Brain and Language **68,** 340–346 (1999)

Linearity and Morphological Structure in Derived Words: Evidence from Category Decision

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The present article investigates the influences of word-internal category information and linearity on the processing of morphologically complex words. Three sets of Finnish derived nouns consisting of a noun, adjective or verb stem, and a suffix were submitted to two on-line category decision tasks, where the subjects had to decide whether the word was a noun or a verb respectively. Both experiments show a stem–suffix category mismatch effect manifesting itself in prolonged reaction time latencies. Thus, the results indicate that the order of presentation and the word-internal structural information are intimately tied together also in the visual processing of morphological complex words. © 1999 Academic Press

Key Words: Linearity; derivation; Finnish; visual word recognition.

INTRODUCTION

The temporal order of information, i.e. linearity, plays a crucial role in auditory word recognition (e.g., Cutler, Hawkins, & Gilligan, 1985). However, the role of linearity in visual word recognition is yet to be resolved, although there is evidence for left-to-right processing of polymorphemic words (e.g., Taft & Forster, 1976; Libben, 1994; Laine, Vainio, & Hyönä, 1999).

Another major issue concerns the role of word-internal structure in representation and processing. Because most studies of morphological processing have concentrated on inflectional morphology, the evidence concerning derivation is rather scarce, even though there is some evidence showing that derived words in general are processed differently from inflected items (e.g., Niemi, Laine, & Tuominen, 1994). Recently, Bergman (1990) and Hudson

We thank Raymond Bertram as well as the two anonymous referees for their comments on an earlier version of this article. This study was financially supported by a grant from the Academy of Finland to the second author.

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0093-934X/99 $30.00

and Buijs (1995) report evidence of both the effects of linearity and of word-internal structure in visual recognition of derived words. Bergman (1990, as reported in Hudson & Buijs, 1995), in an experiment involving doubly suffixed Dutch words, found that inconsistencies between the syntactic categories of the suffixes slowed down reaction times in lexical decision as well as in category decision tasks. Similarly, Hudson and Buijs (1995) found that in doubly suffixed nonwords with legal stems and illegal combinations of suffixes, the location of the illegal forms affected reaction times. They argue that the results indicate a clear effect both of word-internal structure and linearity in visual processing of multiply suffixed derived words.

However, as Hudson and Buijs' (1985) evidence stems mainly from two sources, i.e., nonwords and trimorphemic words with consistent and inconsistent pairs of suffixes (e.g., N+N *vs* A+N), their results are open to possible objections relating to both artificiality effects as well as to effects stemming from the structural complexity of trimorphemic words. Thus, in order to maximize both naturalness and *ceteris paribus* requirements, the most relevant way to test their claims would be to use words which are all real, bimorphemic (i.e., composed of a stem and a suffix), and have a single suffix attached to three categories of stems. In this way it would be possible to ensure that, since the suffix remains invariant, whatever effect would be produced would be due to the influence of the stem.

Finnish has a productive suffix, *-us,* which may attach to typically bound noun (N), adjective (A), and verb (V) stem to form nouns denoting state or quality. For instance,

N+*-us naise+us*	''womanhood''
[[nainen]$_N$ Us]$_N$	[[woman]$_N$ hood]$_N$
A+*-us hita+us*	''slowness''
[[hidas]$_A$ Us]$_N$	[[slow]$_A$ ness]$_N$
V+*-us kuorsa+us*	''snoring''
[[kuorsata]$_V$ Us]$_N$	[[snore]$_V$ ing]$_N$

The present study reports two experiments employing a category decision task in studying the effects of left-to-right processing and word-internal category information on visual word recognition. As Hudson and Buijs (1995) have shown category decision to be sensitive to word-internal morphological structure, we should be able to find an effect of stem–suffix category mismatch on reaction times, given the assumption that sequencing of category information plays a role in visual recognition of morphologically complex words. The absence of such an effect, in turn, would indicate that the syntactic category information denoted by the suffix alone is enough for the category assignment, suggesting that the stem and suffix are processed in parallel without constraints imposed by linearity.

