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Word category conversion causes processing costs: Evidence from adjectival passives

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Constructing syntactic representations in language comprehension begins with the identification of word categories. Whether the category information is stored in the mental lexicon is a matter of debate in current linguistic theorizing. The standard view assumes that the syntactic category of a word is lexically specified (*lexicalist approach*). More recently, it has been proposed within the paradigm of *distributed morphology* that lexical elements (roots) are stored without any syntactic category information: The syntactic category of a lexical element is determined only by the syntactic context in which it appears (*syntactic approach*). For processing category-ambiguous words, different hypotheses can be derived from these two accounts. The lexicalist approach predicts that there are productive grammatical processes, such as nominalization and adjectivization, that convert a word of Category A into one of Category B. Such a conversion might be assumed to create additional processing costs. Within the syntactic approach, on the other hand, no additional processing step is expected, because there is no need for any category shift. In a self-paced reading study on so-called adjectival passives, we found evidence of costs predicted under the lexicalist approach (i.e., for a grammatical process that changes the category of a word). More specifically, the present study provides evidence for category conversion from a verbal participle into an adjectival one. We also discuss an alternative explanation for this finding in terms of frequency.

Identifying the category of an incoming word during sentence processing is assumed to be the first step in understanding a sentence. Building the hierarchical syntactic structure begins with labeling each lexical element. Identifying a word as a noun, verb, or adjective enables the human parser (the syntactic processing mechanism) to project noun, verb, and adjective phrases (Frazier, 1987; Frazier & Clifton, 1996). Typically, the word category can be assigned unambiguously on the basis of phonological and morphological information. But in some cases, the parser has to deal with words that are ambiguous with regard to their syntactic category. Take, for instance, the sentences in Example 1:

(1) a. *Peter is running*.
b. *Peter likes running*.

Although in (1a) *running* is categorized as a verb, in (1b) it belongs to the category of nouns. Obviously these two uses of *running* are systematically related and share one lexical entry. This sets them apart from cases of homonymy, such as *that*, where two distinct lexical items (i.e., determiner vs. conjunction) happen to have the same pronunciation and spelling but are not otherwise related to each other.[1] Although a number of studies have investigated the processing of homonyms (e.g., Gibson, 2006; Juliano & Tanenhaus, 1994; Tabor, Juliano, & Tanenhaus, 1997), cases such as those in Example 1 have not yet been studied.

In the present article, we investigated cases of systematic category change. More specifically, we are interested in the categorization of participial forms, as in Example 2. This sentence can be regarded as either including a verbal passive with an eventive reading or an adjectival passive with a stative reading (see the overview in Emonds, 2006). The two readings are illustrated in Examples 2a and 2b.

(2) *The door was closed*. (adjectival or verbal passive)
a. *The door was slowly closed by the housekeeper*. (verbal passive)
b. *When he came back, the door was still closed.* (adjectival passive)

In linguistic theory, there is an ongoing debate over how lexical elements are stored in the mental lexicon. For cases such as (2), two alternative accounts have been proposed.[2] The standard approach, called the *lexicalist approach* (see, e.g., Bierwisch, 1997), assumes that a lexical item is stored with its syntactic category in the lexicon. For Examples 2a and 2b, this would mean that the participle is categorized as a verb via the lexical entry of its base verb (*to close*). For (2b), the stored category has to be *converted* into another one. Thus, for the processing of sentences such as (2b), the lexicalist view would predict an additional process: a category shift from verb to adjective.[3]

By contrast, advocates (see, e.g., Borer, 1994; Harley, in press; Marantz, 1995, 1997) of distributed morphol-

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ogy (which we call the *syntactic approach*) have proposed that lexical elements (*roots*) are stored without any category information and are categorized only in the course of syntactic derivation. For the sentences in (2), the root *close* is retrieved from the lexicon without any category information. The category is then determined by the different sentence contexts: verb in Example 2a and adjective in Example 2b. Therefore, proponents of a syntactic approach would predict that no conversion process is needed for (2b), because lexical roots are not categorized until syntactic derivation (see, e.g., Alexiadou & Anagnostopoulou, 2008; Embick, 2004).

To test these predictions, we investigated whether the processing of the participle in adjectival passives causes additional processing costs compared with such processing for verbal passives.[4] In the following, we present a self-paced reading experiment that reveals higher processing costs for adjectival passives compared with those for verbal passives. We discuss whether this effect can be correlated with a syntactic category shift in the light of frequency data.

