Subject reactivation depends on the syntactic position of the argument: evidence from eye movements

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Abstract

This paper investigates the on-line processing of different types of intransitive verbs. It shows that the argument of all verb types is reactivated during processing. However the point of reactivation differs per verb type. In agentive verbs, which take a syntactic subject, and assign the agent-role, we find an early reactivation. In unaccusative verbs, which take a syntactic object and assign the theme-role, we find a late reactivation. Mixed verbs (such as *sparkle*), which take a syntactic subject but assign a theme-role, pattern with agentive verbs. This indicates that the point of reactivation of the argument depends on the syntactic position.

1 Introduction

Intransitive verbs (verbs which take only one argument) can be classified on the basis of the thematic role the verbs assign to their argument. The argument can be interpreted as the *agent* (agentive verbs as in (1)) or as the *theme* of the event (unaccusative verbs as in (2)) (Marantz, 1984).

(1) The boy jumped *agentive*
(2) The boy fell *unaccusative*

Another difference is that the argument of unaccusative (and not agentive) verbs has properties that are normally associated with syntactic objects, although the argument appears in subject position (Burzio, 1986; Perlmutter, 1978). Hence, a connection exists between the subject and object position in unaccusative verbs.

Previous experimental research on the different types of intransitive verbs shows that the distinction between the two verb types is reflected in processing (Bever and Sanz, 1997; Friedmann et al., 2008; Poirier, 2009). Several experiments show that the argument of an unaccustive verb is reactivated late after verb offset, whereas this has not been found in agentive verbs (for an extensive overview of the studies see Koring & Mak, submitted).

2 Research Questions

A question that arises is what the source is of the processing difference between agentive and unaccusative verbs. Is the difference caused by the difference in thematic roles: agent vs. theme? Or is the difference the result of the distinction between syntactic subjects and objects? Previous studies cannot disentangle these factors as for all verbs the thematic and syntactic structure matched. That is, an agent would always be a syntactic subject and a theme would always be a syntactic object.

A distinct set of verbs exist for which the classification has so far remained unclear (e.g., *sparkle*). The verbs in this class differ from the agentive and the unaccusative verbs. These verbs show a mixed behavior with respect to the unaccusativity diagnostics (so-called unaccusative mismatches (L. Levin, 1985)). Reinhart (2000) argues that this set of verbs is in thematic structure similar to unaccusative verbs; they assign the theme-role. However, in syntactic structure they are like agentive verbs; the argument is a syntactic subject and lacks object properties (see

Koring and Mak (submitted) for the distinguishing properties). Hence, there is a mismatch in syntactic and thematic structure. Hence, we will call them mixed verbs in this paper. Given their mixed structure, investigating the processing of this class of verbs will enable us to differentiate between thematic and syntactic factors. That is, if they pattern in processing with agentive verbs, the processing difference is the result of a difference in the syntactic position of the argument. On the other hand, if they pattern in processing with unaccusative verbs, the difference is caused by a difference in thematic roles.

Another question is whether the argument of agentive verbs is reactivated during processing. Previous probe-studies were not able to detect this. We hypothesize that also in agentive verbs the argument will be reactivated as a result of integrating the argument and verb into one semantic object. In order to test this we designed a new method to measure activation of the argument throughout the complete sentence instead of at particular probe sites.

3 Method

The experiment used a version of the visual world paradigm (Tanenhaus et al., 1995). Huettig and Altmann (2005) showed that people spontaneously fixate on an object (target) that is semantically related to a spoken word. We hypothesize that people will not only fixate on a target upon *hearing* a related word, but also when this word is *reactivated* upon hearing the verb.

3.1 Participants

Forty Dutch native speakers participated in the experiment. Participants were seated in front of a screen showing visual displays with four objects, one in each quadrant. One of the objects was related to the argument. Participants were told to listen carefully to orally presented Dutch sentences, but had no further explicit task. The sentences all contained an intransitive verb in either one of three conditions (unaccusative, agentive, mixed). While they were listening, people's eye movements were measured by a Tobii eye-tracker sampling at 50 Hz.

3.2 Selection of verbs

Verbs were selected on the basis of several diagnostics, among which the type of auxiliary the verb selects (Hoekstra, 1984; Zaenen, 1993), the availability of the impersonal passive construction (Perlmutter, 1978) and whether or not adding *by itself* yielded an acceptable result (Levin and Rappaport, 1995) (see Koring and Mak (submitted) for a complete overview of the diagnostics). The Log transformed mean frequencies of the different verb classes did not differ significantly.

