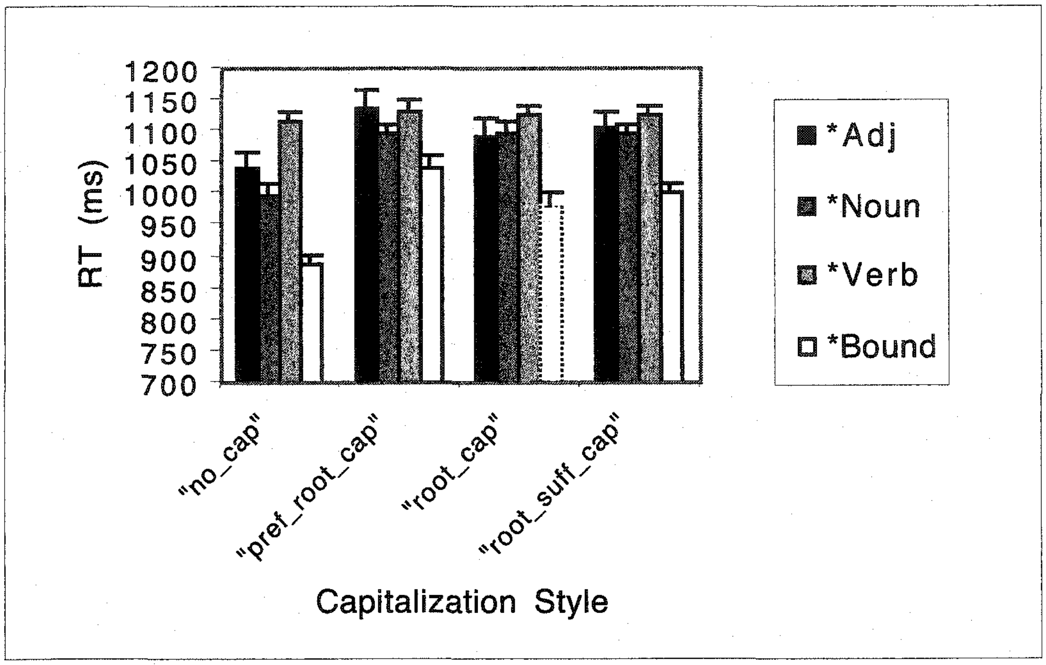



Figure 8.8. Comparison of mean capitalization effects (ms) and standard errors as a function of capitalization style and subset for novel *ver*-verbs in the analysis by items in Experiment 6

8.2.2.2. Preliminary discussion

The purpose of this part of the experiment had been to test whether in a lexical decision paradigm response latencies for novel *ver*-verbs (consisting of the unattested combination of *ver*- and an existing component)[18] differ as a function of both Subset and "Capitalization style". More specifically, the goal had been to investigate whether the response latencies for novel *ver*-verbs belonging to the *Adj, *Noun, *Verb, and *Bound

[18] An invented CVVC or CVCC root in the case of the *Bound subset.

subsets differ depending on whether an item is presented in "no_cap" style (e.g., *"verbunten"), "pref_root_cap" style (e.g., *"VERBUNTen"), "root_cap" style (e.g, *"verBUNTen"), or "root_suff_cap" style (e.g., *"verBUNTEN"). The results of this part of the experiment indicate the existence of both an overall "capitalization effect" and an effect of Subset, as well as a significant interaction between these two factors.

As can be seen in Table 8.7., Table 8.8., and Table 8.9. above, only novel *ver*-verbs belonging to the *Adj, *Noun, and *Bound subsets yielded statistically significant "pref_root", "root", and "root_suff" capitalization effects. By contrast, novel *ver*-verbs belonging to the *Verb subset did not yield significant results in any of these three capitalization styles. In other words, whereas the three capitalization styles incurred an additional processing cost during the visual word recognition of items belonging to the *Adj, *Noun, and *Bound subsets, it did not seem to play a role whether novel *ver*-verbs belonging to the *Verb subset such as **verfühlen* were presented as *"verfühlen", *"VERFÜHLen", *"verFÜHLen", or *"verFÜHLEN", respectively.

In contrast to the analysis of the existing *ver*-verb targets, the analysis of the novel *ver*-verb targets did produce a significant interaction between Capitalization style and Subset. This phenomenon is also graphically represented in Figure 8.8. above. As can be seen in that figure, this interaction is mainly carried by the flat effects obtained for the *Verb subset across the different capitalization styles. Unfortunately, however, the series of unpaired two-tailed *t* tests completed in an effort to gain a more comprehensive picture of the details of this interaction failed to do so: since in some cases the differences in capitalization effects between the "lexical" *Adj, *Noun, and *Verb subsets and the non-lexical *Bound subset were not statistically significant, it is not possible to posit any claims that would suggest any influence of the factor lexicality concerning the magnitude of capitalization effects. Furthermore, the similarity of the overall patterns of the "pref_root_cap", "root_cap", and "root_suff_cap" styles suggest once more that the same basic phenomenon is tapped, namely, "capitalization is costly". As already mentioned, the items belonging to the *Verb subset are exempt from this claim, which presents the most important difference between the results for existing *ver*-verbs and novel *ver*-verbs.

The patterns of response latencies in the "no_cap" style constitute another difference between these two data sets, which is explored in more detail in the following section.

## 8.3. Supplementary results

For both the existing *ver*-verb targets and the novel *ver*-verb targets response latencies obtained for the "no_cap" condition represented the base line against which the effects of the other three capitalization styles were judged. A closer look at these two baseline conditions, however, reveals an interesting difference.

As can be seen in Table 8.10. below, the mean RTs obtained for existing *ver*-verbs in the "no_cap" condition seem to be evenly distributed across the Adj, Noun, Verb, and Bound subsets. A series of unpaired two-tailed $t$ tests confirmed the impression that there is a lack of difference: Adj and Bound, $t(34) = 0.34$, $p = .73$; Adj and Noun, $t(34) = 0.73$, $p = .47$; Adj and Verb, $t(34) = 0.96$, $p = .35$; Bound and Noun, $t(34) = 0.25$, $p = .81$; Bound and Verb, $t(34) = 0.44$, $p = .66$; Noun and Verb, $t(34) = 0.26$, $p = .80$.

Table 8.10. Mean RTs (ms) for existing *ver*-verbs in the "no_cap" condition in the analysis by items in Experiment 6

| Subset | "no_cap" Capitalization Style |
|---|---|
| Adj | 813 (20) |
| Noun | 794 (17) |
| Verb | 788 (18) |
| Bound | 802 (27) |

Note. Numbers in parentheses indicate standard errors.

These mean RTs are also graphically represented in Figure 8.9.

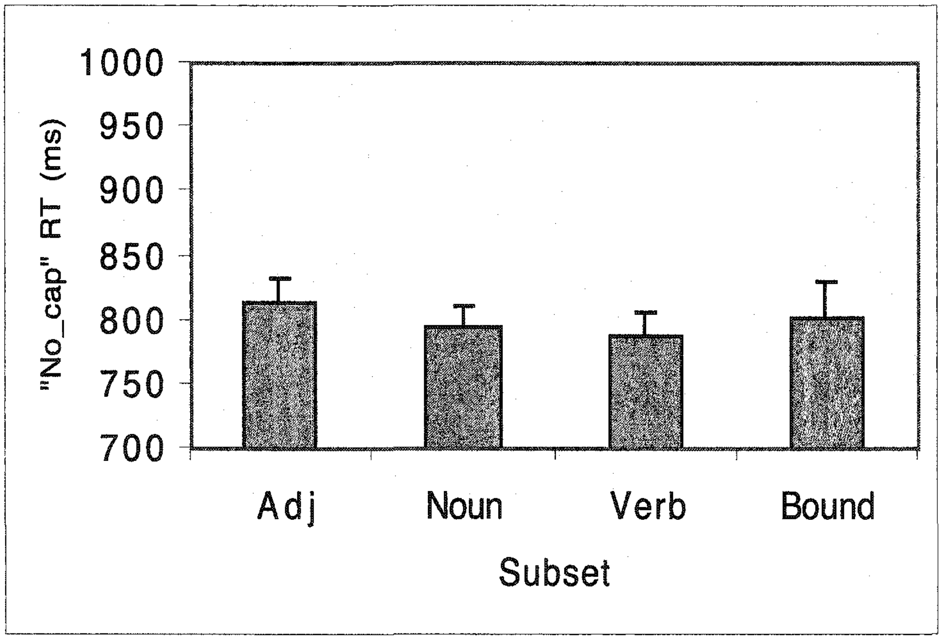



Figure 8.9. Mean RTs (ms) and standard errors for existing *ver*-verbs in the "no_cap" condition as a function of subset in the analysis by items in Experiment 6

