Juhani Järvikivi & Jussi Niemi

Allomorphs as Paradigm Indices: On-line Experiments with Finnish Free and Bound Stems

Abstract

Two masked priming experiments investigated the role of stem allomorphs and the status of the nominative singular in lexical processing of Finnish inflected nouns. The results show that, first, free standing allomorphs significantly prime the corresponding nominative singular, e.g., *saappaa-saapas*. Second, the results also show, that inflected nouns, e.g., *sudelle*, are equally strongly primed by the nominative singular, *susi*, than by an inflected form with a different stem, e.g., *sutta*. We will argue that the stem allomorphs are separately represented at the form level and that the nominative singular does not enjoy a special status vis-à-vis other stem forms. The results are discussed in a decompositional framework that assumes separate levels of modality specific form representation and abstract lemma representation.

Key words: Finnish, morphology, allomorph, processing

1. Introduction

One of the major areas of modern psycholinguistic research concerns the so-called mental lexicon, which can be characterized as a theory of the representation and organization of lexical knowledge in the human mind. Research on the mental lexicon concerns at least the following issues: (1) What is represented in the mental lexicon and what is the nature of the representation, (2) how is lexical knowledge structured and what information does a lexical representation encode, and (3) how is the knowledge put to use in language comprehension and production. A particular concern has traditionally been the question of whether linguistic structure is represented in the mental lexicon, especially whether morphology has a role to play in lexical processing, and if so, when and on which conditions (see, e.g., McQueen & Cutler 1998, Schriefers 1999, for recent summaries). Roughly, the approaches to this question can be divided into two camps.

On one hand, the proponents of holistically based approaches argue that

polymorphemic words are represented in the lexicon as such and the orthographic/phonological information is matched against these holistic representations (Butterworth 1983, Lukatela, Gligorijević & Kostić 1980, Feldman & Fowler 1987). More recent, holistically oriented proponents claim that we cannot speak of representations in the symbolic and/or classical sense at all, but rather, linguistic information is distributed in an associative network of highly connected units, and morphology is an emergent property of the network (e.g., Bybee 1985, 2001). On the other hand, researchers have argued that morphological structure is encoded in the mental lexicon as well as actively exploited in lexical processing. The proponents of the so-called dual-mechanism approaches claim that all regular morphology is combinatorial in nature, thus it is also, for instance, decomposed in comprehension. Irregular forms are processed through and stored in a different mechanism of associative connections (Pinker & Prince 1991, Pinker 1998, Clahsen, Eisenbeiss, Hadler & Sonnenstuhl 2001). Some of the recent approaches claim that both whole word and morpheme-based representations exist even for completely regular morphologically complex words. That is, the whole word and morphologically decomposed information is used in parallel (Schreuder & Baayen 1995, Baayen & Schreuder 1999): whether a particular word is recognized via decomposed or holistic representations, may depend on factors such as frequency (Stemberger & MacWhinney 1986, Alegre & Gordon 1999), transparency (Marslen-Wilson, Tyler, Waksler & Older 1994), productivity (Anshen & Aronoff 1988, Baayen 1994, Bertram, Laine & Karvinen 1999) and ambiguity (Bertram, Schreuder & Baayen 2000, Laudanna & Burani 1995). Thus, in the latter view, the mental lexicon is seen as exhibiting redundancy to a degree greater than usually assumed in linguistic theories.

Recently, Niemi, Laine and Tuominen (1994) and Laine, Niemi, Koivuselkä-Sallinen, Ahlsén and Hyönä (1994) proposed a framework for the lexical representation and processing of Finnish, the so-called *Stem Allomorph Inflectional Decomposition* model (SAID). As the name implies, the following features were thought to be central to the processing of Finnish polymorphemic words:

(1) Inflected nouns are decomposed in lexical access (derived words are not)
(2) Noun stem allomorphs are separately represented at the level of orthographic/phonological lexicon
(3) Nominative singular is the base form for Finnish nouns

This paper reports on two experiments that investigated the above assumptions further. First, we will present further evidence for the decompositional account of the processing of Finnish case inflected nouns and for the psychological status of Finnish noun stem allomorphs. Second, we will investigate the role of nominative singular in lexical processing. Based on the experimental results, we will argue that the nominative singular does not formally enjoy a special status vis-à-vis other (oblique) stem forms, although it is arguably the most basic form morphologically and semantically. The present results are discussed in a decompositional framework that assumes separate levels of modality specific form representation and an abstract morphological/-syntactic level of lemma representation.

1.1. The status of stem allomorphs

Various lexical decision studies have shown that the recognition of monomorphemic (nominative singular) nouns in Finnish is faster and less error prone than the recognition of matched case inflected nouns (Niemi et al. 1994, Bertram et al. 1999, Laine, Vainio & Hyönä 1999). Morphological complexity has also been shown to significantly affect the word reading performance of aphasic patients in Finnish (Laine et al. 1994, Laine, Niemi, Koivuselkä-Sallinen and Hyönä 1995). All these results suggest that inflected words are decomposed in lexical access. Further evidence for this position was found in an eye movement study of Hyönä, Laine and Niemi (1995).

