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A morphological effect obtains for isolated words but not for words in sentence context

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The effect of morphological complexity on word identification was studied in three experiments conducted in Finnish, employing the same set of target nouns. In Experiment 1, the target nouns were presented in isolation, and lexical decision times were employed as lexical access measures. In Experiments 2 and 3, the same words were embedded in sentence contexts, where both the inflected and non-inflected forms were equally plausible, and eye fixation patterns (Exp. 2) and lexical decision latencies (Exp. 3) were recorded. The experiment with isolated words replicated previous lexical decision studies by showing more effortful processing for inflected than monomorphemic nouns. However, this morphological complexity effect did not generalise to the context experiments; fixation durations and response latencies were highly similar for inflected and monomorphemic words. It is suggested that, at least for the type of inflected nouns studied, the morphological effect observed for isolated words may derive from the syntactic and/or semantic level and not necessarily from the lexical level, as previously assumed.

There has been a growing interest to study how morphological properties of words influence their identification (see, e.g., Feldman, 1995). Since languages vary greatly as to how much morphology is exploited in conveying syntactic and semantic information, it is necessary to study morphological processing in a wide variety of structurally distinct languages. For Finnish—the language studied here—rich morphology is one of the main characteristics. Its inflectional system yields over 2000 possible forms for each noun and over 10,000 forms for each verb (Karlsson, 1983). In such a language, morphological parsing of

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polymorphemic words appears more viable than, for example, in English. Indeed, recent evidence from both normals and aphasics suggests morpheme-based lexical access for case-inflected nouns in Finnish: Inflected nouns elicit consistently longer lexical decision latencies and higher error rates than comparable monomorphemic (or derived) nouns (Bertram, Laine, & Karvinen, 1999; Hyönä, Laine, & Niemi, 1995; Laine & Koivisto, 1998; Laine, Niemi, Koivuselkä-Sallinen, Ahlsén, & Hyönä, 1994; Laine, Niemi, Koivuselkä-Sallinen, & Hyönä, 1995; Laine, Vainio, & Hyönä, 1999; Niemi, Laine, & Tuominen, 1994). This morphological complexity effect has been observed for a number of different inflections (see, e.g., Laine & Koivisto, 1998; Laine et al., 1999). These results led to the so-called SAID (stem allomorph/inflectional decomposition) model, which posits that all inflected nouns in Finnish are recognised via the decomposition route (except the most frequent inflectional forms of the most frequent nouns).

The prevailing paradigm for studying morphological processing has been the lexical decision task, in which participants are presented with letter strings (typically half of them are words) and they are to decide as quickly and accurately as possible whether or not a given letter string is an acceptable word form in the language. However, only few studies exist where morphological processing has been studied on-line during continuous reading (Hyönä & Hujanen, 1997; Hyönä & Pollatsek, 1998; Inhoff, 1989; Inhoff, Briihl, & Schwartz, 1996; Lima, 1987; Pollatsek, Hyönä, & Bertram, 2000). Thus, it is an open question whether the results obtained in the lexical decision task generalise to normal reading. The study of Hyönä and Hujanen (1997) does suggest at least for Finnish that inflectional suffixes are exploited immediately on-line in making syntactic assignments during reading. They showed that inflectional noun forms appearing in the sentence beginning were read with longer gaze durations than non-inflectional forms. However, it was not necessarily the morphological complexity as such that produced these longer reading times, because the syntactic status of the target nouns was confounded with morphological complexity. When inflected, the target nouns were a part of an object or an adverbial phrase, whereas the non-inflected forms belonged to the subject phrase. Indeed, Hyönä and Hujanen explained the effect to be due to word order constraints; with sentence-initial phrases, it took longer to assign an object or an adverbial status than a subject status to the phrase.

The present study was designed to examine whether the effect of morphological complexity consistently observed for Finnish in visual lexical decision would generalise to reading. In Experiment 1, a set of non-inflected and inflected nouns were presented in a standard lexical decision task, and in Experiments 2 and 3, the same words were embedded in single sentence contexts, and the participants were asked to read the sentences for comprehension while their eye movements were recorded (Experiment 2), or they made a lexical decision to the probed target word (Experiment 3).