On the other hand, Table 8.11. below shows that the mean RTs obtained for novel *ver*-verbs in the "no_cap" condition seem to follow a stepwise pattern such that items belonging to the *Verb subset yielded the highest RTs, items belonging to the *Bound subset yielded the lowest RTs, and items *Adj and *Noun subsets produced intermediate RTs. A series of unpaired two-tailed *t* tests revealed a lack of difference between the mean response latencies obtained for the *Adj and *Noun subsets, $t(34) = 1.40, p = .17$. By contrast, all the other differences were statistically significant: *Adj and *Bound, $t(34) = 5.19, p < .0001$; *Adj and *Verb, $t(34) = 2.38, p = .02$; *Noun and *Bound, $t(34) = 4.65, p < .0001$; *Noun and *Verb, $t(34) = 4.85, p < .0001$; *Bound and *Verb, $t(34) = 10.83, p < .0001$.

Table 8.11. Mean RTs (ms) for novel *ver*-verbs in the "no_cap" condition in the analysis by items in Experiment 6

| Subset | "no_cap" Capitalization Style |
|---|---|
| *Adj | 1042 (26) |
| *Noun | 998 (19) |
| *Verb | 1114 (15) |
| *Bound | 888 (14) |

Note. Numbers in parentheses indicate standard errors.

These mean RTs are also graphically represented in Figure 8.10.

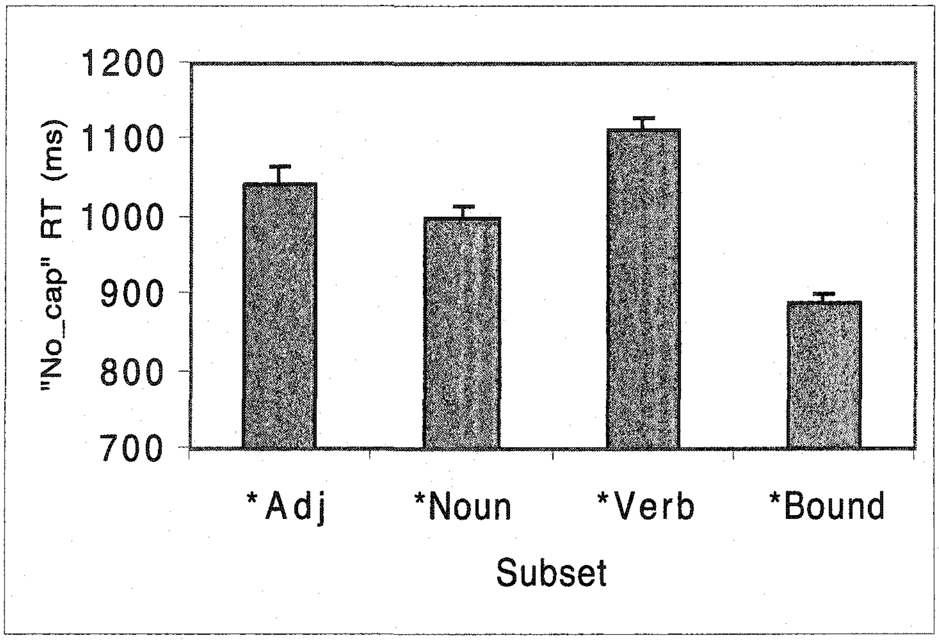



Figure 8.10. Mean RTs (ms) and standard errors for novel *ver*-verbs in the "no_cap" condition as a function of subset in the analysis by items in Experiment 6

**8.4. General discussion**

The supplementary results obtained for the "no_cap" conditions in the data sets for existing *ver*-verbs and novel *ver*-verbs, respectively, provide valuable insight into the role of stimulus effects.

In the case of the existing *ver*-verb targets, the evenly distributed pattern of response latencies suggests that items belonging to the Adj, Noun, Verb, and Bound subsets are subject to basically the same mechanisms of visual word recognition. In other words, there does not appear to be any special treatment for any particular subset. This also implies that, as far as the data set for existing *ver*-verbs is concerned, the lexical decision paradigm does not seem to be sensitive to the internal morphological structure of polymorphemic items.

In the case of the novel *ver*-verb targets, by contrast, the stepwise distribution of response latencies suggests that items belonging to the *Adj, *Noun, *Verb, and *Bound subsets are subject to distinct mechanisms of visual word recognition, a claim that is corroborated by the statistical differences between the mean response latencies for the four subsets revealed by a series of unpaired two-tailed $t$ tests. This state of affairs also implies that, as far as the data set for novel *ver*-verbs is concerned, the lexical decision paradigm seems to be sensitive to the internal morphological structure of these particular stimuli.

The above discussion indicates that in the present experiment stimulus effects played a role in processing. More precisely, these stimulus effects demonstrate that the role of morphology and morpheme salience is not absolute. In the context of all the experiments presented in this dissertation, it also becomes clear that task effects play a role in processing, when looking at the treatment of existing *ver*-verbs. In short, all of these factors seem to affect the lexical processing of *ver*-verbs, albeit not in an equal fashion.

The overall results of this dissertation are summarized and discussed in more detail in the concluding chapter.

# CHAPTER 9

# CONCLUDING REMARKS

## 9.0. Introduction

This dissertation investigated the visual word recognition of German verbs containing the inseparable prefix *ver-* (e.g., *verbittern* 'to embitter') in an experimental setting, using data obtained from adult native speakers of German. Although, on the surface, *ver*-verbs appear to constitute a homogeneous group, a closer inspection reveals subtle descriptive differences in their internal structure, namely, the existence of putative adjectival, nominal, verbal, and (synchronically) bound component forms such as those in ***verbittern*** 'to embitter' (*ver*-Adjective), ***verkleiden*** 'to disguise' (*ver*-Noun), ***verstopfen*** 'to block' (*ver*-Verb), and ***vergeuden*** 'to waste' (*ver*-Bound), respectively. The template [*ver*[ROOT]*(e)n*] can serve to show the commonality of these forms, which, from a descriptive point of view, differ only in their roots. This, in turn, provided a controlled framework in which the effects of root differences could be systematically explored. *Ver*-verbs belonging to the Adj, Noun, Verb, and Bound subsets were, therefore, chosen as the object of study in the present dissertation because they afforded the opportunity of investigating four fundamental issues in psycholinguistics, namely, the roles of morphology, morpheme salience, stimulus effects, and task effects in the lexical processing of complex words.

## 9.1. Experiments

The investigation was based on an array of experimental paradigms including both on-line techniques (to examine subconscious language processing) and off-line techniques (to examine conscious language processing). The on-line techniques comprised:

(a) root-to-whole-word priming [ARM-VERARMEN] (Experiment 1);

(b) base-to-whole-word priming [ARMEN-VERARMEN] (Experiment 2);

(c) whole-word-to-root priming [VERARMEN-ARM] (Experiment 5a);

(d) whole-word-to-base priming [VERSTOPFEN-STOPFEN] (Experiment 5b).

(e) simple lexical decision using four different "capitalization styles" for existing *ver*-verb targets and novel *ver*-verb targets (e.g., "VERBITTERn" *vs*. "verBITTERn" *vs*. "verBITTERN" *vs*. "verbittern"; Experiment 6, referred to as [CAPS]).

