

Grasping ideas with the motor system: Semantic somatotopy in idiom comprehension

Introduction

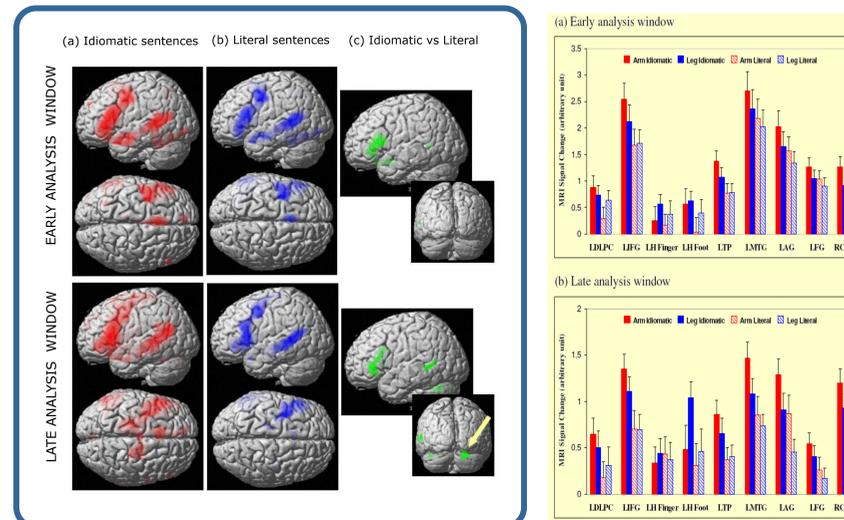
Single words and sentences referring to bodily actions activate the motor cortex (Hauk et al., 2004). This “semantic somatotopy” supports the idea that semantic mechanisms are grounded in the sensory-motor system (Barsalou, 2008; Glenberg, 2007; Pulvermüller, 2005). We ask here whether semantic somatotopy in the motor system persists during processing of idiomatic sentence meaning. If the grounding of semantics in sensory-motor processes is a universal feature of the human cognitive system, action-perception information should play a role in determining the landscape of semantic brain activation to sentences, even if their meaning is highly abstract. We looked at idioms including words denoting arm and leg actions and examined fMRI activation in motor areas related to upper and lower extremities as the dependent variable.

Methods

- 18 right-handed healthy native speakers of English
- 76 English Idioms and 76 Literal sentences including arm- and leg-related action-words (e.g. “He grasped the IDEA” vs. “He grasped the OBJECT”, “He kicked the HABIT” vs. “He kicked the BALL”). Critical words, and action-words, were matched for word form/lemma/bi-/tri-gram frequencies, and number of letters/syllables/orthographic neighbours. Sentences were presented word-by-word (SOA=500ms).
- Silent reading task + occasional yes/no questions about probe sentences
- Motor localizer task (finger/foot movements) after silent reading task
- Early analysis window (HRF time-locked to critical word onset) + Late analysis window (HRF delayed by 3s after critical word offset)

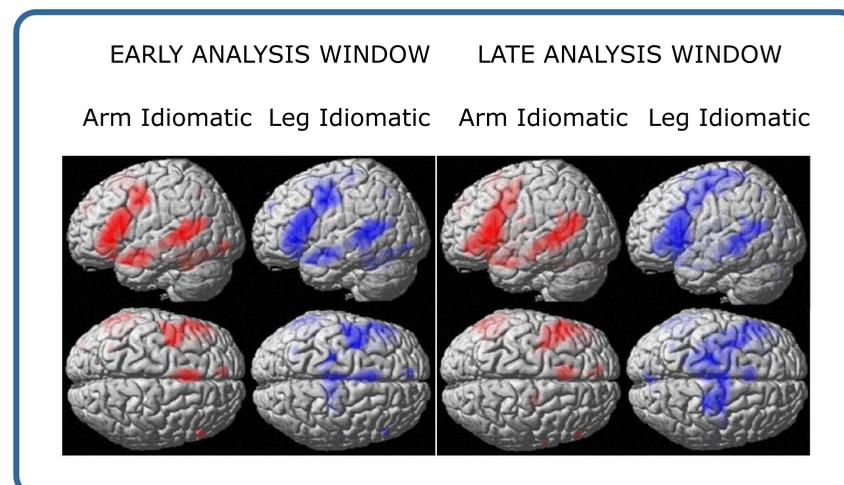
Results (1)

We found a common fronto-temporal cortical network for reading literal and idiomatic sentences in both analysis windows. Idioms also specifically recruited the LIFG, LMTG, R cerebellum, L temporal pole and L angular gyrus ($p < .025$).



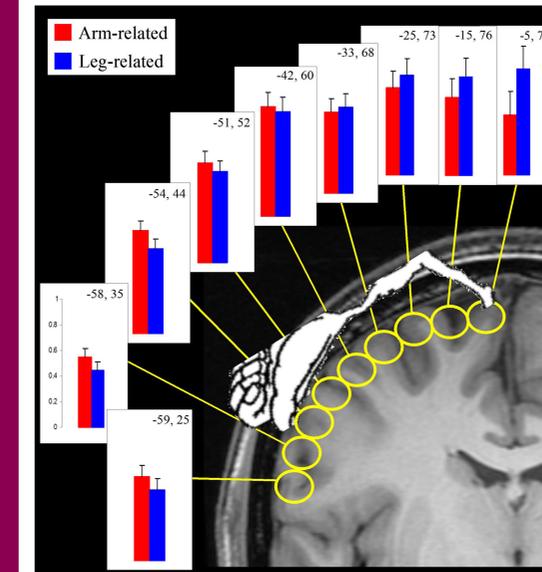
- Semantic somatotopy for idioms

We obtained a significant interaction ($p = .014$) ROI (left-lateralized finger vs. foot loci from the localizer task) x Body Part (arm vs. leg) in the late analysis window. Sentences including leg-related action-words elicited stronger activity in the left dorsal foot area, while arm-related sentences recruited more strongly the left lateral finger area.



Results (2)

Semantic somatotopy was revealed for an array of ROIs along the motor strip (divided into 2 x 9 ROIs aligned along the central sulcus and precentral gyrus). We obtained an interaction Dorsality (superior vs. lateral) x Body Part ($p < .001$) in the late analysis window.



We observed stronger dorsal motor cortex activation for leg-related idioms (“He kicked the habit”), while relatively stronger lateral motor cortex activation for arm-related idioms (“He grasped the idea”).

Conclusion

Our results establish the differential involvement of motor/pre-motor cortex in idiom processing and support theories that view abstract semantics as grounded in action-perception systems (Barsalou, 2008; Pulvermüller, 2005). The orchestration of abstract meaning in the human brain is not solely explained by the activation of unspecific semantic centers in fronto-temporal cortex, but it involves complementary activations in the sensory-motor system, which may play a role in the composition of sentence meaning.

References

- Barsalou L.W., 2008 Ann Rev Psychol
- Glenberg A.M., 2007 Handbook of Psycholinguistics, Oxford.
- Hauk O. et al., 2004 Neuron
- Pulvermüller F., 2005 Nat Rev Neurosci