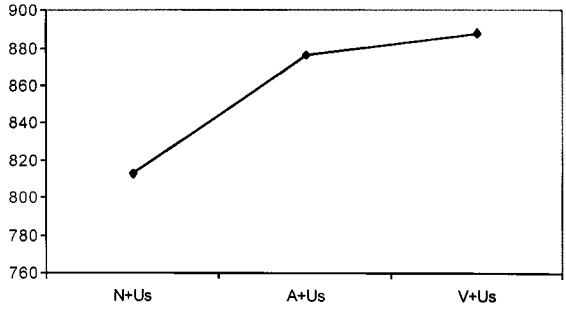

FIG. 1. Mean reaction times in Experiment 1 (in milliseconds).

EXPERIMENT 1

Participants

Twenty-two students of the University of Joensuu participated in the experiment. All participants were native speakers of Finnish and had normal or corrected-to-normal vision.

Materials

Twenty-one target words were selected from the Laine and Virtanen (1996) lexical database (22.7 million running words), seven for each derived condition (*N+-us, A+-us, V+-us*). The sets were matched for lemma frequency (summed frequency of the occurrence of the word and all its inflectional variants 1.5/million), surface frequency (summed frequency of the occurrence of the particular word-form, 0.3/million), bigram frequency (summed frequency of two-letter combinations constituting a word), and length in letters. In addition to the target words, a set of 94 filler words was included, consisting of 40 case-inflected (including nominative singular) nouns and 61 person-inflected verbs.

Procedure

The experiment was run using a Macintosh power PC running PsyScope 1.2. The items appeared in the center of the screen in black uppercase letters on a light gray background. Participants were to decide whether a word appearing on the screen was a noun as quickly as possible by pushing either ''yes'' or ''no'' on the button box. Ten practice trials as well as seven preexperiment items preceded the actual experiment.

Results and Discussion

Before data analysis two participants were excluded due to overall error rates of over 15%. All incorrect responses as well as responses longer than 3 standard deviations above the individual mean were replaced by the individual block average. Figure 1 presents the results concerning the three conditions. One-way ANOVA revealed a reliable effect for a difference between the three conditions ($df = 18$, $p < .001$). Post hoc analyses revealed that the denominal nouns (*N+-us*) were judged significantly faster than either

the deadjectival (*A+-us*) ones ($p < .02$) or the deverbal (*D+-us*) ones ($p < .02$). There was no difference between the deadjectival and deverbal conditions ($p > .8$).

We interpret the findings to support the assumption that visual word recognition shows effects of left-to-right processing on analogy with auditory word recognition, on the grounds that if the words were recognized as wholes the suffixal information alone would have sufficed to assign the category ''noun'' for all three conditions. The results further indicate that because the three groups differ from each other only in word-internal morphological structure, the syntactic category information of the base is checked at some point of the process of word recognition. Otherwise, we should not find any difference in response latencies between the three conditions. That is, the procedure that we call *Incremental Morpho-Lexical Check-Up* (IMC), along with the specific nature of the task, causes a processing burden which results in longer response latencies for the stem–suffix category mismatched cases.

There is one possible source of bias, however, stemming from the relative productivity of the three types of derivations. Although the suffix *-us* is very productive on the whole, it attaches to the three categories with different degrees of productivity, the deverbal and deadjectival ones being equally very highly productive, and the denominal one only mildly productive [based on the Laine & Virtanen (1996) lexical database]. It might be that the mild productivity of denominal *-us* had triggered full-form processing, whereas the high productivity of both deadjectival and deverbal *-us* has induced morpheme-based processing (Aronoff, 1976; Bertram, Laine, & Karvinen, 1999, for evidence on Finnish for this strategy). Since morpheme-based processing is generally slower than full-form processing, our result could merely reflect the influence of productivity on processing strategy. As Bertram *et al*. (1999) demonstrated that degree of productivity influences the processing of Finnish derived words, a second experiment was run in order to look into this question.