The off-line techniques comprised the following two tasks:

(a) meta-linguistic judgments on the potential etymological, morphological, or semantic connection between the members of *ver*-verb-root pairs such as VERARMEN-ARM (Experiment 3, referred to as [ARM IN VERARMEN]);

(b) meta-linguistic judgments on the potential etymological, morphological, or semantic connection between the members of *ver*-verb-root-*en* pairs such as VERARMEN-ARMEN (Experiment 4, referred to as [ARMEN IN VERARMEN]).

## 9.2. Summary of experimental results

The results for the individual studies are as follows (see also summary illustration in Figure 9.1. below):

In Experiment 1 [ARM-VERARMEN] root-to-whole word priming effects were significant for both the Adj and Noun subsets. By contrast, neither the priming effects for the Verb subset nor those for the Bound subsets were statistically significant. Hence, in a root-to-whole-word priming paradigm BITTER and KLEID are more efficient primes for VERBITTERN and VERKLEIDEN, respectively, than STOPF and GEUD are for VERSTOPFEN and VERGEUDEN.

In Experiment 2 [ARMEN-VERARMEN] base-to-whole-word priming effects were significant for all four subsets. Thus, BITTERN was as good a prime for VERBITTERN as KLEIDEN for VERKLEIDEN, STOPFEN for VERSTOPFEN, and GEUDEN for VERGEUDEN. However, in comparison to Experiment 1 the magnitude of priming effects decreased for the Adj subset and increased for both the Verb and Bound subsets. By contrast, the magnitude of priming effects remained stable for the Noun subset.

Experiment 3 [ARM IN VERARMEN] corroborated the picture gained from Experiment 1 in that rating scores were the highest for *ver*-verb-root pairs belonging to the Adj and Noun subsets, and lowest for those belonging to the Bound subset. Crucially, however, the rating results obtained in Experiment 3 showed that although participants rated items in the Verb subset significantly lower than both items in the Adj and Noun subsets, the ratings for the Verb subset were at the same time significantly higher than those for the Bound subset. In other words, participants made a clear distinction between lexical items in the Adj, Noun, and Verb subsets, on the one hand, and non-lexical items in the Bound subset, on the other hand.

Experiment 4 [ARMEN IN VERARMEN] clarified the picture gained from Experiment 2 in that rating scores for *ver*-verb-root-en pairs belonging to the lexical Adj, Noun, and Verb subsets were significantly higher than those for word pairs belonging to the non-lexical Bound subset. This state of affairs suggests that the evenly distributed priming effects obtained in Experiment 2 were, to some extent, based on form, since the primes for the Bound subset were not extant words with lexical representations of their own. However, in comparison to Experiment 3, rating scores for the Adj and Noun subsets decreased, those for the Verb subset increased, and those for the Bound subset remained stable, indicating that morphological structure plays the most important role.

In Experiment 5a [VERARMEN-ARM], in which a whole-word-to-root priming paradigm was employed and which thus constituted the reverse of Experiment 1, *ver*-verbs belonging to the Adj and Noun subsets such as VERBITTERN and VERKLEIDEN, respectively, did not prime their corresponding roots BITTER and KLEID. By contrast, *ver*-verbs belonging to the Verb subset such as VERSTOPFEN did prime their corresponding root (here: STOPF).

In Experiment 5b [VERSTOPFEN-STOPFEN], in which a whole-word-to-base priming paradigm was employed and which thus constituted the reverse of Experiment 2 as far as the Verb subset is concerned, *ver*-verbs such as VERSTOPFEN appeared to inhibit their corresponding bases (here: STOPFEN).

In Experiment 6 [CAPS] results indicated an effect of the lexicality of the whole word such that recognizing existing *ver*-verbs incurred less of a processing cost than rejecting novel *ver*-verbs. Findings also indicated an effect of morpheme salience such that novel *ver*-verbs belonging to the *Verb subset (e.g., **verfühlen*) took longer to reject than items belonging to either the *Adj, *Noun, or *Bound subsets. Furthermore, there was an effect of the lexicality of constituents in the case of novel *ver*-verbs such that items belonging to the "lexical" *Adj, *Noun, and *Verb subsets took longer to reject than items belonging to the non-lexical *Bound subset. Finally, there was an overall effect of "capitalization styles" for both existing *ver*-verbs and novel *ver*-verbs such that capitalization incurred an additional processing cost (except for novel items belonging to the *Verb subset).

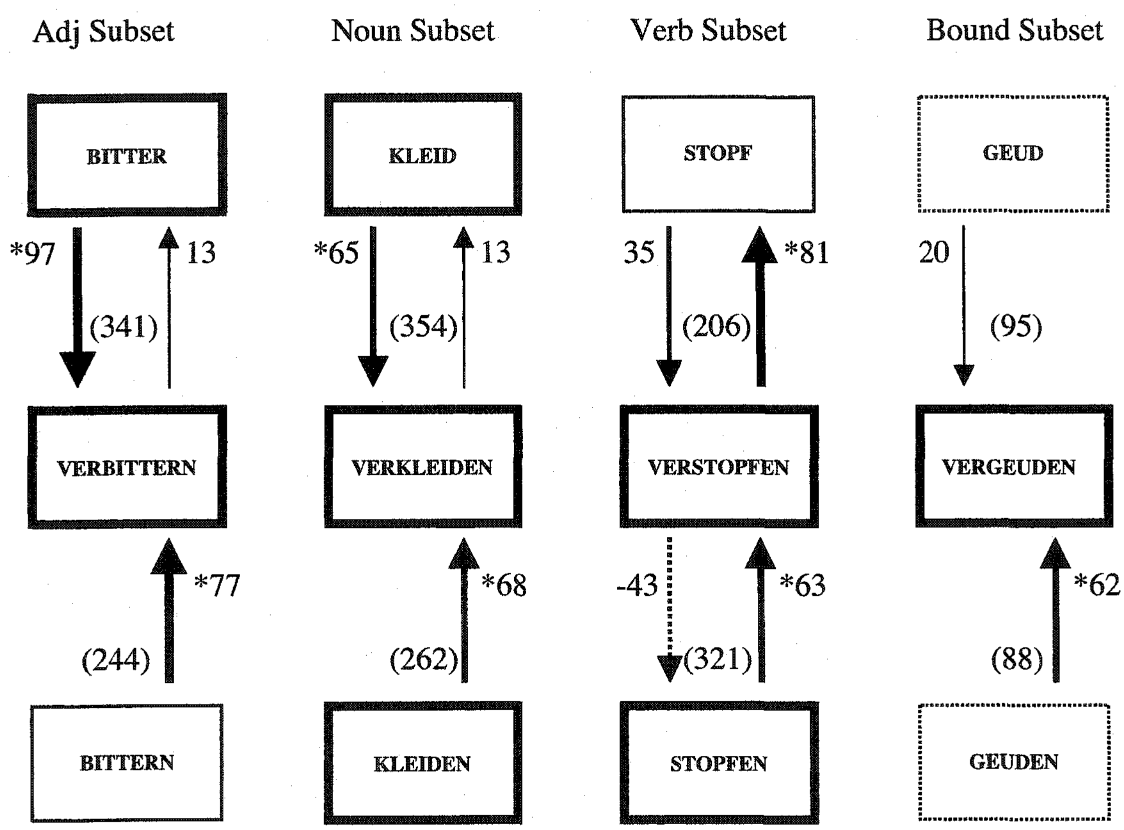
Figure 9.1. below provides a schematic summary of the results obtained for the priming and rating studies, organized by subsets.

Figure 9.1. Summary overview of experimental results

Arrows indicate the direction of priming effects. The thickness of the arrows visualizes the magnitude of priming effects. The broken arrow in the column for the Verb subset indicates an inhibition effect. Asterisks (*) indicate statistically significant effects ($p < .05$). Numbers in parentheses indicate mean ratings. Furthermore, the figure schematically illustrates the degrees of salience of the mental representations of

(a) the root constituent (box in the top row)
(b) the whole *ver*-verb (box in the center row),
(c) the base constituent (box in the bottom row).