To control for differences in syntactic constraints, we employed inflectional forms that can be replaced in certain sentence contexts with an equally plausible non-inflected base form (nominative singular). This requirement is met by certain object phrases in Finnish, which can appear either in an inflected form (either in the partitive or genitive case) or in the monomorphemic form (i.e., in nominative singular). Thus, we were in a position to manipulate the morphological complexity of target nouns without varying the syntactic plausibility of the different morphological forms.

EXPERIMENT 1

In Experiment 1, the recognition of inflected and non-inflected words was studied using the standard lexical decision task, where words and non-words are presented one at a time, and the participant has to decide as fast and accurately as possible about the lexical status of a letter string by pressing a yes/no button. Two inflectional suffixes, the partitive and genitive, were employed. Both case endings consisted of a single character, the partitive with *-a* or *-ä* depending on the vowel harmony[1] (e.g., *juusto* + *a* = cheese + partitive case) and the genitive with *-n* (e.g., *porti* + *n* = gate's). These inflectional forms were then compared to length- and frequency-matched monomorphemic (i.e., non-inflected) words (e.g., *lusikka* = spoon). On the basis of previous lexical decision experiments conducted in Finnish, inflected forms were predicted to take longer to recognise than monomorphemic forms.

Method

Participants. Eighteen university students participated in the experiment. The students were credited with two lunch coupons for their participation. All participants were native speakers of Finnish.

Apparatus. Lexical decision times were registered with an IBM-compatible PC using a specially designed reaction time program.

Materials. Twenty monomorphemic nouns and twenty inflected nouns were used as stimuli. The inflected words appeared either in the partitive or in the genitive case, whereas the monomorphemic nouns appeared in the nominative singular case (i.e., the non-inflected form). The partitive case is denoted by *-a* or *-ä*, and the genitive case by *-n*. These inflectional suffixes were selected, because both of them can be used to mark the sentence object. This allowed the target words to occupy the same syntactic status in Experiment 2, where they were embedded in single sentences.

[1] The partitive suffix can be realised either as the front vowel ''ä'' or the back vowel ''a'', depending on the phonological properties of the word stem.

The two word types were matched for average frequency, length, and bigram frequency. The average lemma frequencies (per million) were 24 (SD = 19) and 33 (SD = 33) and the average surface frequencies (per million) 5.4 (SD = 6.9) and 6.0 (SD = 4.9) for the monomorphemic and inflected words, respectively. The target words were 6–8 characters long, with the average length of 6.9 (SD = 0.75) and 7.1 (SD = 0.89) characters for the monomorphemic and inflected words, respectively. The average bigram frequency (per million) for the monomorphemic words was 8259 (SD = 2589) and that for the inflected words 8934 (SD = 2648). None of the target words were homonymic. All frequency information was obtained by the WordMill lexical database program (Laine & Virtanen, 1999) utilising an unpublished morphologically parsed Finnish newspaper corpus of 22.7 million words.

The 40 target words appeared among 120 non-words and 80 filler words. Non-words were constructed out of real words by changing one–three letters so that they appeared as legal and pronounceable letter strings in Finnish. Among the filler words, there were 40 nouns appearing in the nominative plural, 20 inflected nouns (including other inflectional suffixes), and 20 derived nouns. All non-words consisted of an illegal stem; half of them contained an inflection, another half were non-inflected. The inflections were comparable to those of the word stimuli both in terms of type and quantity.

Procedure. Each participant was tested individually in a quiet room. The stimulus items were presented in the middle of a computer screen. Prior to presenting a stimulus, a fixation point appeared on the screen for 500 ms, which was then replaced with the stimulus item appearing in the same screen position. By pressing a reaction time key, participants were to decide as quickly and accurately as possible whether a letter string was a Finnish word or not. If the participant did not react within 2000 ms from the stimulus onset, the trial was terminated and excluded from the statistical analyses. The stimuli appeared in white lowercase 12 point Helvetica letters on a dark background. Twenty practice trials (ten words and ten non-words) preceded the actual experiment.

Results and discussion

Erroneous responses and reaction times over 3 standard deviations above the individual participant mean were excluded from further analyses.[2] A paired-samples t test was conducted for the mean reaction times with participants as the random factor (t_1) and an independent samples t test with words as the random factor (t_2). In both analyses, inflected words produced significantly longer

[2] The 3 SD exclusion criterion led to only three responses being excluded.

lexical decision times than monomorphemic words (see Table 1), $t_1(17) = 3.45$, $p = .003$, $t_2(38) = 2.55$, $p < .02$.

