Action in language comprehension: Neural basis and time course

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In language comprehension, the mapping between visual and auditory surface forms and their semantic representations is virtually arbitrary. This allows studying the involvement of motor areas and the mirror neurone system in conceptual/semantic processing with minimal visual or auditory confounds. A number of previous neuroimaging studies have suggested an involvement of cortical motor areas during the processing of written and spoken action-related words and sentences. Most strikingly, stimuli referring to different bodily effectors (e.g. arm-, leg- or face-related words such as “pick”, “kick” or “lick”) produced somatotopic activation patterns in motor cortex. This has meanwhile been replicated for action-words in different contexts (e.g. idiomatic sentences, or minimal phrases). We could show that activation that is specific to action-words correlates negatively with word frequency, suggesting that this activation reflects retrieval of lexico-semantic information, rather than mental imagery.

However, due to their low temporal resolution metabolic neuroimaging results can still be ambiguous with respect to the processing stage they reflect. This is a serious limitation for neurolinguistic research, where it is crucial to distinguish early lexico-semantic processing from later strategic or mental imagery effects. Timing information is therefore key to determine the functional significance of motor areas in action-word comprehension. We have shown in several studies on general aspects of visual and auditory word recognition that semantic information can be retrieved within 250 ms of stimulus onset. More specifically, we showed that visually presented arm-, leg- and face-related words could be distinguished by their ERP response as early as 210-230 ms after word onset, and that the putative generators of these signals showed a somatotopic pattern. Similarly, an MEG study using an auditory “mismatch negativity” (MMN) paradigm found somatotopic localisation for face- and leg-related words around 150 ms after stimulus onset. The magnitude of this effect correlated with semantic features of the stimuli. Consistent with these findings, single-pulse TMS at 150 ms after visual word presentation interfered with action-word processing in a lexical decision task. We conclude that there is converging evidence from different metabolic and electrophysiological neuroimaging techniques supporting the
idea of rapid access to embodied semantic representations for action-words in language comprehension.