Degrees of salience, visualized by the thickness of the boxes, are defined as a function of mean rating scores.



### 9.3. Interpretation of experimental results

On the following pages the findings illustrated in Figure 9.1. are discussed in a broader context, using the five research questions introduced at the end of Chapter 2 as guidelines:

(a) Does morphology play a role in the lexical processing of *ver*-verbs?

(b) Does morpheme salience play a role in the lexical processing of *ver*-verbs?

(c) Do stimulus effects play a role in the lexical processing of *ver*-verbs?

(d) Do task effects play a role in the lexical processing of *ver*-verbs?

(e) How are *ver*-verbs structured?

Question (a): Does morphology play a role in the lexical processing of *ver*-verbs?

The answer to this question is a qualified "yes". Although *ver*-verbs are inseparable from a descriptive point of view, the on-line priming studies yielded both facilitatory and inhibitory effects, and the results of the off-line rating studies indicated that participants were aware of the components embedded in composite *ver*-verbs. The lexical decision data obtained for novel *ver*-verbs also indicated the involvement of morphology during processing. In sum, these findings suggest that the components of *ver*-verbs appear to be processing units.

However, a crucial point that the analysis and comparison of the various data revealed is that the involvement of morphology in the lexical processing of *ver*-verbs does not seem to be absolute. Rather, this involvement appears to be a function of morpheme salience, stimulus effects, and task effects.

Question (b): Does morpheme salience play a role in the lexical processing of *ver*-verbs?

The answer to this question is a firm "yes". As the on-line results of Experiment 1 ([ARM-VERARMEN]) have shown, root priming was most effective for the Adj and Noun subsets, leading to significant facilitation for the relevant targets. This phenomenon was corroborated by the off-line results of Experiment 3 ([ARM IN VERARMEN]) in that mean ratings for items in the Adj and Noun subsets were the highest. Furthermore, the analysis of Experiment 3 indicated differences in root salience between the Verb and Bound subsets. Finally, the lexical decision results obtained for novel *ver*-verbs in Experiment 6 ([CAPS]) also suggest that morpheme salience plays a role in lexical processing. Taken together, these findings support the notion of root-specific processing units for *ver*-verbs.

One argument challenging this claim could be that in both the priming studies and the rating tasks participants were in a position to be aware of the relationship between a root and a *ver*-verb, a phenomenon which might thus have generated the priming effects and the rating scores. However, the results of a recent pilot study (Schirmeier, 2004) considerably weaken this challenging argument. This study was almost identical in design to Experiment 1 ([ARM-VERARMEN]), the only difference being the duration of prime exposure: Whereas in Experiment 1 primes were shown for 100 ms, they were only displayed for 60 ms in the pilot. Even under these masked conditions, however, that did not allow participants to be aware of the root primes (see also Forster & Davis, 1984), a bipartite pattern of priming effects very similar to the one observed in Experiment 1 emerged. Priming effects for items belonging to the Adj and Noun subsets were statistically significant, those for the Verb subset approached statistical significance, and those for the Bound subset did not reach significance. It is therefore reasonable to assume that the effects of morpheme salience obtained in the present dissertation do not reflect an artifact of conscious language processing, i.e., strategic effects.

Question (c): Do stimulus effects play a role in the lexical processing of *ver*-verbs?

The answer to this question is a clear "yes". Whereas the data obtained for novel *ver*-verbs in Experiment 6 clearly indicate the involvement of morphology in general and morpheme salience in particular, this is not the case with existing *ver*-verbs in this specific experiment. However, the different "capitalization styles" used in this experiment did not have the expected effects of highlighting specific constituents, but merely increased response times across the board.

Question (d): Do task effects play a role in the lexical processing of *ver*-verbs?

The answer to this question is "yes". Comparing the results of root-to-whole word priming in Experiment 1 ([ARM-VERARMEN] and base-to-whole word priming in Experiment 2 ([ARMEN-VERARMEN]) revealed dramatic differences in the overall priming pattern (leveling). The reversals of these two studies, namely Experiment 5a ([VERARMEN-ARM]) and Experiment 5b ([VERSTOPFEN-STOPFEN]) yielded yet another pattern of results (including inhibitory effects). Furthermore, the off-line rating tasks (Experiment 3 [ARM IN VERARMEN] and Experiment 4 [ARMEN IN VERARMEN]) allowed for a better understanding and clarification of the on-line results obtained in Experiment 1 and Experiment 2. Finally, whereas priming results suggest the influence of morphology and morpheme awareness on the lexical processing of existing *ver*-verbs, this is not true of the results obtained in the simple lexical decision task.

Question (e): How are *ver*-verbs structured?

The key findings in the investigation of this question derived from the comparison of root *vs*. root+en constituents across experiments. Whereas the results obtained for root priming in Experiment 1 [ARM-VERARMEN] show a bipartite pattern such that the processing of *ver*-verbs belonging to the Adj and Noun subsets was facilitated more than that of *ver*-verbs belonging to the Verb and Bound subsets, equally large priming effects for all four subsets were obtained in Experiment 2 [ARMEN-VERARMEN]. Viewed in isolation, the results of Experiment 2 seem to suggest the occurrence of an effect of form priming, since all of the primes were of the form [ROOT*(e)n*]. The comparison with the results of Experiment 1, however, makes it clear that there are also other factors at play. In Experiment 2, *ver*-verbs belonging to the Verb and Bound subsets seemed to enjoy rather large benefits from the change from a root prime to a root+en prime. In contrast, items belonging to the Adj subset seemed to be disadvantaged, while *ver*-verbs belonging to the Noun subset seemed to be largely unaffected by the change in prime structure. Furthermore, the comparison of Experiment 3 [ARM IN VERARMEN] and Experiment 4 [ARMEN IN VERARMEN] showed considerable changes in the rating patterns, especially for the items belonging to the Verb subset, indicating the importance of semantic transparency.

The findings of the present dissertation, therefore, support the argument that there are *preferred* morphological structures in the processing of *ver*-verbs. This phenomenon can be illustrated by morphological trees that provide a descriptive breakdown of the internal structure of these items. Basically, these trees represent the different types of *ver*-verbs as three-tiered structures. Figure 9.2. illustrates the case of items belonging to the Adj subset such as *verbleichen* 'to fade away' and *verbittern* 'to embitter'.

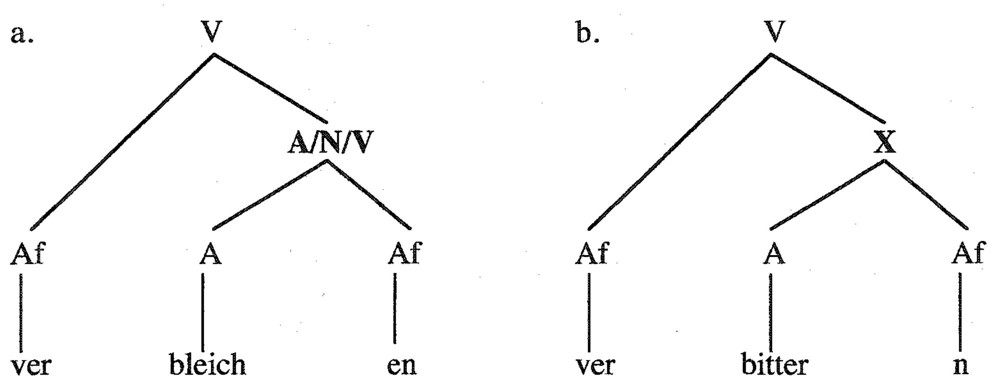



Figure 9.2. Potential ambiguity as to the status of certain root+(e)n elements embedded in *ver*-verbs belonging to the Adj subset

The lowest tier indicates that the basic descriptive components of *verbleichen* and *verbittern* are an affix (Af; here: the prefix *ver-*), an adjectival root (A; here: *bleich* or *bitter*), and another affix (here: the infinitival suffix *-(e)n*). This tier illustrates the rationale for the use of primes with the form [ROOT] to investigate the role of the morphological template [*ver*[ROOT]*(e)n*] in Experiment 1 [ARM-VERARMEN]; at the same time these forms served as roots in the *ver*-verb-root pairs in Experiment 3 [ARM IN VERARMEN].