The standard lexical decision experiment demonstrates that inflected nouns as morphologically more complex words take longer to recognise than non-inflected words. This is a straightforward replication of previous lexical decision studies conducted in Finnish (Bertram et al., 1999; Laine & Koivisto, 1998; Laine et al., 1999; Niemi et al., 1994), which have consistently observed longer recognition times for inflected than for monomorphemic words for a number of different inflectional suffixes of Finnish. The finding is consistent with the view that inflected words are recognised via the slower decomposition route, whereas monomorphemic words are accessed via the direct route (see Laine et al., 1999, for further discussion).

The fact that a reasonable number of the experimental items contained an inflection (a third of the words and half of the non-words) may, if anything, have reduced the morphological complexity effect. This may be derived from Laine et al. (1999, Exps. 1 and 2), who observed a smaller, but still statistically significant morphological effect (i.e., inflected nouns producing longer response latencies than monomorphemic nouns): When the ratio of inflected words in the word list was increased from 29% up to 67%, the effect size decreased from 106 ms to 47 ms. Thus, had we included fewer inflected items in Experiment 1, the morphological effect could have been larger.

TABLE 1
Mean lexical decision (LD) times (error rates in parentheses) and standard deviations (in ms), and mean eye fixation times and standard deviations, for the monomorphemic and inflected target nouns

	Monomorphemic		*Inflected*		*Difference*
	M	*SD*	*M*	*SD*	*M*
Experiment 1 (LD)					
Response latency	561 (1.7%)	71	596 (0.6%)	75	35
Experiment 2 (reading)					
First fixation duration	214	42	209	40	−5
Second fixation duration	171	43	183	56	12
Gaze duration	263	75	264	82	1
Duration of following fixation	212	49	210	46	−2
Regressive fixation time (all regressions)	74	57	93	58	19
Regressive fixation time (immediate returns)	32	34	36	32	4
Experiment 3 (LD in context)					
Response latency	763 (1.7%)	121	764 (1.4%)	110	1

EXPERIMENT 2

In Experiment 2, the target words used in Experiment 1 were embedded in sentence contexts, and the participants were asked to read the sentences for comprehension while their eye fixations were recorded. There is now ample evidence that fixation times on words faithfully reflect lexical access processes (including morphological processes) that take place during reading and word recognition (for a recent review, see Rayner, 1998). For example, Beauvillain (1996) demonstrated that the pattern of fixation durations was different for prefixed and suffixed words and was modulated by the frequency of constituent morphemes. In the study, the participants inspected the words to complete a semantic comparison task. In a study involving normal reading, Lima (1987) observed longer gaze durations for pseudoprefixed than prefixed words, which was taken to support the claim of prelexical prefix stripping (Taft & Forster, 1975).

For morphological processing in Finnish, Hyönä and Hujanen (1997) demonstrated that when the morphosyntactic status of a noun was constrained by the preceding adjective, fixation times were shortened in comparison to a non-constrained situation. Hyönä et al. (1995) presented isolated words for identification and recorded participants' eye fixations on these words. They observed significantly longer second fixations for inflected than for monomorphemic words (for the processing of compound words, see Hyönä & Pollatsek, 1998; Pollatsek et al., 2000). To sum up, all the previously cited studies provide consistent support for the view that durations of fixations can reliably reflect morphological processing during reading and word recognition.

Experiment 2 was carried out to examine if the morphological effect obtained in Experiment 1 using lexical decision times as the measure of word recognition would generalise to normal reading where the target words appeared in context, and the participants were not required to make any overt response to the target words. Semantically non-constraining sentence frames were constructed for the target words so that an inflected and a non-inflected form were both acceptable and equally plausible syntactically. All target nouns appeared as clause objects that can take either the nominative case (i.e., the base form) or one of the two inflectional forms (either the partitive or genitive suffix). As differences in syntactic constraints cannot explain a possible processing difference between monomorphemic and inflected forms, such as effect would be unequivocally explainable as a morphological complexity effect.