3.3 Pictures and sentences

For each verb an argument was selected that was not semantically related to the verb. Each argument was combined with a target object that *was* strongly related to the argument, but not to the verb. Semantic relations were pre-tested in a semantic relatedness judgment task (Perraudin and Mounoud, 2008) (see Koring and Mak (submitted) for the discussion).

In between the argument and the verb, material was added that was not related to the argument, target, or verb. In addition we added material after the verb in order to avoid end-of-sentence effects which resulted in sentences as in (3) translated from Dutch.

(3) Bert said that *the wood* (argument) of the fat gentleman with the bald head *fell* (V) hard after the heavy thunderstorm had begun with a flash.

This sentence was combined with a visual display showing a saw (target), a shell, a buggy, and a peacock (all distracters). The control condition consisted of the same visual display combined with the same sentence in which the argument was replaced by a word that was *not* related to the target (*clock* instead of *wood*). The difference in strength of relation between argument – target and control argument – target does not differ across verb types. The control condition served as a baseline (for a complete discussion of the method see Koring and Mak (submitted)).

4 Results

Figure 1 shows the distribution of fixation proportions over time. Looks to the target in the control condition (without a related argument) are subtracted from looks to the target in the test condition (with a related argument). The first and biggest increase in looks to the target is the result of presenting the argument itself (looks to the *saw* increase upon presenting *wood*). Later rises are the result of reactivating the argument.

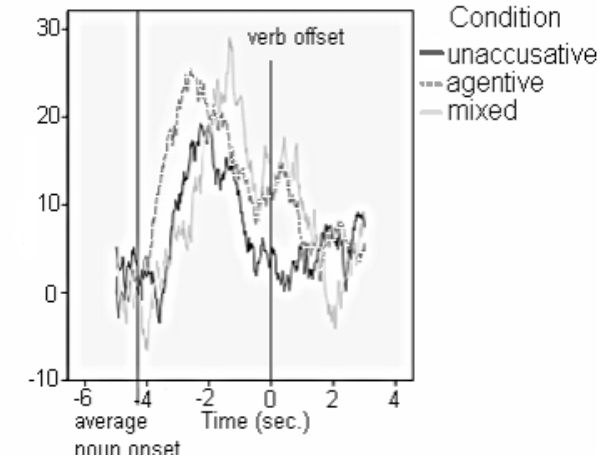

Figure 1. Mean percentage of looks to the target over time in the different conditions. The curves are synchronized to the acoustic offset of the verb.

For analysis we defined two regions on the basis of previous experiments: the verb frame (600 ms. before verb offset until 1000 ms. after verb offset) and the post-verb frame (200 ms. until 1700 ms. after verb offset). The verb frame takes verb offset plus 200 ms. as the mid-point. It does not take exactly verb offset as the mid-point as it takes 200 ms. to initiate and program an eye movement (Huettig and Altmann, 2005). The starting point is 600 ms. before verb offset as this is the average length of a verb. The post-verb frame takes 950 ms. after verb offset as the mid-point (previous literature found reactivation of the argument in unaccusative verbs 750 ms. after verb offset). The starting point is verb offset plus 200 ms.

Results of regression analyses in the verb frame show that the curves in all different conditions have a significant quadratic component. The quadratic component is positive for agentive and mixed verbs, but negative for unaccusative verbs. Growth curve analyses reveal that the quadratic component differs for the unaccusative verbs compared to the agentive and mixed verbs. (see Koring and Mak (submitted) for the details of the analysis).

Regression analyses on the individual curves in the post-verb frame indicate that the curves in the different conditions have a significant linear component which is positive for the unaccusative verbs, but negative for both the agentive and mixed verbs. Growth curve analyses show that unaccusative verbs differ in slope from the mixed and agentive verbs, whereas mixed and agentive verbs do not differ significantly in slope.

5 Discussion

The results of our eye-tracking experiment show that the argument of agentive verbs *is* reactivated during processing: looks to the target start rising from verb onset. That means that the argument of agentive verbs is reactivated much earlier than the argument of unaccusative verbs. Previous probe-tasks were not able to detect this reactivation as they did not probe at verb onset.

Mixed verbs show unaccusativity mismatches. They behave like agentive verbs in some diagnostics, but like unaccusative verbs in others. According to Reinhart (2000) they have the thematic structure of unaccusative verbs (they assign a theme-role), but they have the syntactic structure of agentive verbs. Our processing results show that they pattern in processing with agentive verbs. The argument of mixed verbs is reactivated as early as the argument of agentive verbs. The finding suggests that the point of reactivation of the argument depends on the syntactic position of the argument, and not on the thematic role that is assigned to the argument.

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