EXPERIMENT

With a self-paced reading study, we tested whether higher processing costs arise from the processing of adjectival passives in German. In contrast to English, verbal and adjectival passives are expressed differently in German: Whereas the verbal passive is built with the auxiliary *werden* (*become*), the adjectival passive uses *sein* (*be*), as illustrated in (3) versus (4). That is, although the English sentence (*The door was closed*.) in (2) is ambiguous between an eventive and a stative reading and can be disambiguated only by the linguistic or extralinguistic context (cf. 2a vs. 2b), its German counterparts in Examples 3 and 4 are unambiguous.

(3) *Die Tür wurde geschlossen*. (verbal passive)
(*The door became closed.*) (verbal participle + auxiliary *werden*)

(4) *Die Tür war geschlossen*. (adjectival passive)
(*The door was closed.*) (adjectival participle + copula *sein*)

Whereas the verbal passive in (3) is analyzed as the combination of the verbal participle and the passive auxiliary *werden*, it is widely assumed that the adjectival passive in (4) is a copula–adjective construction comparable to the copula–adjective construction with genuine adjectives like that in (5) (cf. Gese, Stolterfoht, & Maienborn, 2009; Kratzer, 2000; Maienborn, 2007, 2009; Rapp, 1996).

(5) *Die Tür ist offen*. (adjective + copula: *sein*)
(*The door is open.*)

The lexicalist approach assumes that conversion has to take place in (4): The verbal participle has to be converted into an adjective. According to the syntactic approach, how the participle is categorized depends on the sentence context—that is, as a verb in (3) and as an adjective in (4). No additional conversion has to take place in (4).

Predictions

For the processing of sentences like those in Example 6, the lexicalist approach predicts longer reading times for the participle *verschüttet* (*spilled*) after the copula *sein* than after the passive auxiliary *werden*, because the adjectival conversion process is necessary for the adjectival passive in (6a), whereas the verbal passive in (6b) requires no conversion.

By contrast, the syntactic approach, which assumes uncategorized lexical entries, predicts no reading-time difference for the participle in 6a and 6b, since no conversion is necessary.

To control for effects of different lexical material preceding the critical word (i.e., the participle), we also tested sentences with *sein* and *werden* plus a genuine adjective, for which neither account predicts any additional process. Thus we should find no reading-time difference on the adjective in Examples 7a and 7b. Furthermore, the sentences with adjectives were used to prevent participants from predicting and preparing a conversion process when confronted with an occurrence of *sein*, which would have been possible if every form of *sein* had been followed by a participle. Conversely, an occurrence of *werden* could not be used to predict a verbal continuation of the sentence.

To avoid wrap-up effects, the sentences continued with a sentence coordination after the critical word.

(6) a. (*sein*—participle) *Die Milch* ***war*** *verschüttet und Frau Meier schimpfte*.
b. (*werden*—participle) *Die Milch* ***wurde*** *verschüttet und Frau Meier schimpfte*.
(*The milk was spilled and Mrs. Meier cursed.*)

(7) a. (*sein*—adjective) *Die Milch* ***war*** *sauer und Frau Meier schimpfte.*
(*The milk was sour and Mrs. Meier cursed.*)
b. (*werden*—adjective) *Die Milch* ***wurde*** *sauer und Frau Meier schimpfte*.
(*The milk became sour and Mrs. Meier cursed.*)

Method

Participants. Forty-eight undergraduate students of the University of Tübingen were paid for their participation. All were native speakers of German.

Materials. Materials consisted of 24 experimental sentences and 72 filler sentences. Each experimental item was prepared in four versions, which differed with respect to the two parts of the predicate (*sein* vs. *werden* and *participle* vs. *adjective*; see Examples 6 and 7). To make sure that participants read the sentences carefully, simple comprehension questions were constructed for 25% of the sentences. Half of these required a "yes" response, and the other half required a "no" response.

Design and Procedure

Four presentation lists were constructed in which the 24 experimental items were randomly mixed with the 72 filler items. The four lists were counterbalanced across items and conditions: Each list included only one version of each experimental sentence. Half of

(8)

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--- ----- --- ----------- --- ---- ----- ---------.
Die Milch --- ----------- --- ---- ----- ---------. Region 1 (noun phrase 1)
--- ----- war ----------- --- ---- ----- ---------. Region 2 (sein/werden)
--- ----- --- verschüttet --- ---- ----- ---------. Region 3 (participle/adjective)
--- ----- --- ----------- und ---- ----- ---------. Region 4 (conjunction)
--- ----- --- ----------- --- Frau Meier ---------. Region 5 (noun phrase 2)
--- ----- --- ----------- --- ---- ----- schimpfte. Region 6 (verb)
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the sentences had *sein*, and the other half had *werden*; half of each of these included a participle, and the other half included an adjective. Thus, we employed a 2 (*sein*/*werden*) × 2 (participle/adjective) design, with both factors being manipulated within participants and within items.