Method

Participants. Twenty-four university students participated in the experiment to fulfil a course requirement. None of them took part in Experiment 1. All were native speakers of Finnish.

Apparatus. Eye movements were collected by the EYELINK eyetracker manufactured by SR Research Ltd (Canada). The eyetracker is an infra-red video-based tracking system combined with hyperacuity image processing. There are two cameras mounted on a headband (one for each eye) including two infra-red LEDs for illuminating each eye. The cameras sample pupil location and pupil size at the rate of 250 Hz. Registration is binocular and is performed for the selected eye(s) by placing the camera(s) and the two infra-red light sources 4–6 cm away from the eye. In the present study, registration was done monocularly using the right eye. The resolution of eye position is 15′ of arc and the average spatial accuracy approximately 0.5°. Head position with respect to the computer screen is tracked with the help of a head-tracking camera mounted on the centre of the headband at the level of the forehead. Four LEDs are attached to the corners of the computer screen, which are viewed by the head tracking camera, once the participant sits directly facing the screen. Possible head motion is detected as movements of the four LEDs and is compensated for on-line from the eye position records. The system allows free head motion within a 100 cm^3 cube. The compensation is better than 1° over the acceptable range of head motion.

Materials. The target words used in Experiment 1 were embedded in single sentences and appeared sentence-medially. To control for differences in syntactic constraints between monomorphemic and inflected words, all target words appeared as clause objects. Two types of sentence structures were employed, both of which allowed the use of either the nominative case (i.e., the monomorphemic form) or an inflected form, either the partitive or the genitive case.[3] One such structure is the imperative sentence, for which an option exists between the use of the nominative and the partitive case for the sentence object. The choice is made on the basis of the relative completion of the act; if the act is asked to be completed, the nominative form is used, while in the case of an uncompleted act, the partitive form is preferred. Ten sentences were constructed in which one of the non-inflected target words appeared and another ten sentences in which one of the inflected targets appeared. The sentence frames were matched pairwise across the two conditions; the verb preceding the target noun was identical in the sentence pairs. An example sentence pair is given next (in 1a the target is monomorphemic, in 1b it is inflected; the target appears in bold).

[3] It may be noted that the genitive and partitive cases are not only used to mark the sentence object. The genitive case can also be used to signal possession (*auto+n omistaja* = car's owner), and the partitive case is sometimes used for the sentence subject when the main verb is intransitive. Attaching an inflectional suffix to the word stem can introduce a change in the stem (e.g., *lusikka* → *lusika+n*). However, for the majority of our targets, a stem change did not take place.

1a. ‘‘Hädissään Martti huusi: ‘Poimi **seteli** nopeasti, sillä muutoin tuuli vie sen mennessään.’ ’’
‘‘Martti shouted anxiously: ‘Pick up the **bill** fast, because otherwise the wind will blow it off.’ ’’

1b. ‘‘Painokkaasti Reijo totesi: ‘Poimi **salaatti+a** lisukkeeksi, jos pinaattia ei löydy.’ ’’
‘‘Reijo emphasised: ‘Pick up **lettuce** for the side dish, if you can’t find spinach.’ ’’

Ten participants who did not take part in the actual experiment, performed a cloze-task for the imperative sentences. The sentence frames up to the target word were presented on a sheet of paper, and the participants were asked to continue the sentence with a word that first came to their mind. Of all the responses, 31% appeared in the partitive case, 36% in the nominative case, and the rest took another case ending or were adverbs or verbs. In other words, the partitive and the nominative cases were the dominant and equally plausible completions for the target word position. The target nouns were semantically unpredictable as none of the participants continued the sentence frame with the target noun.

Another sentence structure where a sentence object can take either a monomorphemic or an inflected form (either genitive or partitive) is one in which the object is preceded by an infinitive verb form (e.g., *tunnistaa hedelmä* (nominative) ‘‘to recognise a fruit’’/*tunnistaa hedelmä+n* (genitive) ‘‘to recognise the fruit’’). Another set of 20 sentences like the ones following (2a has a monomorphemic target and 2b has an inflected target) was included in the experiment. Although it was not possible to create identical sentence frames for the target noun pairs, we controlled for the length of the preceding infinite verb form; it was 7.0 characters in the non-inflected condition and 7.1 characters in the inflected condition.

