The timing of the on-line activation of visual shape information during sentence processing

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Recent evidence suggests that language comprehenders routinely activate visual representations of objects that are referred to. However, evidence for such activation (priming between objects with similar shapes: e.g., pizza – coin) has only been obtained under certain circumstances: 1) during metalinguistic tasks (e.g., lexical decision), 2) during the processing of single words, or 3) when pictures of the objects were (co-)present in the task (e.g., visual world eye-tracking or sentence-picture verification). It is still unclear whether and when visual representations are activated when listeners hear sentences without looking at pictures or performing additional tasks.

In the present ERP study, 21 adult native speakers of Dutch were presented with spoken sentences (32 per condition) in a passive listening task. The lead-in sentences (e.g., the translation equivalent of “In 1969 Neil Armstrong was the first man to set foot on the...”) were highly predictive of specific words. The critical word following the lead-in sentence was 1) correct and expected (correct condition, e.g., “moon”), or 2) a semantic violation with the referent having a visual shape similar to the expected referent (shape condition, e.g., “orange”), or 3) a semantic violation with a shape-unrelated referent (unrelated condition, e.g., “banana”). The ERP component of interest was the N400, a sensitive index of semantic processing. If listeners activate shape information, the amplitude of the N400 for the shape condition should differ from that of the unrelated condition.

The objects mentioned in the shape and unrelated condition belonged to the same semantic category. Norming studies had established that the critical words in the correct condition had a high cloze probability and that the plausibility ratings for the critical words in the shape and unrelated condition were equally low. The referents of the critical words in the correct and the shape conditions (e.g. “moon” and “orange”) were judged to be highly related in shape. The critical words were rotated across sentence contexts to form the different conditions, with every sentence context and critical word occurring once on each of three lists.

We observed a significant N400 effect between 300 and 500 ms after word onset for both the shape and the unrelated condition relative to the correct condition (Fig. 1). More importantly, the unrelated condition also elicited a significantly more negative mean voltage than the shape condition, however this shape effect emerged somewhat later, from approximately 500 to 700 ms.

These results demonstrate that on-line evidence for the activation of visual shape representations can be found during listening to sentences in the absence of any metalinguistic judgments or pictures of the referent objects. The timing of the shape effect is important with regard to the information flow between cognitive representations and suggests that shape information is activated relatively late during the processing of linguistic information. Shape information may therefore not receive the same degree of priority as semantic category information, which usually elicits N400 effects at 300-500 ms after word onset.
Figure 1: ERP results. A) Grand average ERPs from a central electrode (Cz). Word onset is at 0 ms. Negative is plotted up. B) Scalp topographies of the mean difference between each of the conditions in two time intervals. Blue color indicates negative voltage.