Even though the empirical evidence for decomposition is quite extensive for inflected words, certain types of inflected words might nevertheless be accessed holistically. For instance, inflected words with altered stems due to morphophonological operations would be good candidates for holistic access. However, the available evidence indicates that (morpho)phonology does not complicate the processing in any way, i.e., (morpho)phonologically opaque and transparent[1] inflected nouns showed no difference either in lexical decision latencies in normals or in aphasic reading performance, thus, indicating that the access to inflected words is stem allomorph based (Niemi et al. 1994, Laine et al. 1995). In a recent study, Järvikivi and Niemi (2002)

[1] Transparency and opacity as mentioned here refer to a situation where the nominative singular stem is a part of the word or not. Thus, *auto+lla* 'with a car' [auto-ADE-SG] would be considered transparent, whereas, e.g., *saappaa+ssa* 'in a boot' [saapas-INE-SG] would be deemed opaque. There are degrees of opacity presumably having to do with the linguistic complexity of the processes involved (see Niemi et al., 1994).

provided further evidence for this position, using the so-called repetition priming paradigm.[2] In two experiments isolated (free standing) stem allomorphs were presented as primes for the corresponding nominative singular targets to which a lexical decision was made, e.g., *SAAPPAA – saapas*. The results showed that the recognition of the monomorphemic nouns was significantly facilitated by the preceding stem allomorphs. Moreover, in a subsequent experiment where the primes were (phonologically) transparent and opaque inflected nouns, e.g., *saapas+ta vs. saappaa+sta,* significant facilitation was found with both types and both also primed the nominative singulars equally strongly. The authors interpreted this as positive evidence for the assumption that Finnish noun stem allomorphs are independently represented at the form level. Furthermore, they claimed that the representations are linked via lexical-semantic connections at a separate level of morphological/morphosyntactic representation (Järvikivi & Niemi 2002).

In addition to the experimental psycholinguistic evidence, there are also linguistic and distributional grounds for assuming independent representations of Finnish noun stem allomorphs at the form level. Finnish is a fusional-agglutinative language with rich morphology, thus, Finnish nouns may be morphologically marked for case (13-14 cases in active use) and number. Moreover, nouns may carry possessive suffixes and clitics, for example, *auto+i+ssa+ni+ko* 'in my cars?' [car-PL-INESS-POSS-CL]. In Karlsson and Koskenniemi's (1985) estimation a Finnish noun can have ca. 2000 inflected and cliticized forms, of which around 150 are so-called paradigmatic/core forms constituted by combinations of number, case and possessive marking. Furthermore, Niemi et al. (1994) have estimated that about 79 percent of Finnish nouns have more than one stem form (based on Karlsson 1983). According to Vannest et al. (2002), of the some 1,022,900 distinct noun types in the Turun Sanomat lexical database (Laine & Virtanen 1996), only 2.6% are accounted for by monomorphemic nominative singulars, and more than 95% of the morphologically complex nouns appear with no more than once per million words. Thus, the bulk of Finnish words in running text is polymorphemic and of relatively low surface frequency. Along with the productive inflection, the processing load induced by the frequent many-to-

[2] In the so-called immediate repetition priming paradigm a prime word is presented for a short time before the target to which the actual lexical decision is made. It is argued that any observable effects would take place at the lemma level rather than at lexical access. Thus, a facilitatory effect between morphological relatives – e.g., *käde+llä-käsi* – is taken to mean that the two share a common lemma (see Forster 1999).

one relation between phonology and morphology can perhaps be argued to be by itself a reason enough to store the stem allomorphs as such. (Niemi et al. 1994, Järvikivi & Niemi 2002).

Recently, the body of empirical evidence supporting a similar view has been extended to other languages as well. Clahsen, Eisenbeiss, Hadler and Sonnenstuhl (2001) and Clahsen, Prüfert, Eisenbeiss & Cholin (2002) found evidence for a decompositional account for regular German verb inflection, with separate representations for strong stems. Allen and Badecker (1999) presented evidence from Spanish showing that responses to targets such as *mor+os* 'moors' were significantly slower and less accurate when they were primed with an inflected form of a different lexeme with a homographic stem allomorph, e.g., *mor+ir* 'to die' than when the prime was either an unrelated control, e.g., *sill+a* 'chair' or an orthographically related monomorphemic word, e.g., *moral* 'moral'. Furthermore, the authors observed an analogous inhibitory effect even when the prime involved an allomorphic variant of the homophonous stem, e.g., *muer+e* 'she/he/it dies'. The results were interpreted in a framework with separate levels for (modality specific) form-representations of the allomorphic stem variants and a modality neutral level of lexical representation (Allen and Badecker 1999, 2002), i.e., in the terminology of Levelt (1989), *lexeme* and *lemma* levels, respectively. Recent evidence also indicates that – contrary to the dual-mechanism accounts (e.g., Pinker 1998) – even irregular morphology may be represented and processed analogously. Kelliher and Henderson (1990) found that the recognition of English irregular verb-forms such as *rode* depended on the cumulative frequency of *all* variants of the lexeme RIDE. Allen and Badecker (2002) found reliable priming between forms of English strong verbs, e.g., *teach – taught*. They argue that the earlier findings of lack of priming in this domain (see, e.g., Pinker 1998) were due to the inhibitory effect stemming from the use of phonologically closely related forms, such as *ring – rang*, whereas significant priming can be observed with phonologically more distinct, although equally irregular, forms.

Whatever the precise architecture of the representational system, the above evidence points to separate form-based and form-independent lemma-based representations of stem allomorphs.

1.2. The status of the nominative singular

It has been argued, that the frequently observed processing difference between the nominative singular and (inflected) oblique forms may in fact not be

indicative of morphological parsing at all. More specifically, it has been claimed that the processing difference is due to a special status of the nominative singular. The assumption has received experimental support from a variety of studies: A series of lexical decision experiments in Serbo-Croatian[3] showed systematic differences between the processing of nominative singular and other inflected forms, while there was no difference within the oblique cases. More crucially, no difference was observed between the masculine and feminine nominative singulars despite the latter being morphologically complex (e.g., Lukatela, Mandić, Gligorijević, Kostić, Savić & Turvey 1978, Lukatela et al. 1980, Feldman & Fowler 1987). Similar evidence was provided by Günther (1988) for German. On the basis of the Serbo-Croatian results a specific kind of full-listing model, the Satellite model, was put forth. In this model all inflectional variants are thought to be listed as full-form units with the nominative singular serving as the nucleus via which lexical access would take place. In other words, the comprehension of oblique forms would always require accessing the nominative singular first, after which the subsequent retrieval of the whole-word representation of the oblique word form would occur. A difference in processing time between the nominative and oblique forms could thus be explained by the extra step for the latter. Although the critical results from Serbo-Croatian have later on failed to replicate (see Kostić 1995 for a summary), the precise nature of the additional processing time for oblique case inflected forms in comparison to nominative singular forms is still under dispute.