The intermediate tier indicates the concatenation of the adjectival roots *bleich* and *bitter* with the infinitival suffix *-(e)n*. This illustrates the rationale for the use of primes with the form [ROOT*(e)n*] to investigate the role of the morphological template [*ver*[ROOT*(e)n*]] in Experiment 2 [ARMEN-VERARMEN]. At the same time these forms served as root+*(e)n* forms in the *ver*-verb-root-*en* pairs in Experiment 4 [ARMEN IN VERARMEN]. Whereas the interpretation of the root node (A) in both morphological trees should be uncontroversial, the status of the intermediate "root+*(e)n*" node (A/N/V in tree (a) and the X node in tree (b)) is much less clear.

Morphological tree (a) illustrates the situation for 14 of the 18 *ver*-verbs belonging to the Adj subset. In these cases the "root+*(e)n*" forms could be interpreted, first, as inflected forms of adjectives or nouns or, second, as verbal infinitives. The first case would apply to forms such as FREMDEN, which is embedded in VERFREMDEN (with *fremden* meaning, e.g., 'strange (dative singular)', *Fremden* meaning, e.g., 'stranger (dative singular)', and *verfremden* meaning 'to make unfamiliar'). The second case would apply to forms such as BLEICHEN, which is embedded in VERBLEICHEN (with *bleichen* meaning 'to bleach').

Morphological tree (b) illustrates the situation for the remaining four *ver*-verbs belonging to the Adj subset. In these cases the "root+*(e)n*" form is a non-word that could be interpreted as some inflected form of an adjective, if epenthesis or metathesis were applied (e.g., BITTERN/VERBITTERN: **bittern* > *bitteren* meaning 'bitter (dative singular)').

The decreased magnitude of priming effects for *ver*-verbs belonging to the Adj subset in Experiment 2 and the lower rating scores for these items in Experiment 4 may be indicative of the uncertainty surrounding the status of the intermediate A/N/V node in morphological tree (a) and of the intermediate X node in morphological tree (b).

By contrast, in the case of *ver*-verbs belonging to the Verb subset it seems to be the status of the root node (Vr) rather than the status of the intermediate "root+*(e)n*" node that is uncertain, as Figure 9.3. below illustrates for the example *verstopfen* 'to block'.

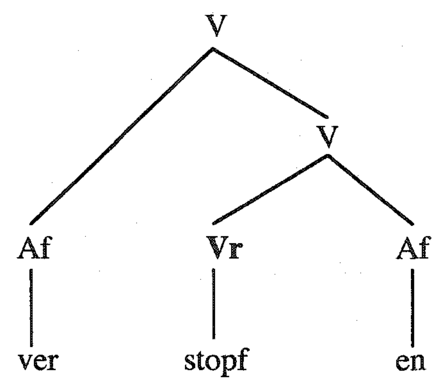



Figure 9.3. Potential ambiguity as to the status of the root element embedded in *ver*-verbs belonging to the Verb subset

On the lowest tier, the root *stopf* represents primes with the form [ROOT] used to investigate the role of the morphological template [*ver*[ROOT]*(e)n*] in Experiment 1 [ARM-VERARMEN]; at the same time such forms served as roots in the *ver*-verb-root pairs in Experiment 3 [ARM IN VERARMEN]. On the intermediate tier, the "root+*(e)n*" form *stopfen* represents primes of the form [ROOT*(e)n*] used to investigate the role of the morphological template [*ver*[ROOT*(e)n*]] in Experiment 2 [ARMEN-VERARMEN]; at the same time these forms served as root+*(e)n* forms in the *ver*-verb-root-*en* pairs in Experiment 4 [ARMEN IN VERARMEN].

In contrast to the situation in the Adj subset, the status of the intermediate node in the Verb subset does not leave much room for competing interpretations: it corresponds to the infinitive.[19] However, there seems to be a considerable level of uncertainty surrounding the status of the root node (Vr) in the Verb subset. Root forms can be interpreted as either the obscure truncated forms of the infinitive, or as the equally obscure familiar imperative. This uncertainty is reflected in both the small priming effects obtained for these items in Experiment 1 and the intermediate rating scores obtained for them in Experiment 3. By contrast, the increase in the magnitude of the priming effects for *ver*-verbs belonging to the Verb subset in Experiment 2 (using "root+*(e)n*" primes) and the dramatic increase in the rating scores in Experiment 4 may be indicative of the equally increased clarity surrounding the status of the intermediate V node.

*Ver*-verbs belonging to the Noun subset present an interesting case between the extremes of the Adj and Verb subsets, as is illustrated in Figure 9.4. below for the examples *verkleiden* 'to disguise' and *verfeinden* 'to become enemies'.

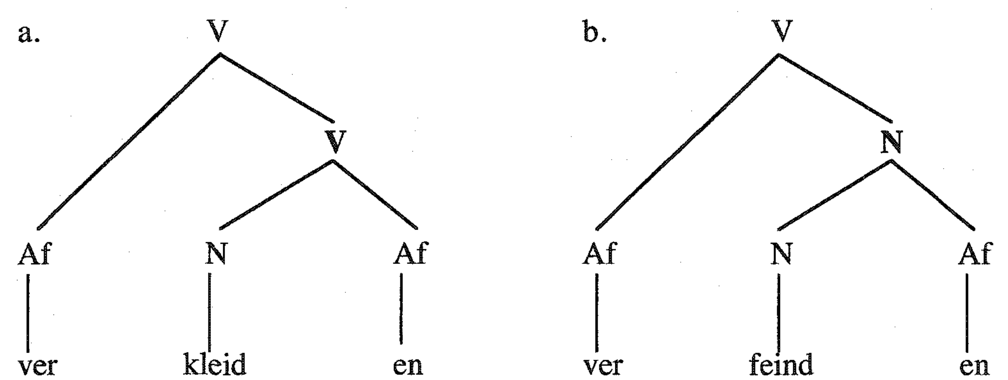



Figure 9.4. Potential ambiguity as to the status of the root+(e)n element embedded in *ver*-verbs belonging to the Noun subset

[19] The infinitive forms could also be interpreted as the homographic high-frequency first and third person plural forms. Although some infinitives could also be interpreted as inflected forms of nouns, the consistently higher ratings for pairs belonging to the Verb subset indicate that native speakers of German prefer the infinitive interpretation.

On the lowest tier, the roots *Kleid* and *Feind* represent primes of the form [ROOT] used to investigate the role of the morphological template [*ver*[ROOT]*(e)n*] in Experiment 1 [ARM-VERARMEN]; at the same time these forms served as roots in the *ver*-verb-root pairs in Experiment 3 [ARM IN VERARMEN]. On the intermediate tier, the "root+*(e)n*" forms *kleiden* and *feinden* represent primes of the form [ROOT*(e)n*] used to investigate the role of the morphological template [*ver*[ROOT*(e)n*]] in Experiment 2 [ARMEN-VERARMEN]; at the same time these forms served as root+*(e)n* forms in the *ver*-verb-root-*en* pairs in Experiment 4 [ARMEN IN VERARMEN]. In contrast to the situation in both the Adj and Verb subsets, the interpretation of neither the status of the root node nor that of the intermediate node appears to pose a true challenge in the Noun subset. While the root node should be uncontroversial, the intermediate node can also easily be interpreted in many cases.

Morphological tree (a) illustrates the case for half of the cases investigated, i.e., nine out of 18 where the "root+*(e)n*" form can be readily identified as the infinitive (e.g., KLEIDEN/VERKLEIDEN, with *kleiden* meaning 'to clothe'). These cases are marked in Appendix A.

Morphological tree (b) illustrates the other cases the status of the "root+*(e)n*" form is less clear as it can be identified as some inflected form of a noun (e.g., FEINDEN/VERFEINDEN, with *Feinden* meaning, e.g., 'enemy (dative plural)').