Experiment 2 employed the same set of stimuli as Experiment 1 and differed from Experiment 1 only in that the participants were to decide whether the words appearing on the screen were verbs. It is possible to make two predictions based on results involving the deadjectival (*A+-us*) condition in the second experiment. On one hand, if the difference in response latencies in Experiment 1 was due to the influence of productivity alone, we should observe behavior identical to Experiment 1 between the deadjectival and deverbal conditions also in Experiment 2. On the other hand, if the difference was due to the joint effects of left-to-right processing and the category information of the base given the type of task used, we should observe the deadjectival condition to concur with the denominal condition in Experiment 2. In other words, the change in the task should reflect the processing of the

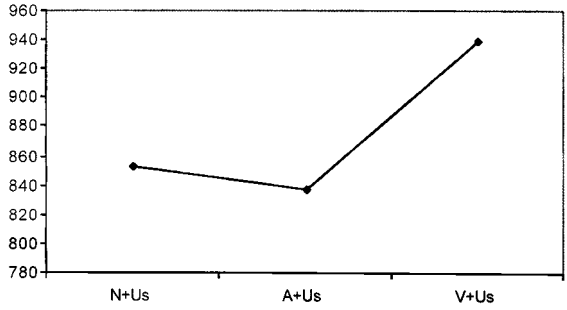

FIG. 2. Mean reaction times in Experiment 2 (in milliseconds).

category of the stem, even though the required ''no'' was unambiguously available by looking at the suffix alone.

EXPERIMENT 2

Participants

Twenty-one students, who had not participated in Experiment 1, from the University of Joensuu participated in the experiment. All participants were native speakers of Finnish and had normal or corrected-to-normal vision.

Materials

The materials were the same as those used in Experiment 1.

Procedure

The procedure was identical to Experiment 1 except that the participants were to decide as quickly as possible whether the words appearing on the screen were verbs.

Results and Discussion

Before data analysis all incorrect responses as well as responses longer than 3 standard deviations above the individual mean were replaced by the individual block average. The results are summarized in Fig. 2. One-way ANOVA revealed a reliable effect between the three conditions ($df = 18$, $p < .005$). Post hoc analyses revealed reliable differences between the three conditions, both the deadjectival (*A+-us*) and the denominal (*N+-us*) nouns being rejected faster than the deverbal (*V+-us*) ones ($p < .04$, and $p < .04$, respectively). There was no difference between the deadjectival and denominal conditions ($p > .7$).

The results allow us to dismiss the possible objection that the results in Experiment 1 were due to the differences in productivity alone. If this was indeed the case, we should have observed the deadjectival condition here to

behave exactly as it did in the first experiment. On the contrary, however, the deadjectival nouns patterned with the denominal ones, indicating that, indeed, there is both a left-to-right process as well as syntactic category checking of the base going on. In other words, the specific task of deciding whether a stimulus is a verb together with the mismatch between the verbal bases and the nominal identity of the *V+-us* nouns combine to yield prolonged response latencies.

CONCLUDING REMARKS

In general, our results are in accordance with those obtained by Bergman (1990) and Hudson and Buijs (1995) with analogous methods. The results show a clear stem–suffix category mismatch effect in both experiments, which manifests in delayed reaction times for the inconsistent types as compared to the consistent types. We take this to indicate that, indeed, also visual word recognition is affected by considerations of left-to-right processing. Moreover, the present result has been obtained, in contrast to the Bergman (1990) and Hudson and Buijs (1995) studies, by employing real words with a formally identical suffix across the three types of bases.

Furthermore, the present results indicate that the category information of the base is also accessed at some point of recognition, perhaps at a central level of processing as suggested by the elevated response latencies in the experiments. However, the exact nature of this process must be investigated by further experimentation. Furthermore, the results also confirm that the particular task used, i.e., category decision, is specifically sensitive to word-internal morphological information. Thus, the order of presentation and the word-internal structural information seem intimately tied together also in the visual processing of morphologically complex words.

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