There is also linguistic evidence for the view that all forms are not equal. It is frequently the case that in morphologically rich languages one form of the paradigm is the form which other inflected forms can be related to and/or derived from via (morpho)phonological rules (Bybee 1985, Wurzel 1990). Bybee (1985), for instance, conceives the representation of a morphological paradigm as a cluster of (possibly complex) words that are inter-connected through both phonological and semantic relations. Thus, both morphologically complex and simplex words (regular and irregular) are assumed to have whole word representations of different lexical strengths and the inter-word connections are modulated by shared phonological and semantic features. One constituting factor in the representation of a morphological paradigm is the so-called basic-derived relation, whence one (or more) form(s) is phonologically and/or semantically more prominent than the others (e.g., Bybee 1985: 111-

[3] Serbo-Croatian was the name used in the original studies for the language. Nowadays it is referred to as Serbian (e.g., Kostić 1995).

135). Often this role is filled by the nominative singular form for the nominal categories. In many cases, the particular form is also (the) independently occurring free form used for citation and/or ostensive function, as well as the unmarked and the most frequent one. More importantly, the basicness of the unmarked form as compared to the more marked ones is exemplified in its tendency to take part in diachronic change, esp. analogical leveling, i.e., the unmarked form is frequently used in producing a novel marked form but not the other way around (cf. e.g., Bybee 2001). Sometimes, e.g., due to the effects of frequency, the markedness relations are reversed (for local markedness, see Tiersma 1982, for the notion of focal form, which may or may not be the same as. e.g., the nominative singular, see Karlsson 1985). Karlsson (1983) argues that nominative singular is also the base form of Finnish nouns. The position is arguably supported by strong evidence from language acquisition and aphasia. For example, the so-called agglutinative errors (Niemi & Niemi 1987), in which the child incorrectly appends the affix(es) to the nominative singular stem, are typically attested at early stages of acquisition. Also, Niemi et al. (1994) claim that the fact that the nominative singular forms – whether monomorphemic or derived – are easier to process in agrammatic aphasia, indicates that the nominative singular is the psychologically real base form of Finnish nouns.

However, there is also evidence that the Finnish child may produce forms that on the face of it are in discord with the nominative singular as the base hypothesis. Children also produce isolated bound stems like *avaime* of *avain* 'key' (as in avaime+lla 'with key') instead of the nominative form. According to Niemi and Niemi (op.cit.), the bound stems used as the nominative are typically found in lexemes that rarely or never appear in caretaker language in the nominative singular (like 'key', 'seat', 'sauna stove', 'hallway'). Adults, or children for that matter, frequently encounter these items either in the instrumental ('Open the door with key') or locative function ('Keep to your seat'; Throw more water on the sauna stove'; Wait in the hallway until mommy is ready'). Interestingly, Niemi, Laine and Koivuselkä-Sallinen (1990) also report of an agrammatic patient who both omitted inflectional markers *and* substituted the nominative singulars for the correct inflected forms in conversation. Thus, both errors, such as *tytö* for *tytö+ille* of *tyttö* 'girl' [in 'mä jutteli *tytö*'] and *Espanja* for *Espanjassa* [in 'mut jos sä olet *espanja*...'], may be found in one patient. By no accident, perhaps, nominative singular is usually (one of) the most frequent form(s) in a language, occurs as a free form and is used in a very basic ostensive function, which may also explain much of the data from acquisition, aphasia and

language change.

On one hand, the special status allotted to the nominative singular is potentially problematic for the SAID account, which assumes decomposed access to inflected nouns independent from allomorphic stem variation. As the model also assumes a special status for the nominative singular, it is left open, whether the time cost observed in various studies for inflected nouns and/or the processing cost found in aphasic reading experiments, can be interpreted as resulting from morphological complexity or from the special nature of the nominative singular as a base form.

However, the type of decompositional account as proposed on the basis of the results of Järvikivi and Niemi (2000), depicted here in Figure 1, does not entertain a special status for the nominative singular stem in lexical processing. More precisely, the different stem forms are assumed to have separate representations on the level of form, which are connected to one single lemma at a higher form-independent level (see also Allen & Badecker 2002, for such a suggestion).

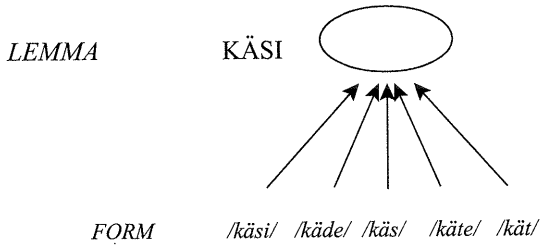

Figure 1. A schematic representation of the lexeme KÄSI at the form and lemma levels.

The present study comprises two masked priming studies with visual lexical decision. The experiments examine the role of stem allomorphy and the status of the nominative singular in lexical processing of Finnish inflected nouns. In Experiment 1 it is investigated with the masked priming paradigm whether the nominative singular is primed better by a stem allomorph than by an orthographic control condition. If it does, we could conclude that stem allomorphs are represented separately. In Experiment 2, it is investigated whether the nominative singular is a better prime for inflected words with an allomorphic stem than another inflected form with a different allomorphic stem is. If the nominative has a special status in lexical access, as held by the Satellite model, we should observe more facilitation in the former than in the

latter case. If, alternatively, the nominative singular and allomorphic variants have equal status in lexical access, no differences in facilitation should be observed.