Sometimes even both the interpretations illustrated in morphological tree (a) and morphological tree (b) are possible, i.e., forms could be interpreted as infinitive and inflected form of a noun (e.g., LAGERN/VERLAGERN, with *lagern* meaning 'to store', *Lagern* meaning, e.g., 'camp (dative plural)', and *verlagern* meaning 'to shift').

Crucially, however, the choices for "root+*(e)n*" forms in the Noun subset are less varied and thus more straightforward than those in the Adj subset.[20] Furthermore, "root+*(e)n*" forms in the Noun subset do not result in the creation of non-words. The rather stable magnitude of the priming effects obtained for *ver*-verbs belonging to the Noun subset across the first two priming experiments, i.e., root priming in Experiment 1 and "root+*(e)n*" priming in the Experiment 2, and the fairly stable rating scores across Experiment 3 [ARM IN VERARMEN] and Experiment 4 [ARMEN IN VERARMEN] thus seem to be reflective of this state of affairs.

Finally, the case of *ver*-verbs belonging to the Bound subset is, in certain respects, similar to that of *ver*-verbs belonging to the Verb subset. Figure 9.5. illustrates this for the example *vergeuden* 'to waste'.

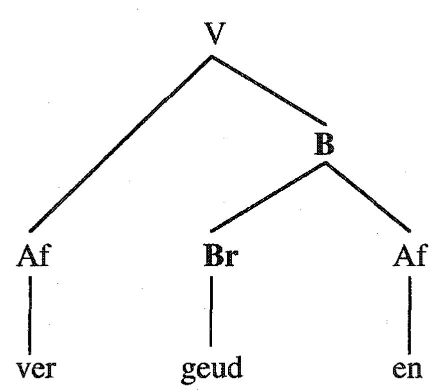



Figure 9.5. Potential ambiguity as to the status of both the root and the root+(e)n element embedded in *ver*-verbs belonging to the Bound subset

On the lowest tier, the root *geud* (Br) represents primes of the form [ROOT] used to investigate the role of the morphological template [*ver*[ROOT]*(e)n*] in Experiment 1 [ARM-

[20] The only exception in the stimulus set was *versilbern* 'to silver-plate' (*silbern* is the poetic form of *silber* 'silver').

VERARMEN]; at the same time these forms served as roots in the *ver*-verb-root pairs in Experiment 3 [ARM IN VERARMEN]. On the intermediate tier, the "root+*(e)n*" form *geuden* represents primes of the form [ROOT*(e)n*] used to investigate the role of the morphological template [*ver*[ROOT*(e)n*]] in Experiment 2 [ARMEN-VERARMEN]; at the same time these forms served as root+*(e)n* forms in the *ver*-verb-root-*en* pairs in Experiment 4 [ARMEN IN VERARMEN]. Whereas neither of these forms corresponds to an existing word in the German language, the dramatic increase in the magnitude of the priming effects for *ver*-verbs belonging to the Bound subset in Experiment 2 (using "root+*(e)n*" primes) as compared to Experiment 1 (using root primes) seems to suggest that, nevertheless, the status of the intermediate B node in this particular subset is similar to that of the intermediate V node in the Verb subset. However, the rating scores for *ver*-verbs belonging to the Bound subset are consistently and clearly the lowest in both Experiment 3 and Experiment 4. This finding sets the items belonging to the Bound subset clearly apart from the items in all the other subsets, undermining their peculiar and uncertain status.

To sum up, there is no clear answer to the question of how *ver*-verbs are structured. Whereas *ver*-verbs belonging to the Verb and Bound subsets appear to have a hierarchical right-branching structure, such a structure would not make sense for most of the *ver*-verbs belonging to the Adj subset. Rather, it would appear that these latter items would be better described as having a flat structure. For *ver*-verbs belonging to the Noun subset, finally, proposing both a hierarchical right-branching structure and a flat structure seems to be appropriate since there was an almost even number of exemplars in the stimulus set fitting each description. This argumentation is corroborated by a descriptive statistical analysis of the mean priming effects obtained for the items in the Noun subset in Experiment 1 ([ARM-VERARMEN]) and Experiment 2 ([ARMEN-VERARMEN]). In Experiment 2, the mean priming effect for items in the Noun subset that could be interpreted as having a verbal base is around 80 ms, whereas it is only around 55 ms for the remainder of this set. By contrast, in Experiment 1 the "verbal" items in the Noun subset yielded a mean priming effect of only 60 ms, whereas the "regular" items yielded an average of around 70 ms.

Thus, the evidence available to date for all subsets allows for the postulation of two basic structures for *ver*-verbs, as illustrated in Figure 9.6. below.

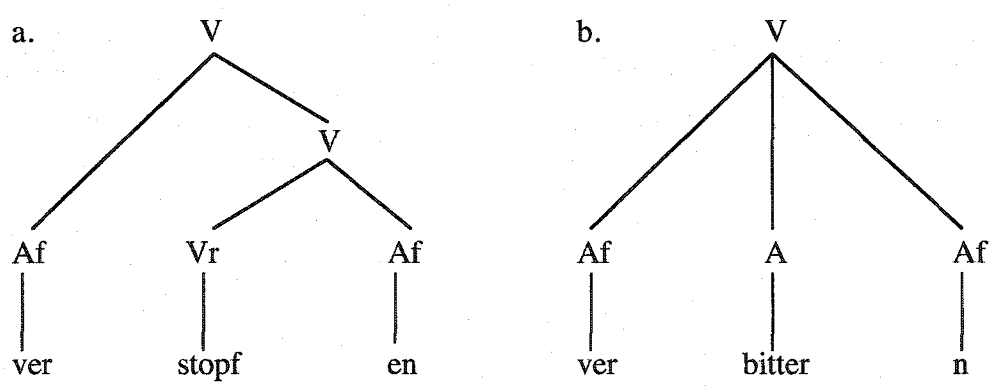



Figure 9.6. Two basic structures for German *ver*-verbs

### 9.4. Contextualization of experimental results

A last question concerns what the findings of the present dissertation mean in the context of the models of lexical processing that have been introduced in Chapter 2 above, namely, Taft and Forster (1975), Butterworth (1983), Caramazza et al. (1988), and Plaut and Gonnerman (2000).

In the context of Taft and Forster (1975), both the priming results obtained for existing *ver*-verbs and the lexical decision results obtained for novel *ver*-verbs are compatible with the claim that morphology plays a role during lexical processing. On the other hand, the lexical decision results obtained for the existing *ver*-verbs do not confirm Taft and Forster's claim. Crucially, however, the findings of the present dissertation enable a more detailed account of the role of morphology. The occurrence of differential effects for the four different subsets, which varied only in the lexical class of their roots, suggests that morpheme salience is important, i.e., that some morphological components embedded in composite *ver*-verbs might be more easily retrievable than others. Furthermore, the difference between root priming (differential effects) and root+en priming (equal effects), as well as the results for the off-line rating tasks (differential effects) suggest that morphological structure and semantic transparency also play an important role.

In the context of Butterworth (1983), the results obtained in the present dissertation are not incompatible with the full-listing approach proposed by that author, although he does not give an explicit account of the role of morphology in lexical processing. The lexical decision results obtained for existing *ver*-verbs, which showed a lack of difference between items belonging to the four different subsets, are compatible with Butterworth's view of the primacy of whole-word processing. Furthermore, the lexical decision results obtained for novel *ver*-verbs, which did show root effects, are compatible with that author's view that the involvement of morphology is a "fall-back strategy", used out of necessity. Still, it is not obvious how the differential priming results obtained for existing *ver*-verbs would be accommodated within this particular framework.