The experiment was run on a PC using E-Prime software (Psychology Software Tools, Inc.). The sentences were presented in six regions in a self-paced mode with a moving window technique. Participants pressed the space bar of the keyboard to begin the trial, at which time a row of dashes appeared on the screen preceded by an asterisk. A dash (–) represented each character of the sentence. Then, participants pressed the space bar to present each region of the sentence (see Example 8, at top of page).

In 25% of the trials, following the sentence, a comprehension question appeared on the screen when participants pressed the space bar, preceded by a question mark to signal the new task. To answer the question, participants chose "YES" or "NO" by pressing one of two keys. They were told to read through the sentences at a natural pace and to read closely enough to answer the questions. Each experimental session lasted approximately 30 min.

Data Analysis

We analyzed participants' reading times for the six regions. To eliminate outliers for the analysis, we employed a two-step procedure: We first excluded reading times that were shorter than 100 msec or longer than 5,000 msec. We also excluded reading times that were more than 2 *SD* from the mean per participant and condition. This led to 1.02% data loss. The remaining reading times were submitted to two separate ANOVAs for each region—one with an error term that was based on participant variability (F_1) and one with an error term that was based on item variability (F_2). The ANOVAs we conducted were 2 (*sein*/*werden*) × 2 (participle/adjective) × 4 (list) ANOVAs with repeated measurement on the first two factors in both the participant analysis and the items analysis. The counterbalancing factor "list" was included in the analyses to reduce error variance. Because it lacks theoretical relevance, we will not report the results of this factor in what follows.

Results

A total of 99% of the answers to the comprehension questions were correct.

The mean reading times in the six regions are displayed in Figure 1. As we expected, the largest differences between the four conditions were observed in Region 3, which contained the participle or the adjective.

For Regions 1 (noun phrase 1), 2 (*sein*/*werden*), 5 (noun phrase 2), and 6 (verb), we observed no significant effects, but observed only tendencies toward a main effect of the factor participle/adjective in Region 2 [$F_1(1,44) = 3.46$, $p_1 = .07$; $F_2(1,20) = 2.96$, $p_2 = .10$] and toward an in-

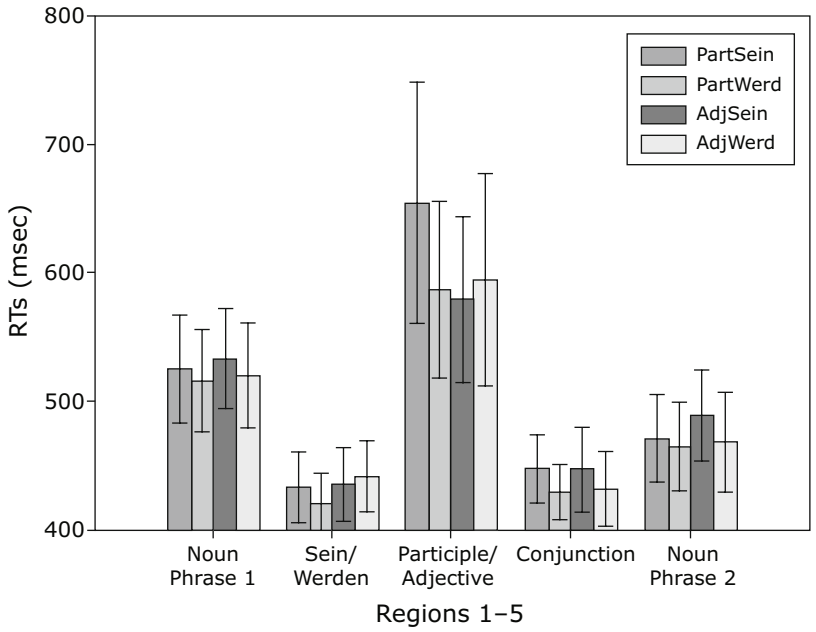

Figure 1. Reading times in milliseconds for the four conditions in Regions 1–5 (error bars represent confidence intervals).