2. Experiments

In the first experiment free-standing noun stem allomorphs are employed to prime the corresponding nominative singulars to find confirmation for the results obtained by Järvikivi and Niemi (2002) with a different paradigm. In the second experiment, the role of nominative singular is assessed by priming fully inflected (oblique) nouns with the corresponding nominative singular as compared to another stem variant of the paradigm.

Priming, in general, occurs when the recognition of the target word, e.g., *laine* 'wave' is facilitated by a preceding prime word, e.g., *vesi* 'water'. It is commonly assumed that the representations of the prime and target are connected in such a way that the activation of the former automatically activates the representation of the latter (see e.g., Forster 1999). Although the analogical assumption behind morphological priming is that any priming effect obtained with morphological relatives, e.g., *käde+ssä – käsi* 'in hand', and 'hand', respectively, is due to prior activation of their common lexical representation of the target by the prime word, there is a possibility that the effects could be of episodic origin, i.e., that they originate from the creation of the whole processing event in the episodic memory.

A particularly relevant argument for this type of criticism is offered by the so-called expectancy effect, where strong expectancy for the anticipated target leads to a strong facilitation of the target. Forster (1998) has shown that if the prime is an incomplete initial form of a real word target, e.g., *colos-* COLOSSAL, strong priming is obtained. Analogically, it is possible that the facilitation observed by Järvikivi and Niemi (2002) was (at least partly) due to participants having enough time to notice that the isolated stem allomorph primes were in fact incomplete forms of existing words. This could have caused a strong expectancy leading to activation of the members of the paradigm, and, thus, to significant priming of the corresponding nominative singular target. Although it is arguably unlikely that this was truly the case[4], the present experiments employ instead of the *immediate* repetition-priming

[4] Clear evidence against such an account is the fact that expectancy effects usually produce stronger priming than identity primes (Forster 1998), which was not the case in Järvikivi and Niemi (2002).

paradigm a so-called masked priming paradigm. In this particular method, the forward-masked prime is shown for a very short period of time – usually for 30-60 ms – followed immediately by the target word to which a lexical decision is made. In contradistinction to the standard priming paradigms, when explicitly asked after the experimental session, the participants are not usually aware of the presence of the prime at all; nevertheless, morphological effects have been found at the same magnitude as with the conscious prime durations (e.g., Grainger, Colé & Segui 1991). Thus, the method enables us to distinguish between the arguably truly lexical effects from effects springing from the possible influence of episodic learning better than with the standard repetition priming paradigms (Forster 1998, 1999; see also Bodner & Masson 2001, Badecker and Allen 2002).[5]

2.1. Experiment 1

In Experiment 1 we attempted to replicate the isolated stem allomorph priming reported in Järvikivi and Niemi (2002). If the priming found there was genuinely of lexical origin, it is expected that the stem allomorphs show comparable effects with the masked priming paradigm. If, however, the observed priming was due to non-lexical origin, episodic learning for instance, no priming should appear.

2.1.1. Method

Materials and participants.[6] Twenty-eight frequent Finnish monomorphemic nouns (nominative singular) were selected (using the Laine and Virtanen (1996) WordMill lexical search program) from the Karjalainen lexical database[7] (comprising 34.5 million word tokens) to serve as targets. The

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[5] The actual nature of "subliminal" priming is not discussed any further here (see e.g., Badecker and Allen (2002) for a summary). The crucial assumption for the present experiments is that it has been shown that masked priming is not subject to effects of expectancy when an incomplete word is presented as a prime (see Forster 1998) and that there is a real difference between having a glimpse of a word-like object in passing and having an experience of recognizing the prime as a familiar word.

[6] The materials were the same as those used in Järvikivi and Niemi (2002), Experiment 3.

[7] The database was compiled by Patrik Virtanen from the *Karjalainen corpus* consisting of seven consecutive years (1991-1997) and 34.5 million running words of the newspaper Karjalainen. The *Karjalainen corpus* is available through Kielipankki at http://www.csc.fi/kielipankki.

average lemma frequency for the targets was 9.1 per million and average length in letters 5.2. Four sets of items were constructed to serve as primes:

(1) Identity primes: The target nouns themselves, e.g., *sormi* 'finger-NOM-SG'
(2) Stem Allomorphs: A corresponding stem allomorph of the target lexeme, e.g. *sorme* [*sorme+sta,* 'finger-from']. The average cumulative frequency of the stems was 3 per million.
(3) Controls: A phonologically unrelated but phonotactically legal pseudo-word, e.g. *nuuli*.
(4) Form primes: A formally/phonologically matched pseudo-word, which differed from the target as minimally as possible, e.g., *sorma.*

Thus, each of the twenty-eight selected target nouns was paired with four types of primes, for example, the target *sormi* was primed with *sormi* (identity), *sorme* (stem), *sorma* (form), and *nuuli* (unrelated control). Because free standing bound stems are non-words per definition, non-words were also used in the other conditions (expect the identity one). The employed stem allomorphs were of four types:

(1) Consonant gradation (quantitative): *hatu – ssa* 'in a hat' [hattu + Inessive Sg].
(2) Consonant gradation (qualitative): *kummu– lla* 'on a knoll' [kumpu + Adessive Sg].
(3) Consonant gradation (retrograde): *saappaa– ssa* 'in a boot' [saapas + Inessive Sg].
(4) (Vowel) stem formation: *lase– ja* 'glasses' [lasi + Partitive Pl].