In the context of Caramazza et al. (1988), the findings of the present dissertation are completely compatible with the dual-route approach proposed by these authors. First, the lexical decision results obtained for existing *ver*-verbs (equally distributed RTs) support the view of whole-word access. Second, the priming results obtained for these same items (differential effects) endorse the notion of constituent-based access. Third, the lexical decision results obtained for novel *ver*-verbs (differential effects) highlight the role of constituent-based access in the treatment of unfamiliar words. Fourth, the priming results obtained for *ver*-verbs belonging to the Bound subset in Experiment 2 [ARMEN-VERARMEN] (non-lexical bound primes as effective as lexical adjectival, nominal, and verbal primes) in connection with the off-line rating results in Experiment 4 [ARMEN IN VERARMEN] (mean ratings for word pairs belonging to the Bound subset significantly lower than the rest) support Caramazza et al.'s notion of two levels of processing: a form-based access level and a truly lexical level. Crucially, however, the difference between root priming (differential effects) and root+en priming (equal effects), as well as the results for the off-line rating tasks (differential effects) found in the present dissertation, highlight the role of morphological structure and semantic transparency, and allow for the postulation of mental representations and processing units that are more complex than the ones Caramazza et. al (1988) deal with.

In the context of the connectionist model proposed by Plaut and Gonnerman (2000), one can only speculate as to the extent to which the findings of the present dissertation can be accommodated. It is hard to know in advance if the kind of structural diversity that German *ver*-verbs seem to manifest can be captured within such a connectionist framework. Whichever approach to modeling ultimately proves to be the most successful, it will need to accommodate the processing diversity that has been found in this dissertation for a putatively homogeneous class of verbs. In other words, "one size will not fit all".

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# APPENDICES

## Appendix A

Targets and the four types of primes used in Experiment 1 and Experiment 2:

(a) root primes and neutral primes [ARM-VERARMEN]

(b) root+en primes and neutral primes [ARMEN-VERARMEN].

"[*" indicates cases where an *Umlaut* is required in the *-en* form.

"✳" indicates cases in the Noun subset where the *-en* form could be interpreted as a free-standing verb.

Targets and primes also correspond to the word pairs used in Experiment 3 [ARM IN VERARMEN] and Experiment 4 [ARMEN IN VERARMEN].

Furthermore, the targets in Appendix A correspond to the existing *ver*-verbs used in Experiment 6 [CAPS].

Due to their peculiar synchronic status, roots in the Bound subset are not provided with glosses.

Neutral primes and their glosses are in italics.

| | Prime | | | Gloss | |
|---|---|---|---|---|---|
| Target | Root/+(e)n | Neutr./+(e)n | Subset | Target | Root-Neutral Prime |
| VERBITTERN | BITTER(N) | *SAUBER(N) [*Ä* | Adj | to embitter | bitter - *clean* |
| VERBLEICHEN | BLEICH(EN) | *MUNTER(N)* | Adj | to fade | pale - *awake* |
| VERDUMMEN | DUMM(EN) | *EWIG(EN)* | Adj | to dull sb.'s mind | silly - *eternal* |
| VEREITELN | EITEL(N) | *TRÜBE(N)* | Adj | to thwart | vain - *cloudy* |
| VERFÄLSCHEN | FALSCH(EN) [*Ä | *HÜBSCH(EN)* | Adj | to distort | false - *pretty* |
| VERFETTEN | FETT(EN) | *RAUH(EN)* | Adj | to become (too) fat | fatty - *rough* |
| VERFINSTERN | FINSTER(N) | *KOMPLEX(EN)* | Adj | to obscure | dark - *complex* |
| VERFREMDEN | FREMD(EN) | *STILL(EN)* | Adj | to de-familiarize | foreign - *silent* |
| VERGREISEN | GREIS(EN) | *FEIGE(N)* | Adj | to go senile | aged - *cowardly* |
| VERHEILEN | HEIL(EN) | *QUER(EN)* | Adj | to heal (up) | unhurt - *crossways* |
| VERIRREN | IRRE(N) | *REIF(EN)* | Adj | (refl.) to get lost | mad - *ripe* |
| VERKRÜMMEN | KRUMM(EN) [*Ü | *INTIM(EN)* | Adj | to bend | bent - *intimate* |
| VERKÜHLEN | KÜHL(EN) | *WILD(EN)* | Adj | (refl.) to catch a chill | cool - *wild* |
| VERMINDERN | MINDER(N) | *LAUTER(N)* | Adj | to reduce | inferior - *pure* |
| VERSTUMMEN | STUMM(EN) | *STEIL(EN)* | Adj | to fall silent | silent - *steep* |
| VERTEUERN | TEUER(N) | *STOLZ(EN)* | Adj | to increase the price | expensive - *proud* |
| VERWELKEN | WELK(EN) | *FEIL(EN)* | Adj | to wilt | withered - *for sale* |
| VERWÜSTEN | WÜST(EN) | *TRÄG(EN)* | Adj | to devastate | desolate - *sluggish* |
| VERANKERN✳ | ANKER(N) | *TADEL(N)* | Noun | to anchor | anchor - *reprimand* |
| VERBANNEN✳ | BANN(EN) | *TAKT(EN)* | Noun | to banish | spell - *bar* |
| VERFEINDEN | FEIND(EN) | *HAFEN(-)* | Noun | to make an enemy of | enemy - *harbor* |
| VERKLEIDEN✳ | KLEID(EN) | *KREUZ(EN)* | Noun | to disguise | clothes - *cross* |
| VERKÜMMERN✳ | KUMMER(N) [*Ü | *MANGEL(N)* | Noun | to wither away | sorrow - *lack* |
| VERLAGERN✳ | LAGER(N) | *WAFFE(N)* | Noun | to shift | camp - *weapon* |
| VERNAGELN✳ | NAGEL(N) | *MÜHLE(N)* | Noun | to nail up | nail - *mill* |
| VERNEBELN | NEBEL(N) | *KETTE(N)* | Noun | to shroud in fog | fog - *chain* |
| VERRIEGELN | RIEGEL(N) | *KIEFER(N)* | Noun | to bolt | bolt - *jaw* |
| VERSEUCHEN | SEUCHE(N) | *SCHACH(EN)* | Noun | to contaminate | epidemic - *chess* |
| VERSILBERN | SILBER(N) | *MANTEL(N)* | Noun | to silver-plate | silver - *coat* |
| VERSPOTTEN✳ | SPOTT(EN) | *FADEN(-)* | Noun | to mock | mockery - *thread* |
| VERSUMPFEN | SUMPF(EN) | *GLEIS(EN)* | Noun | to become marshy | marsh - *track* |
| VERTEUFELN | TEUFEL(N) | *FERIEN(-)* | Noun | to condemn | Devil - *holidays* |
| VERTRÄUMEN✳ | TRAUM(EN) [*Ä | *STURM(EN) [*Ü* | Noun | to (day-)dream away | dream - *storm* |
| VERTRÖSTEN✳ | TROST(EN) [*Ö | *SITTE(N)* | Noun | to put off | consolation - *custom* |
| VERWURZELN | WURZEL(N) | *TENNIS(EN)* | Noun | to be rooted | root - *tennis* |
| VERZWEIGEN | ZWEIG(EN) | *WOLKE(N)* | Noun | (refl.) to branch (out) | branch - *cloud* |
| VERÄRGERN | ÄRGER(N) | *GLÄNZ(EN)* | Verb | to annoy | annoy - *shine* |
| VERÄUSSERN | ÄUSSER(N) | *FÖRDER(N)* | Verb | to dispose of | express - *support* |
| VERBEISSEN | BEISS(EN) | *KLAPP(EN)* | Verb | to suppress | bite - *work* |
| VERBUCHEN | BUCH(EN) | *PARK(EN)* | Verb | to enter | enter - *park* |
| VERHÜTEN | HÜT(EN) | *WEH(EN)* | Verb | to prevent | tend - *blow* |
| VERKLINGEN | KLING(EN) | *TRENN(EN)* | Verb | to fade away | ring - *divide* |
| VERKNÜPFEN | KNÜPF(EN) | *BREMS(EN)* | Verb | to tie | tie - *brake* |

