

³Frost .R, ²Goelman .G, ¹Bick .A

Medical Biophysics, Haddasa Hebrew University Hospital, ²ICNC, Hebrew University, Jerusalem, Israel, ¹ Psychology, Hebrew University, Jerusalem, Israel³Jerusalem, Israel,

Objective: Although the neural representation of processing printed words has been extensively investigated, little is known about the neural correlates of morphological processing. Dispute exists whether morphology is a discrete and independent element of lexical structure or whether it simply reflects a fine-tuning of the system to the statistical correlation that exists among the orthographic and semantic properties of words. Imaging studies in English failed to unequivocally show morphological activation that is independent of semantic or orthographic activation (1). We performed imaging experiments using Hebrew, a Semitic language, in order to verify the existence of independent morphological activation and identify its location. Cognitive research in Hebrew has revealed that morphological decomposition is an important component of print processing (2). Hebrew morphology is complex and systematic, as most words are created by combining two morphemes, a root (usually containing three consonants) and a phonological word-pattern that contains vowels and occasionally consonants. This morphological structure has two important features: 1) The two morphological constituents are intertwined and not linearly combined; 2) Morphological relatedness does not necessarily induce a clear semantic relatedness. Thus, Hebrew provides a unique opportunity to investigate the neural substrates of morphological processing.

Methods: 14 normal volunteers, all native speakers of Hebrew, participated in an fMRI experiment (GE 1.5 T scanner, RT-EPI, TE = 55, 27 slices 4/0, TR = 3000, FOV = 21, 64*64). Participants were required to perform judgment tasks of morphological relatedness, semantic relatedness, rhyming, and orthographic similarity. Half of the morphologically related words were semantically related (i.e. mishpat [trial] – shofet [judge]), and half were semantically unrelated (takciv [budget] – mikcav [rhythm]). Words were presented in blocks of five pairs (total time 18sec); blocks were counterbalanced in a pseudo-random order. Each block was preceded by an instruction phrase notifying the subject what type of judgment is required for the following block. A judgment task of line patterns was used as a control. Subjects performed a training session before entering the magnet, and did not reveal any significant difficulty in performing the tasks (as measured in error percent and reaction time). Brain Voyager was used for data analysis.

Results & discussion: Contrasting the two morphological conditions (semantically related+unrelated) with the other linguistic tasks revealed two loci of activation (random effect, $p < 0.005$): around the left middle frontal gyrus (TAL 42,17,32) and around the left parietal gyrus (TAL 33 -59 34). In both locations activity in morphological conditions was significantly higher than in any of the other conditions (figure 1). Comparing location of morphological related activation to the locations of semantic and orthographic related activation, we found that the areas were neighboring but only partially overlapping (figure 2). The similarity in activation between the two morphological conditions further eliminates the possibility that morphological activation simply results from the semantic properties of the words. It should be noted that all conditions (except the line judgment task) included real words; therefore all conditions could have activated all areas related to different processes involved in reading to some extent.

Conclusions: Our study provides evidence concerning the existence of morphological related activity in an explicit task design. We identified two locations involved in morphological deposition of visually presented words and showed that this activity does not result from the joint contribution of orthographic and semantic properties. Since our results show activation that is independent of the semantic overlap between words, the possibility that this activation results from semantic factors alone seems unlikely. These results thus coincide with the behavioral data previously obtained in Hebrew, demonstrating the important role of morphological processing in reading, thereby suggesting that morphological analysis is an independent process of visual word recognition.

References & acknowledgments:

- 1) Devlin et al, PNAS, **101** (2004)
- 2) Frost et al, J Exp Psychol, **26**, (2000)