The prime-target pairs were distributed over four experimental lists. The materials were counter-balanced in such a way that each target appeared only once per list and all lists had an equal number of primes from each condition. All lists included also 204 prime-target pairs of which 115 had a non-word as a target in order to balance the number of 'yes' and 'no' responses.

Forty-eight students from the University of Joensuu participated in the experiment. The participants were assigned to one of the experimental lists, twelve per list. Thus, an individual participant encountered only one of the four prime-types per target. All participants were native speakers of Finnish.

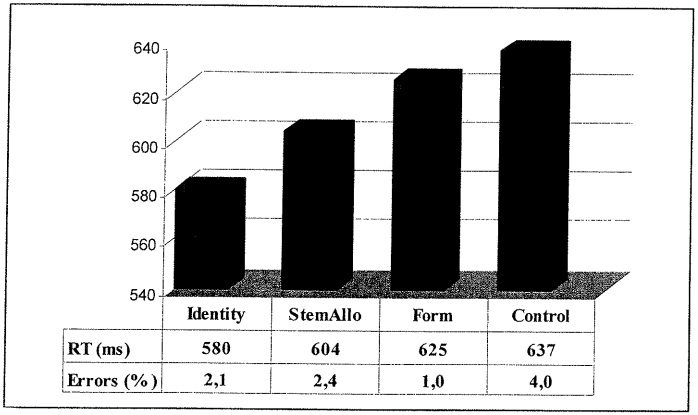
Procedure. A forward mask consisting of a line of hashmarks (##########) was presented in the center of the computer screen for 500 ms. Immediately after that, the prime appeared in the same location for 60 ms in upper case letters, and was immediately followed by the target presented in lower case letters for 1500 ms or until the subject made a response. The next sequence was preceded by an empty screen for 1500 ms. The participants were instructed to decide as quickly and carefully as possible whether the letter string presented on the screen was a Finnish word or not by pushing the

corresponding 'yes' or 'no' button on the button box. All participants were tested individually in an experimental room. Twenty practice trials preceded the experiment and an additional ten trials preceded the experimental items. The prime-target pairs were presented randomized for each participant. Response latencies and erroneous responses were recorded for data analysis.

2.1.2. Results

The results are presented in Figure 2. Before data analyses, as is the custom in the lexical decision paradigm, all incorrect responses as well as responses that were 2 standard deviations below or above individual means were removed. The remaining observations were used to calculate the mean response latencies and error scores for the experimental sets. The data of one participant was removed due to an error rate of over 25 %. Analyses of variance were carried out both by participants ($F1$) and by items ($F2$)[8]. The analyses revealed a reliable effect of prime-type with the identity prime producing the fastest (580 ms) and the Control condition the slowest (637 ms) average response latencies. The two critical conditions, StemAllo and Form, fell in between the two with average response latencies of 604 and 625 ms, respectively.

[8] ANOVAs for prime-type (RT): $F1(3,138) = 22.26, p < .001$, $F2(3,81) = 12.46, p < .001$. Critical pairwise comparisons: StemAllo vs. Control ($t1(46) = 5.41, p < .001$, $t2(54) = 3.26$, $p < .005$), StemAllo vs. Form ($t1(46) = 3.16, p < .005$, $t2(54) = 2.00$, $p = .050$), Form vs. Control ($t1(46) = 1.42, p > .1$, $t2(54) < 1$), StemAllo vs. Identity ($t1(46) = 2.81, p < .01$, $t2(54) = 2.07$, $p < .05$).



	Identity	StemAllo	Form	Control
RT (ms)	580	604	625	637
Errors (%)	2,1	2,4	1,0	4,0

Figure 2. Mean response latencies (ms) and error percentages by Prime-type in Experiment 1.

In order to assess the two critical conditions further, a series of t-tests was carried out (see footnote 8). The analyses confirmed that the differences in the response latencies between the Stem Allomorphs and both the Control and Form conditions were statistically significant. The Form condition, in turn, did not differ reliably from the Control condition. None of the observed differences in the error scores were statistically significant.[9]

The results from Experiment 1 are similar to those found by Järvikivi and Niemi (2002), thus lending further support for the assumption that Finnish noun stem allomorphs have separate form representations. However, here, as well as in the previous studies, the difference between the Identity and StemAllo conditions was statistically significant, indicating that the facilitation fell short of what is called full priming. We will return to this point below.

Having established further confirmation for the representation of bound stem allomorphs as mental lexical units, we will turn to inspect the role of the nominative singular in lexical processing further.

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[9] *Post hoc* analyses showed neither significant effect of stem type nor significant interaction.

2.2. Experiment 2

The present experiment was designed to examine the role of the nominative singular form as well as the organization and representation of oblique forms of the paradigm. We used oblique inflected forms, e.g., *sude-lle* 'to/for a wolf' [wolf-ALL-SG], as targets and contrasted the nominative singular, e.g., *susi* 'wolf', another oblique case with a different stem, e.g., *sut-ta* [wolf-PTV-SG], as well as an identity prime with each other. This way we were able to investigate whether the nominative singular has a special role to play as a mediating nuclear form and whether the recognition of an inflected member of the paradigm would need to activate the nominative singular as well. If the processing of Finnish inflected nouns is in fact allomorph-based in the sense of Niemi et al. (1994) and Järvikivi and Niemi (2002), then it logically follows that the nominative singular allomorph – despite the fact that it is a free form – should not have a more privileged status than other allomorphs. Consequently, the priming effect should be similar for the nominative singular and for the oblique case with a different stem. In contrast, if oblique cases are accessed via the nominative singular, we should observe more priming for the nominative than for the oblique condition.