| | Prime | | | Gloss | |
|---|---|---|---|---|---|
| Target | Root/+(e)n | Neutr./+(e)n | Subset | Target | Root-Neutral Prime |
| VERLOCKEN | LOCK(EN) | *BOHR(EN)* | Verb | to tempt | lure - *drill* |
| VERLÖSCHEN | LÖSCH(EN) | *SPEND(EN)* | Verb | to go out | extinguish - *donate* |
| VERPUTZEN | PUTZ(EN) | *KLEB(EN)* | Verb | to plaster | clean - *stick* |
| VERRUTSCHEN | RUTSCH(EN) | *MURMEL(N)* | Verb | to slip | slide - *murmur* |
| VERSCHNEIDEN | SCHNEID(EN) | *SCHWIMM(EN)* | Verb | to cut all wrong | cut - *swim* |
| VERSCHWITZEN | SCHWITZ(EN) | *SCHLING(EN)* | Verb | to make sweaty | sweat - *gobble* |
| VERSINKEN | SINK(EN) | *WARN(EN)* | Verb | to sink | sink - *warn* |
| VERSTOPFEN | STOPF(EN) | *KRATZ(EN)* | Verb | to block | darn - *scratch* |
| VERTAUSCHEN | TAUSCH(EN) | *STREIT(EN)* | Verb | to exchange | exchange - *argue* |
| VERTILGEN | TILG(EN) | *TAST(EN)* | Verb | to exterminate | delete - *feel* |
| VERZERREN | ZERR(EN) | *HEMM(EN)* | Verb | to contort | drag - *hinder* |
| VERDAMMEN | DAMM(EN) | *BÖLK(EN)* | Bound | to condemn | --- |
| VERDAUEN | DAU(EN) | *FÖN(EN)* | Bound | to digest | --- |
| VERDERBEN | DERB(EN) | *MAUZ(EN)* | Bound | to go bad | --- |
| VERDRIESSEN | DRIESS(EN) | *FUSSEL(N)* | Bound | to irritate | --- |
| VERGESSEN | GESS(EN) | *FIER(EN)* | Bound | to forget | --- |
| VERGEUDEN | GEUD(EN) | *RAPS(EN)* | Bound | to waste | --- |
| VERGNÜGEN | GNÜG(EN) | *PETZ(EN)* | Bound | to amuse | --- |
| VERHEDDERN | HEDDER(N) | *BUNKER(N)* | Bound | to get tangled up | --- |
| VERLIEREN | LIER(EN) | *HUCK(EN)* | Bound | to lose | --- |
| VERPÖNEN | PÖN(EN) | *GEI(EN)* | Bound | to scorn | --- |
| VERQUICKEN | QUICK(EN) | *BISCH(EN)* | Bound | to combine | --- |
| VERSEHREN | SEHR(EN) | *FEIM(EN)* | Bound | to disable | --- |
| VERTEIDIGEN | TEIDIG(EN) | *BOSSEL(N)* | Bound | to defend | --- |
| VERUNSTALTEN | UNSTALT(EN) | *SPEDIER(EN)* | Bound | to disfigure | --- |
| VERWAHRLOSEN | WAHRLOS(EN) | *STAMMER(N)* | Bound | to get into a bad state | --- |
| VERWESEN | WES(EN) | *FUG(EN)* | Bound | to decompose | --- |
| VERWÖHNEN | WÖHN(EN) | *GEHR(EN)* | Bound | to spoil | --- |
| VERZICHTEN | ZICHT(EN) | *GACKS(EN)* | Bound | to renounce | --- |

## Appendix B

Targets corresponding to the novel *ver*-verbs used in Experiment 6 [CAPS].
The existing *ver*-verb targets used in this experiment are identical to the ones used in the priming and metalinguistic judgment tasks are identical to the items listed in Appendix A.
"Roots" for the *Bound subset consist of invented four-letter strings and are, therefore, not provided with glosses.

| Target | Root | Subset | Gloss for Root |
|---|---|---|---|
| VERBUNTEN | BUNT | *Adj | colored |
| VERFAHLEN | FAHL | *Adj | pale |
| VERFALBEN | FALB | *Adj | dun |
| VERFEINEN | FEIN | *Adj | fine |
| VERGEILEN | GEIL | *Adj | randy |
| VERGELBEN | GELB | *Adj | yellow |
| VERHERBEN | HERB | *Adj | sharp |
| VERHOLDEN | HOLD | *Adj | fair |
| VERKAHLEN | KAHL | *Adj | bald |
| VERKALTEN | KALT | *Adj | cold |
| VERKÜHNEN | KÜHN | *Adj | bold |
| VERLEISEN | LEIS | *Adj | silent |
| VERLINDEN | LIND | *Adj | balmy |
| VERMILDEN | MILD | *Adj | mild |
| VERMÜRBEN | MÜRB | *Adj | crumbly |
| VERREINEN | REIN | *Adj | pure |
| VERTUMBEN | TUMB | *Adj | stupid |
| VERWILDEN | WILD | *Adj | wild |
| VERHAHNEN | HAHN | *Noun | cock |
| VERHELDEN | HELD | *Noun | hero |
| VERHIRNEN | HIRN | *Noun | brain |
| VERLIEDEN | LIED | *Noun | song |
| VERMAISEN | MAIS | *Noun | corn |
| VERMARSEN | MARS | *Noun | mars |
| VERMEEREN | MEER | *Noun | sea |
| VERPAKTEN | PAKT | *Noun | pact |
| VERPEINEN | PEIN | *Noun | pain |
| VERPELZEN | PELZ | *Noun | fur |
| VERPFADEN | PFAD | *Noun | path |
| VERRANDEN | RAND | *Noun | edge |
| VERRESTEN | REST | *Noun | rest |
| VERSAALEN | SAAL | *Noun | hall |
| VERSEKTEN | SEKT | *Noun | champagne |
| VERWEIBEN | WEIB | *Noun | woman |
| VERWOLFEN | WOLF | *Noun | wolf |
| VERZORNEN | ZORN | *Noun | wrath |
| VERFÜHLEN | FÜHL | *Verb | feel |
| VERGÄHNEN | GÄHN | *Verb | yawn |
| VERHINKEN | HINK | *Verb | limp |
| VERHUSTEN | HUST | *Verb | cough |
| VERLEHNEN | LEHN | *Verb | lean |
| VERPIEPEN | PIEP | *Verb | cheep |
| VERRAUFEN | RAUF | *Verb | fight |
| VERREIMEN | REIM | *Verb | rhyme |
| VERSAUSEN | SAUS | *Verb | buzz |
| VERTARNEN | TARN | *Verb | camouflage |
| VERTASTEN | TAST | *Verb | feel |
| VERTAUFEN | TAUF | *Verb | baptize |
| VERTAUGEN | TAUG | *Verb | be suitable for |
| VERWANKEN | WANK | *Verb | sway |
| VERWIDMEN | WIDM | *Verb | dedicate |
| VERWINKEN | WINK | *Verb | wave |
| VERWÖLBEN | WÖLB | *Verb | curve |
| VERZAUSEN | ZAUS | *Verb | ruffle |
| VERDEFFEN | DEFF | *Bound | --- |
| VERDEISEN | DEIS | *Bound | --- |
| VERFAUGEN | FAUG | *Bound | --- |

| Target | Root | Subset | Gloss for Root |
|---|---|---|---|
| VERFILGEN | FILG | *Bound | --- |
| VERGELMEN | GELM | *Bound | --- |
| VERHAPFEN | HAPF | *Bound | --- |
| VERHEINEN | HEIN | *Bound | --- |
| VERKIRLEN | KIRL | *Bound | --- |
| VERLAUMEN | LAUM | *Bound | --- |
| VERLUKSEN | LUKS | *Bound | --- |
| VERMOLSEN | MOLS | *Bound | --- |
| VERNANFEN | NANF | *Bound | --- |
| VERPENDEN | PEND | *Bound | --- |
| VERSALFEN | SALF | *Bound | --- |
| VERTAULEN | TAUL | *Bound | --- |
| VERTINKEN | TINK | *Bound | --- |
| VERTOLSEN | TOLS | *Bound | --- |
| VERTORGEN | TORG | *Bound | --- |