2a. ‘‘Pertti näki tarpeelliseksi hakea **lusikka** kattauksen täydennykseksi.’’
‘‘Pertti considered it necessary to bring a **spoon** to complete the dinner table.’’

2b. ‘‘Väinö näki tarpeelliseksi lisätä **peito+n** maassa makaavan uhrin päälle.’’
‘‘Väinö considered it necessary to add a **blanket** on the victim who lay on the ground.’’

There are no explicit rules as to which form to use in these kinds of constructions, and both forms are in regular use. To ensure that there was no bias for one form over the other, we asked 10 participants who did not take part in the actual experiment to choose the preferred form for the critical words. Participants were given a list of 40 sentences like those given earlier, in which the critical word was replaced with an empty space. Below the sentence, an inflected form and a nominative form of a word were given, and the participants were asked to choose the preferred form. If they felt that both were equally plausible, they were asked to indicate that. From the 40 sentences we selected 20 for which the inflected and non-inflected form were rated as equally plausible (10 inflected and 10 non-inflected target words).

As the final step, the 40 selected sentences (20 imperative constructions and 20 infinitive verb constructions) were tested for the semantic predictability of the target nouns. Another 10 participants, who did not participate in the experiment proper, completed a cloze-task for the target sentences. The cloze-task responses proved that all target nouns were semantically unpredictable as none of the participants continued the sentence frame with the target noun.

All target nouns appeared in the middle of the sentence and never occupied an initial or final line-position. The target sentences were presented as dark against a light background. The sentences ranged from 7 to 16 words in length. The target sentences were mixed with 56 filler sentences. The sentences were presented in two blocks, and the block order was counterbalanced across participants. The order of sentences within a block was randomised separately for each subject.

Procedure. The eyetracker was first calibrated using a nine-point calibration grid. Participants were then asked to read the sentences for comprehension at their own pace. After completing reading a sentence they pressed a button and the sentence was erased from the computer screen and replaced with a fixation point at the left corner of the screen. The participant was asked to gaze at the fixation point and the eyetracker automatically corrected for possible drifts in calibration. The next sentence was presented to the right of the fixation point. The participant was instructed to paraphrase on request the last sentence he or she read (on average about every tenth sentence). They always gave an adequate paraphrase for the probed sentence; typically, the participants were able to repeat the sentence verbatim.

Results and discussion

Durations of fixations on the target word were analysed using paired samples (i.e., in the participant analysis) or independent samples (i.e., in the item analysis) t tests. The means and standard deviations are presented in Table 1. The target words were typically read with one fixation (73.9% of the trials), so we first used the initial fixation duration as the dependent measure (including all first fixations no matter if it was also the only fixation or not). There was no indication for a morphological complexity effect, in fact there was a non-significant trend for the monomorphemic targets to produce a longer first fixation, $t_1(23) = 1.47$, $p > .1$, $t_2(38) < 1$. Neither was the duration of second fixation affected by the morphological status of the target word, $t_1(21) = 1.16$,

$p > .1$, $t_2(38) < 1$ (the analysis by subjects was based on the data of 21 subjects who made at least one refixation for both wordtypes). Perhaps the most informative measure is the gaze duration, which is the summed duration of fixations landing on the target word when it is first encountered (i.e., before fixating away from it to another word). However, also here we were unable to find any indication for a morphological effect, as the gaze durations were almost identical for the non-inflected and inflected targets, $t_1(23) < 1$, $t_2(38) < 1$. Neither was the number of fixations constituting the gaze measure nor the probability of making at least one refixation on the word affected by morphological complexity, $t_1(23) < 1$, $t_2(38) < 1$. The probability of making a refixation was .24 for both wordtypes.

To examine possible lagged effects in processing, we first analysed the duration of the following fixation after fixating away from the target. There was a 2 ms difference between the two conditions, which was clearly non-significant, $t_1(23) < 1$, $t_2(38) < 1$. We then analysed the duration of regressive fixations back to the target (trials with no regressive fixations were coded as 0 ms) regardless of where they were initiated from. In this measure, inflected nouns tended to receive longer regressive fixation times than monomorphemic nouns, but the effect was significant in the subject analysis only, $t_1(23) = 2.17$, $p < .05$, $t_2(38) = 1.06$, $p > .1$. Quite often a sequence of second-pass fixations was initiated after first reading through the whole sentence. In such occasions, typically most of the target sentence was reread including the target word itself. Thus, this measure is not a particularly pure measure of a possible lagged effect for the target noun. Therefore, we conducted another analysis of regressive fixations, in which only those regressions were considered that returned to the target very soon after leaving it (we allowed a maximum of two fixations away from the target). For this measure the two wordtypes did not differ from each other, $t_1(23) < 1$, $t_2(38) < 1$. In sum, no lagged or spill-over effects in processing were observed that could be reliably associated with the identification of the target nouns.