2.2.1. Method

Materials. The target items consisted of twenty-four familiar case inflected nouns selected from the Karjalainen Lexical Database using Laine and Virtanen (1996) WordMill search program. The lemma frequency of the experimental words ranged from 1.1 (*mesi* 'honey, mead') to 84.2 (*susi* 'wolf') occurrences per million words. All targets were inflected forms with a bound stem, for example, *sude+lle* [wolf-ALL-SG]. The primes in the four experimental conditions were constructed as follows (for clarity, primes below carry morphological segmentation marks):

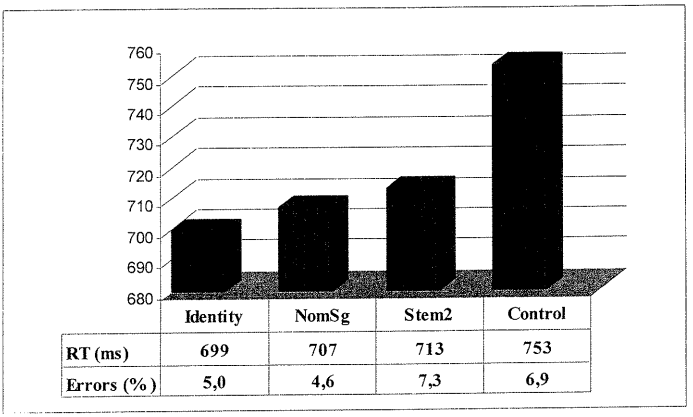
(1) *Identity*: In the Identity condition the target item was also given as a prime, e.g., *sude+lle – sudelle.*
(2) *NomSg*: In the NomSg condition the prime was the Nominative Singular form of the target lexeme, e.g., *susi* [wolf-NOM-SG] – *sudelle.*
(3) *Stem2*: In the Stem2 condition the primes were case inflected members of the target lexeme, however with a different stem allomorph, e.g., *sut+ta* [wolf-PTV-SG] – *sudelle.*
(4) *Control*: The Control condition consisted of phonotactically legal non-words with no phonological resemblance to the target words, e.g., *lonki – sudelle.*

The prime-target pairs were distributed over four experimental lists. The materials were counter-balanced in such a way that the target appeared only once on each list and all lists had an equal number of primes from each condition. In addition, all lists included 206 prime-target pairs of which 115 had a non-word as a target in order to balance the number of 'yes' and 'no' responses. Forty students from the University of Joensuu participated in the experiment for a cafeteria coupon (ca. 2 euro). All were native speakers of Finnish.

2.2.2. Results

Before data analyses all incorrect responses as well as responses that were two standard deviations below or above individual means were removed. The data from one participant was removed due to a high overall percentage of errors. One target item, viz., *meden* (gen. sg. of *mesi*), was also removed from all conditions due to an overly high amount of 'no' responses (over 40 % in all conditions). The remaining observations from thirty-eight subjects and twenty-three items per condition were used to calculate the mean response latencies and error scores for the experimental sets.[10] The results from Experiment 2 are presented in Figure 3.

[10] ANOVAs for prime-type (RT): $F1(3,114) = 5.52, p < .005$, $F2(3,66) = 5.18, p < .005$. Critical pairwise comparisons: Identity vs. Control ($t1(38) = 3.91, p < .001$, $t2(44) = 2.84$, $p < .01$), NomSg vs. Control ($t1(38) = 3.03, p < .005$, $t2(44) = 3.11$, $p < .01$) , Stem2 vs. Control ($t1(38) = 3.99, p < .001$, $t2(44) = 2.28$, $p < .05$). All other contrasts: $t1 < 1$ and $t2 < 1, p$ = n.s.



	Identity	NomSg	Stem2	Control
RT (ms)	699	707	713	753
Errors (%)	5,0	4,6	7,3	6,9

Figure 3. Mean response latencies (ms) and error percentages by prime-type in Experiment 2.

The analyses revealed a significant main effect of prime-type. Further analyses confirmed that all experimental conditions differed significantly from the Control condition. Furthermore, as neither the Nominative Singular nor the Stem2 differed from the identity condition, this indicates that *full priming was obtained with all members of the paradigm*. The observed differences in the error rates did not reach statistical significance.

It is notable that the reaction times were somewhat longer in the present Experiment than in Experiment 1. As also the results from the present Experiment indicate, the differences in reaction time latencies observed in previous studies (Niemi et al. 1994, Laine et al. 1999) can be attributed to the difference in morphological complexity. In other words, the difference is most probably due to the fact that the target items in Experiment 1 were short nominative singular word forms, requiring no morphological parsing, whereas the target items in the present experiment were longer inflected word forms, predominantly calling for a decomposition procedure.

3. General discussion

The present study investigated the role of both bound stem allomorphs as well as the role of the nominative singular in the processing of Finnish inflected nouns. Two masked morphological priming experiments showed that (1) the

presentation of a free standing bound stem as a prime (like *sorme* as in *sorme+ssa* 'in finger', of *sormi* 'finger') resulted in significant facilitation in the comprehension of the corresponding nominative singular nouns, and (2) that the nominative singular prime did not exert a larger priming effect than either the inflected word identical to the target or an inflected word with a different stem in the recognition of inflected nouns. The results are well in accordance with the previous findings from the processing of Finnish polymorphemic words.