Table 1
Frequencies and Log of Occurrence of Participles and Adjectives With *sein* and *werden*

	Participle		Adjective	
	Frequency	Log	Frequency	Log
sein	1,261	3.10	2,478	3.39
werden	5,595	3.75	413	2.60

teraction between participle/adjective and *sein*/*werden* in Region 2—the latter is confined to the analysis by participants [$F_1(1,44) = 3.46$, $p_1 = .07$; $F_2(1,20) = 1.95$, $p_2 = .18$; all other Fs < 2.4; all other ps $> .14$]. By contrast, in Regions 3 and 4, we did observe significant effects. In the critical Region 3 (participle/adjective), the analyses revealed a marginally significant effect of participle/adjective in the analysis by subjects [$F_1(1,44) = 3.73$, $p_1 = .06$; $F_2(1,20) = 2.32$, $p_2 = .14$]. We found no main effect of *sein/werden* (ps $> .10$). As we predicted, there was a significant interaction of the two factors in the subject analysis and a marginally significant interaction in the item analysis [$F_1(1,44) = 5.95$, $p_1 < .05$; $F_2(1,20) = 4.08$, $p_2 = .057$]. In order to obtain more information about this interaction, planned comparisons were conducted. As we predicted, we found significantly longer reading times for participles following *sein* than for those following *werden* [654 vs. 587 msec: $t_1(47) = 2.22$, $p_1 < .05$; $t_2(23) = 1.98$, $p_2 < .05$, one-tailed]. No corresponding difference was found for sentences with adjectives (579 vs. 594 msec; both ts < 1). Likewise, for the conditions with *sein*, reading times were significantly longer for participles than for adjectives [$t_1(47) = 2.22$, $p_1 = .01$; $t_2(23) = 1.98$, $p_2 < .05$, one-tailed]; whereas, for conditions with *werden*, no such difference was observed (both ts < 1).

In Region 4 (i.e., the conjunction following the critical word), the reading times showed a main effect of *sein/werden*, with longer reading times for the conjunction after *sein* than after *werden* [447 vs. 431 msec: $F_1(1,44) = 5.1$, $p_1 < .05$; $F_2(1,20) = 6.1$, $p_2 < .05$]. There was no significant main effect of participle/adjective and no significant interaction of the two factors (all Fs < 1).

Discussion

Reading times in Region 3 (participle/adjective) revealed a significant interaction of participle/adjective and *sein/werden*. We found significantly longer reading times for the participle following *sein* than for the participle following *werden*. By contrast, we found no significant difference for the sentences with adjectives. This pattern of results was predicted by the lexicalist approach, which assumes that an adjectival conversion process has to take place on the participle in the adjectival passive sentences with *sein*, but not in the verbal passive sentences with *werden*. For sentences with genuine adjectives, for which no additional process was predicted, we found no reading-time differences.

Before discussing the results for Region 3 in more detail, let us make a short aside on the results for Region 4—the conjunction following the critical Region 3. This region was read more slowly in sentences with *sein* than in those with *werden*. This might reflect the semantic difference between sentences with *werden*, which express an event or a change of state, and sentences with *sein*, which refer to a state. The conjunction *and* typically triggers a generalized implicature leading to an interpretation for *and* as *and then* (see Levinson, 1983). This temporal interpretation is highly compatible with events and changes of state, but does not fit with states. Therefore, the temporal implicature has to be canceled in the case of *sein*, which would explain the longer reading times on the conjunction in these sentences (see, e.g., Katsos, 2003, and Bezuidenhout & Morris, 2004, for increased processing costs in connection with implicature canceling).

Turning back to the discussion of the central results for Region 3, our study shows that participles in adjectival passives require additional processing as compared with their verbal counterparts in verbal passives. This finding can be taken as first evidence for an additional category-conversion process during sentence comprehension.

An alternative explanation for these reading-time differences on the participle after *sein* and *werden* could be based on frequency differences. It has been shown that participants are sensitive to the frequency of specific lexical items occurring in particular structures (e.g., Mitchell, Cuetos, Corley, & Brysbaert, 1995). With regard to the processing of category-ambiguous homonyms, it has also been shown that syntactic expectancies regarding a specific category, as well as item-specific category frequencies, influence the ease of processing (see, e.g., Gibson, 2006; Juliano & Tanenhaus, 1994; Tabor et al., 1997).

To determine whether syntactic expectancies on the word preceding the critical participles and adjectives can explain our results, we looked at the frequencies of occurrence of participles and adjectives with *sein* and *werden*.