The results of Experiment 2 are very straightforward: There was no indication that inflected nouns as morphologically more complex words would produce reliably longer fixation times than monomorphemic words. In other words, the morphological effect that was present in the lexical decision experiment was wiped out when the words were placed in sentence contexts. The reading experiment suggests that, as far as processing time is concerned, the inflected words were processed similarly to monomorphemic words.

The previous conclusion about the role of context in morphological processing may not be totally warranted, however. As Experiment 1 and 2 not only differed in the way the target nouns were presented (words in isolation vs in context), but also in the experimental method used (lexical decision vs eye-tracking), it is at least logically possible that the observed difference in results would be due to the different methods used, and not due to context. In order to rule out this potential confound, Experiment 3 was carried out. Experiment 3 employed the lexical decision paradigm, in which the to-be-responded targets appeared in the same sentence contexts as in Experiment 2. If the disappearance of the morphological effect in the reading experiment was indeed due to context, lexical decisions made in sentence contexts should also lead to a null effect.

EXPERIMENT 3

Experiment 3 was a modified replication of Experiment 2, in which target nouns were presented in sentence contexts. It differed from Experiment 2 in that the lexical decision task was used instead of silent reading. If the disappearance of the morphological effect in reading was indeed due to context, we should also here observe a clear null effect. In the experiment, the sentence context was presented cumulatively one word at a time from left to right, and the participants were to decide as quickly as possible whether the probed letter string in the sentence frame was a word or not. To-be-responded letter strings were marked by a different colour.

Method

Participants. Twenty-one university students participated in the experiment to fulfil a course requirement. None of them took part in the previous experiments. All were native speakers of Finnish. One subject was discarded, because she did not adequately report back the probed sentence frames (she omitted half of them).

Apparatus. The MEL Professional software package (Psychology Software Tools, Inc., Pittsburgh) was used to present stimuli and record response times.

Materials. The target nouns that were used in the previous experiments appeared in the same sentence frames employed in Experiment 2 (excluding the words after the target noun). For each non-word used in Experiment 1, a sentence frame was created that was similar in structure to the ones including the target words. A set of 60 filler sentences was included (30 ending with a word and 30 ending with a non-word) that conformed to a sentence structure that was different from the target sentences. Across all filler and target sentences, the sentence position of the to-be-responded lexical item varied considerably, but it never occupied the sentence-initial position. In the target word contexts, the target word completed a phrase (see the examples given for Experiment 2), but this was not necessarily the case with filler items. By varying the sentence position of the to-be-responded words the participants were encouraged to pay close attention to every word in a sentence.

The sentence context was presented one word at a time from left to right in the centre of the computer screen. The presentation mode was cumulative so that previous words remained on the screen, and a new word was added at a rate of

500 ms. The target item was marked by presenting it in white, and the context words appeared in red (the background was dark).

Procedure. The participants were instructed to read silently the context words as they appeared on the screen. When a white lexical item appeared on the screen, they were to respond as quickly and accurately as possible whether it was a word or not. The response was given by pressing designated keys in the computer keyboard. When a response was given, or if no response was given within 2 s, the sentence frame was erased, and the participant was to press a key to start the next trial. To encourage participants to attend to the context, they were periodically asked to paraphrase the most current sentence frame. The computer randomly chose the probed sentence frame so that 8% of all sentence frames was probed.

Results and discussion

The means and standard deviations of the lexical decision times for the target nouns are presented in Table 1. Erroneous responses and reaction times over 3 standard deviations above the individual participant mean were excluded from further analyses.[4] Participants properly attended to the sentence contexts, as they adequately paraphrased 97% of the probed sentence frames. As is apparent from Table 1, inflected and monomorphemic nouns produced practically identical lexical decision times, t_1 and $t_2 < 1$. Thus, Experiment 3 replicated the null effect observed in Experiment 2, which lends further support for the view that sentence context is capable of wiping out the morphological effect observed for isolated words.