There have been basically two interpretations for the often attested processing difference between the (monomorphemic) nominative singulars and (oblique) inflected forms of nouns: one interpretation has been to take the processing cost to imply that a decompositional morpheme-based analysis is being performed at the level of form and/or meaning for the polymorphemic inflected words. Therefore, the nominative singular (monomorphemic) nouns, being less complicated at either level, are recognized faster. The alternative explanation is one in which the nominative singular base form is presumed to have a special status, independent of morphological complexity. The results from Experiment 2 indicate that the latter is clearly not the case and these results quite unquestionably rule out any form of the so-called satellite hypothesis, where the nominative singular form (or any other, for that matter) is supposed to play a central role in the processing of any other member of the paradigm. Had this been the case, i.e., had the recognition of a complex form depended on the activation of the nominative singular, we should have obtained a significant difference in facilitation between the nominative singular and inflected (Stem2) primes. However, no such difference was observed regardless of the fact that in the former condition the nominative singular was activated *before* the target word. Thus, the evidence suggests that the extra processing cost for inflected words stems from the time-consuming decomposition procedure rather than from a two-stage full listing access procedure via the nominative singular.

One question is, however, whether the evidence rules out other variants of full listing models, for example that presented in Bybee (1985). Since this model does not include specific allomorph representations, it would predict a larger effect of facilitation with inflected nouns formed with the nominative singular stem (e.g., *rauta+na* 'as iron') than nouns with other (morpho)phonological variants (e.g., *rauda+sta* 'from iron') in priming nominative singular targets (*rauta* 'iron'). Contrary to this prediction, Järvikivi and Niemi (2002) found equal effects of facilitation for both prime types.

A further and even greater challenge for any full listing model in the present context is the observed significant allomorphic priming in Experiment 1. The facilitation observed with isolated stem allomorph primes, stripped of their compulsory suffix material, bears evidence for independent stem allomorph representations. More importantly, the significant priming effect implies that inflected words with stem allomorphs are parsed in lexical access, going against any framework that does not assume an active role for morphology in lexical processing.

However, a few words need to be said about the fact that the facilitation fell short of being full. In other words, the observed priming was reliably weaker for the stem allomorphs than for the Identity condition. Laine et al. (1999) have demonstrated that both what they call morphologically ambiguous nouns, e.g., *aari+a* (*aaria* 'aria' or *aari+a* ptv. sg. of *aari* 'acre') as well as pseudo-ambiguous nouns, e.g., *sei(+)ta* (cf. *sei* 'saithe (*Gadus virens*)' or *seita* 'Saame religious boulder') affect lexical processing by slowing down the decision as compared to matched unambiguous nouns. The authors argue that the delay is caused by simultaneous morphological parsing of the potential combination of morphs irrespective of the combination being illegal. Thus the morpheme-based formal decomposition procedure is seen as both fast and extremely simple. It thus seems, that the morphophonological legality of the combination of morphs is not checked until later in the process. In Järvikivi and Niemi (2002) the priming observed for the stem allomorphs in Experiments 1 and 3 was also smaller than the effect of the identity primes, although in the latter it was wholly comparable to the priming obtained with fully inflected forms. Therefore, it was deliberated that the partial priming was due to the above checking procedure, resulting in a decreased activation for the prime before the processing of the target. However, as the priming observed here shows similar partiality, despite the fact that masked priming is sensitive to the early stages of processing, this does not seem to be the case. Instead, it may be simply due to the fact that the full activation of the lemma representation and/or semantic analysis requires information carried in both the stem and the affix (as is assumed in SAID, also Laine et al. 1999). In other words, the mere activation of the stem representation is enough to produce partial activation of the target lexeme but not enough to facilitate it in full. A plausible explanation may simply have to do with the fact that a bound stem allomorph presented in isolation is a non-word. It should be noted though, that even this requires that a form-representation is matched once the prime is presented. Moreover, the identity primes have the advantage of being identical in form, i.e., it is possible that (some of) the advantage comes from the form

overlap. However, Forster and Azuma (2000) demonstrate that the masked priming used here is extremely sensitive to morphological structure in the early stages of lexical access and that the morphological effects are not reducible only to mere effects of overlapping form between the prime and the target.[11]

Another potential explanation for the observed differences in Experiment 1 is that they are due to frequency effects alone.[12] That is, because SORMI is more frequent than SORME, which is (obviously) more frequent than (non-existent) SORMA, they also receive different levels of initial activation, respectively. This might thus lead to full priming, partial priming and no priming, for SORMI, SORME and SORMA, respectively. What grounds do we then have to claim that the effects are indeed morphological and not due to frequency alone?

First, it is not unusual that the priming effect for a morphologically complex condition falls short of full priming (e.g., Clahsen et al. 2001). In fact, the priming effects found by Järvikivi and Niemi (2002) for free standing stem allomorphs were exactly in the same range of magnitude than those found for fully inflected nouns under similar conditions (ca. 40 ms). In addition, in those experiments the two effects were also ca. 30 ms smaller than the effects observed for the identity condition (RTs for the identity condition in the two experiments were 592 and 594 ms, respectively). Second, if we take the stem frequency as a constitutive factor, we would expect a larger priming effect for transparent than for opaque stems of the same paradigm. What is observed however, seems to be quite the contrary: Thus, inflected nouns with an oblique stem, e.g., *liekke+jä* 'flames' were found to exert a full priming effect, whereas inflected nouns with the nominative stem, e.g., *liekki+nä* (Järvikivi & Niemi 2002) only exerted partial priming.

As to the present experiments, Experiment 1 included as fillers a set of items with fully inflected opaque and transparent primes, i.e., primes with oblique and nominative stems, and an identity condition. A post hoc analysis of those fillers shows a comparable effect to that obtained with isolated stems: there was a significant priming effect of about 20 ms for both inflected types, and both also fell short of full priming with ca. 20 ms. The above, taken together with the fact, that, despite being non-words, the isolated stems still

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[11] Forster and Azuma's (2000) priming effects for English bound stems are constantly in the same magnitude range as ours, i.e., 26-36 ms. Similarly, the identity priming, though not statistically reliable, produces stronger effects as well.