We conducted a corpus search in the morphosyntactically annotated German corpus TIGER 1.0 consisting of 700,000 tokens (40,000 sentences) of German newspaper text (www.ims.stuttgart.de/projekte/TIGER). We extracted all occurrences of *sein* + participle, *werden* + participle, *sein* + adjective, and *werden* + adjective. The results are given in Table 1.[5]

As the figures in Table 1 indicate, there are clearly fewer occurrences of participles with *sein* than with *werden* (log: 3.10 vs. 3.75). This frequency difference could explain longer reading times on the participle after *sein* than after *werden*. But the figures in Table 1 also show a clear frequency difference for adjectives, which combine far more often with *sein* than with *werden* (log: 3.39 vs. 2.60). Under a frequency-based expectancy account, we should therefore also find longer reading times on the adjective after *werden* than after *sein*. But this was not the case. The results revealed no significant difference in the reading

Table 2
Sum of Frequencies and Log of Occurrence of Participles and Adjectives With *sein* and *werden* Used in the Experiment

	Participle		Adjective	
	Frequency	Log	Frequency	Log
sein	12,753	4.10	122,847	5.09
werden	68,442	4.83	55,643	4.74

times on the adjective, which makes a frequency-based explanation of the reading-time difference for the participle quite unlikely.

To see furthermore whether item-specific frequencies might explain the observed processing difference, we did a corpus search in the German corpus COSMAS II with ~3.6 billion word forms (www.ids-mannheim.de/cosmas2).[6] We extracted all occurrences of *sein* and *werden* with each participle and adjective used in the experiment, as shown in Table 2.

Again, we see a clear frequency difference for participles with *sein* versus *werden* (log: 4.10 vs. 4.83). As before, we also see more occurrences of adjectives with *sein* versus *werden*, but for the specific items used in the experiment, the difference is smaller (log: 5.09 vs. 4.74). To see whether this is a statistically reliable difference, we performed a chi-square test for the adjectives and participles separately. The observed differences were highly significant for both analyses [participles, 12,753 vs. 68,442, $\chi^2(1) = 38{,}195.27$, $p < .001$; adjectives, 122,847 vs. 55,643, $\chi^2(1) = 25{,}303.25$, $p < .001$].

To sum up, on the basis of our corpus data for syntactic expectancy, an explanation of the reading-time differences on the participles in terms of frequency seems to be highly implausible. The results for the item-specific frequencies revealed a smaller frequency difference for the adjectives, but the statistical analysis could show that this is still a highly significant difference. Therefore, we conclude that the frequency data cannot provide us with a convincing account of the reading-time results. Further research looking at other types of conversion (e.g., nominalization of verbs) might help to clarify the interaction of frequency and category shift.

CONCLUSIONS AND OUTLOOK

Our study revealed evidence for processing costs on the participle in adjectival passives, which we interpret as evidence for a lexical conversion process. This result contributes to the long-standing debate on the grammatical status of adjectival passives and provides additional support for the adjectival analysis of this construction. Furthermore, it gives rise to a methodological point. Since category conversion is a costly process, one should be very cautious in designing sentence materials for language processing studies: Costly conversion processes might be confounded with the processes under investigation.

Our results are also relevant to the ongoing debate on how lexical elements are stored in the mental lexicon. The standard lexicalist approach assumes that a lexical item is stored with its syntactic category, and, in such constructions as adjectival passives, the stored category has to be converted into another one. By contrast, advocates of the syntactic account have proposed that lexical elements (*roots*) are stored without information about their syntactic category. These roots get categorized only in the course of syntactic derivation, and no conversion is needed. The results of our study can be interpreted as evidence for lexicalist approaches. In order to substantiate this conclusion, further research is necessary to determine whether evidence for lexical conversion processes can be found, not only for conversion between verbs and adjectives, but also with other types of category changes—for instance, between verbs and nouns.

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NOTES

1. In (i), *that* is a determiner; in (ii), *that* is the conjunction of the embedded clause.

i. *The lawyer insisted that cheap hotel was clean and comfortable*.
ii. *The lawyer insisted that cheap hotels were clean and comfortable*.

2. The two accounts also capture examples like those in Example 1.

3. Whether the converted form is derived by means of a direct category shift or the affixation of a null morpheme is a matter of debate (see, e.g., Spencer, 1991), but it is of no relevance for our predictions.

4. So far, no psycholinguistic evidence has been adduced for the assumption that category conversion is a costly process, but, in the domain of semantic processing, a change of category causes processing difficulties. A number of studies have shown that the change of the semantic type in such sentences as *John began the book* (complement coercion) increases processing costs (cf. Frisson & McElree, 2008; McElree, Pylkkänen, Pickering, & Traxler, 2006; McElree, Traxler, Pickering, Seely, & Jackendoff, 2001).

5. Present perfect tense occurrences of the verbal passive with *sein* + participle + *worden* were excluded from the *sein* + participle count and were counted as *werden* + participle.

6. Since we did not find records for all of our items in the TIGER corpus, we used the larger COSMAS corpus for this search.

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