To examine further whether the two lexical decision tasks indeed produced a different pattern of results, we computed a pooled analysis of variance for Experiments 1 and 3. In the subject analysis, wordtype was a within-subject variable and experiment a between-subject variable; in the item analysis, wordtype was a between-item variable and experiment a within-item variable. The crucial Wordtype $\times$ Experiment interaction proved significant, $F_1(1, 37) = 4.92$, $p < .05$, $F_2(1, 38) = 4.68$, $p < .05$; the morphological effect obtains in a standard lexical decision, but not when the same words are presented in sentential context.

It may be noted that overall response times are notably longer in Experiment 3 than in Experiment 1. This difference has to do with the fact that in Experiment 3 the length of the context preceding the target noun varied from trial to trial so that the subjects could not anticipate the appearance of the to-be-responded word (the target noun appeared in a different colour than the context words). This is in stark contrast to the standard lexical decision task, in which

[4] Three trials were excluded as outliers.

the subject is required to respond to every lexical item, and their appearance on the computer screen can be easily anticipated.

GENERAL DISCUSSION

The main finding of the present study is that a morphological complexity effect observed for words presented without a proper linguistic context did not obtain when the same words were embedded in context. The lexical decision data for isolated words replicated those observed in previous studies conducted in Finnish using the same task (Bertram et al., 1999; Laine et al., 1999; Niemi et al., 1994). These data are in line with the view that inflected Finnish nouns are recognised via the more time-consuming morphological decomposition route. The fact that the effect does not generalise to word identification in context calls for an explanation.

Before offering an explanation, we first want to rule out the possibility that the pattern of results could be explained as a methodological confound. One may either advocate the view that the previously observed morphological effects are a mere epiphenomenon of specific task requirements, such as decision making and/or button pressing, or alternatively, that eyetracking employed here is not sufficiently sensitive to yield reliable effects. Neither alternative appears to be true, as in the context experiments we observed a consistent pattern of results across the two experimental paradigms.

We suggest two possible mechanisms for how the sentence context may affect the process of identifying the morphological status of a word; the two accounts differ as to which contextual features are assumed to be relevant. Common to both these views is the idea that the cause of the longer response times in a standard lexical decision for our inflected nouns is the absence of a fitting context. According to the first alternative, syntactic constraints in a sentence facilitate the recognition of noun inflections so that inflected words no longer require additional processing time as they do when no context is provided (see Hyönä & Hujanen, 1997). This model assumes that inflections are not represented at the lexical level, but they are processed in a separate syntactic module. Taft (1994) considers such a possibility by assuming that inflections are automatically stripped off the word stem so that they can be independently fed into the syntactic module. By further assuming that the identification of inflectional suffixes is facilitated by providing a sentence context which makes the inflectional form equally plausible to the non-inflected form, as was the case in Experiments 2 and 3, the model is capable of accounting for the observed pattern of results.

The view that syntactic context exerts an effect on the processing of the type of inflected nouns studied here appears quite plausible from a more linguistic point of view. Booij (1996) makes a distinction between contextual and inherent inflections; contextual inflections (e.g., structural case markers on nouns) are dictated by syntax, whereas inherent inflections (e.g., category number for nouns) are not required by the syntactic context. The genitive and partitive case markers denoting a sentence object are clearly contextual inflections, and it is thus easy to see that these kinds of inflected nouns typically appear in a linguistic context. From this perspective, it makes a lot of sense that when these forms are presented in isolation their identification is delayed, which is not the case when they appear in a proper linguistic context.

According to an alternative account, more in line with the SAID model which posits lexically based access to inflected word form via form- and meaning-level analysis (Laine et al., 1994; Niemi et al., 1994), the morphological effect we observed for isolated words stems from the level of meaning analysis. According to this account, the processing of case-inflected nouns takes place in two stages—in the decomposition and the composition stages. In the first stage the word is decomposed into its morphological constituents, and during the second stage the constituents are then composed to form a meaning for the whole word. The first stage is carried out at the lexical level, which is assumed to represent only form-based information, but the second stage involves a semantic-level analysis. By further assuming that without any sentence context the second stage is harder to compute for case inflections, this model can explain why inflected nouns take longer to identify in isolation but not in context. The reason for the composition process demanding extra time in lexical decision is that without any prior linguistic context the exact meaning of the inflectional form (stem + suffix) cannot be readily derived and lexical decision is delayed.