[12] This potential problem was pointed out by one of the reviewers.

prime the nominative singular in a masked priming experiment – a paradigm that minimizes possible strategic and episodic effects – it is very unlikely that the observed priming is not morphological in origin. If the effect were simply due to frequency (e.g., bigram or otherwise), one could ask, why the fact that the string SORM, encapsulated in all conditions, was not enough to make the differences between the conditions go away completely. If the answer to that question depends on the status of the string as a whole, then the phenomenon is already lexical in nature.

The results from Experiments 1 and 2 are readily explainable in a framework, such as that of Levelt (1989), which assumes two levels of representation, a modality-specific form-level and a modality-neutral level of morphological-morphosyntactic representation, i.e., so-called lemma representation. Allen and Badecker (1999, 2002) have proposed that the lexeme (form) level of the *two-level* model of lexical representation encodes bound stem allomorphs, which are linked to a common lemma representation. The effects found in Experiment 1 are in line with such a model. They also demonstrate that the information on that level of representation does not extend over and above that of the form (cf. Laine et al. 1999, Forster 1999). In this sense, stem allomorphs are only formal indices to the lemma information. Hence, the present results show that *also* in on-line processing of morpho-lexical material the allomorphs function as indices to morphological and morpho-syntactic/-semantic information. Seen from the opposite direction, it can be claimed with rigorous experimental support that stem allomorphs are pure forms the function of which is to realize the morphological categories in question (Aronoff 1992, and dissociate views of morphology, see, e.g., Spencer 1991).[13]

How are we to explain the assumed psychological reality of the nominative singular as a base-form, despite its non-special status in morphological comprehension? The key to this may lie in the sort of representational architecture that was very roughly sketched above. It is not a coincidence that the so-called base-forms are (usually) free forms and very

[13] Empirical evidence for the "morphology by itself" argument is provided by Roelofs and Baayen (2002), who demonstrate that morphemes are planning units in production irrespective of considerations of (morpho-) semantic transparency. To us, though, it seems probable, that since genuine suppletion is rare, i.e., allomorphs tend to resemble each other in form, they may be inter-connected in an associative representational structure of unspecified nature. In all respects, this is more plausible than the idea of the allomorphs being represented separately in a discretely symbolic manner.

(usually, the most) frequent forms in a word paradigm. Thus, the mere considerations of frequency coupled with the functions carried by these forms, e.g., nominative singular in ostension for most nouns, may explain a great deal of the fact that these are the forms generalized by children at the early stages of inflectional acquisition. The fact that at later stages we start to see (frequent) stems used in place of the base forms as well as complete forms substituted in place of the correct inflectional stems – e.g., often partitives for mass nouns – further speaks for this interpretation. This may also be (at least partly) the key to the role of the base-forms in diachronic change, as suggested by Bybee (1985). Frequency considerations are also behind instances of local markedness where in diachrony a non-nominative form – or, rather the stem (sic!) of the non-nominative – replaces the former base/nominative singular of the paradigm (Tiersma 1982).

In passing, it is interesting to observe that parents and other caretakers typically engage – at least in the cultures of mainstream psycholinguistic research – in naming rituals, during which the child is ostensively taught (and subsequently trained with) the names of objects and actions (if any), either in natural environment or in children's books (e.g., Halliday 1975). In addition to enhancing the phonetic and social skills and supra-token categorization, these sessions most probably highlight the role of the *naming form* (in Finnish singular: nominative, plural: partitive[14]) of referents of nouns and noun-like (nominal) categories like adjectives. What furthermore makes the nominative singular focal in literate societies is the pervasive use of glossaries and dictionaries in second-language teaching. Finally, although we now enter the realm of speculation, we would like to point out that it is interesting to observe that finite verbs, which are basically non-ostensive, have retained relatively rich morphologies in languages typologically as different as English and Finnish when compared to the nouns (e.g., cf. the relatively high number of ablaut verbs in comparison with the relatively speaking extinct umlaut nouns in English). However, at the level of form, the nominative singular stem is just as any other (bound) stem, no more and no less complicated. At the level of morphology (or lemma), nominative singular is morphologically and

[14] Bertram et al. (1999) have provided experimental evidence to the effect that partitive plurals of the form *–j+A*, e.g., *autoja* 'cars', are accessed and stored as wholes(in contradistinction to evidence from other inflectional categories in Finnish). Although their argument is based on its being perceptually homonymous with the agentive *–jA*, it is probable that also other considerations, such as the ones presented here, may contribute to this phenomenon.

morphosemantically simple, in this sense basic. Thus the substitution errors that are often encountered in agrammatic aphasia may be explained by the deficit of (morpho)semantic origins, thus at the level of lexical (or in the present context, stem) selection (see, e.g., Menn and Obler 1990).[15] Therefore, the nominative is the most basic category morphologically and semantically, although it – quite naturally – does not function any differently from the other stems in morphological processing of Finnish inflected nouns.

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[15] This is also indicated by the results presented from an agrammatic H.H. in various publications of Niemi and Laine and their associates (e.g., Laine et al. 1995, Laine & Niemi 1997). Unpublished data from a visual segmentation task administered to H.H. shows a striking ability to carry out simple morphological segmentation correctly in the presence of surmountable difficulty to read the same words aloud. Thus, remembering that H.H.'s deficit has been thoroughly diagnosed as a centrally based (morpho-)semantic one (see refs. above), it is no surprise that he would make substitution errors but would not show sensitivity to differences in morphological transparency. The large number of nominative singular substitutions is thus readily explainable from the (morpho-)semantic simplicity at the lemma level relative to other inflected forms, whereas the level of form representation seems to be intact in H.H.

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Contact address:
Juhani Järvikivi
Mäntymatinkatu 22
05900 Hyvinkää
E-mail: juhani.jarvikivi@joensuu.fi