As we pointed out earlier, the type of inflected words we employed are less likely to appear in isolation. When they do appear in isolation (i.e., as complete phrases), they are typically used in elliptic expressions, such as an answer to a question (e.g., ''What did you say you drank up?'' ''The milk'' = *maido+n* (genitive). As may be recalled, the main difference between the use of the partitive versus the genitive case suffix has to do with the degree of the completeness of the act denoted by the clause predicate; thus, a semantic-level analysis would indeed be required to derive the meaning of these inflectional forms. The claim that a full semantic analysis is completed before a lexical decision is made may not be very plausible, however. First, the task does not necessarily require full semantic analysis to be carried out; second, as argued previously, the inflected nouns appearing in isolation are underspecified and would need a context to allow a full meaning analysis. On the other hand, the semantic account can still be defended by arguing that meaning analysis is attempted even though a proper analysis may not be achieved.

An argument somewhat similar to our semantic account is put forth by Taft (1990) for the processing of closed class words which are functionally constrained in that they can be defined only in terms of their syntactic function (e.g., *than*, *nor*). Taft (1990) observed longer lexical decision times for these kinds of words in comparison to closed-class words that can be readily used as a one-word sentence (e.g., *here*, *soon*). The processing time difference is ascribed to the fact that for the former type of word no meaning can be associated with them when presented in isolation, whereas for the latter type of word a meaning can be defined. It should be noted, however, that our stimulus words are not comparable to those of Taft in that our inflected words were content words and they can appear as one-word utterances (see earlier), so they differ in an important way from Taft's closed class words, which cannot stand on their own. Thus, our results do not reduce to a mere difference between words that can or cannot stand alone.

These two accounts assume that the morphological effect derives from the level of syntactic or semantic analysis and not from the lexical level. This suggestion contradicts with the generally held view that the longer recognition times for inflected words reflect the decomposition process carried out at the lexical level, where a morphologically complex word is parsed into its morphological components. Both models we have proposed assume that the decomposition process is carried out so fast and automatically that no difference is observed between monomorphemic and inflected words. We do not like to argue, however, that the decomposition process is necessarily always instantaneous; with highly complex forms (say, including three–four morphemes, as is frequently the case in Finnish) the decomposition process would probably slow down lexical access also in reading. The fact that in the present study the suffix contained only a single character may have also rendered the decomposition phase relatively easy. It should also be noted that clear morphological effects at the lexical level have been reported for reading compound words (e.g., Hyönä & Pollatsek, 1998; Pollatsek et al., 2000) and derived words (Niswander, Pollatsek, & Rayner, 2000).

In conclusion, we suggest that at least some of the morphological effects observed previously in lexical decision experiments (e.g., the longer decision latencies for inflected than monomorphemic words) may derive from the level of syntactic and/or semantic assignment, where the word meaning is constructed from the stem and the suffix, and not from the lexical level, as it is generally assumed. As regards the inflectional suffixes employed in the present study, semantic and syntactic information is intertwined so that it is not possible to determine their relative contributions. In future studies, one possibility could be to prime the inflectional suffix either semantically (''***Yesterday*** *he invest**ed**...*'') or syntactically (''*Perhaps* ***he*** *invest**s**...*'') to disentangle more precisely the process of identifying morphologically complex words and how the morphosyntactic information they carry is integrated with the sentence context (for the effects of grammatical incongruence, see Colé & Segui, 1994; Gurjanov, Lukatela, Moskovljevic, Savic, & Turvey, 1985; Hyönä & Lindeman, 1994; Schriefers, Friederici, & Rose, 1998; for semantic priming of inflections, see Laine, 1999). Finally, studying the identification of morphologically complex words in context is recommended for two reasons: (1) The generalisability of the lexical decision results to continuous reading is tested directly, and (2) by clever context manipulations one may be able to determine more precisely the locus of morphological effects.

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