Marie Curie IOF – 271671. ACTION CONCEPTS

In this project we addressed two main questions related to verb and action processing and representation in the bran that have been long object of controversial debates:

1. What drives the verb-noun distinction in the brain?

The most common observation in brain-imaging studies is that comprehension of verbs (relative to nouns) leads to increased activity within a specific brain area: ***the posterior-lateral-temporal cortex***. However, whether this differential activation of verbs relative to nouns reflects the existence of a differential representation of action relative to object concepts rather than a grammatical class distinction has been unclear.
In the first part of this Action Concept project we have been investigating **what drives verb specificity in the brain**. The grammatical distinction between nouns and verbs is of fundamental importance since a word's grammatical category determines the types of phrases in which it appears (*The boy likes the candies*, but not **The likes boy the candies*) and determines the morphological transformations it undergoes (*The boy liked the candies,* but not **The boyed like the candies*). There is considerable evidence showing neural differentiation between verbs and nouns. Specifically, functional neuroimaging studies have found regions that are particularly sensitive to verbs relative to nouns. However, the precise basis for the observed neural distinction remains elusive. Part of the difficulty lies in that it is not obvious whether the distinction is grammatical in nature, that is, whether it reflects different grammatical roles in sentences. Instead, it could reflect different semantic dimensions that are correlated with grammatical category – e.g. verbs prototypically refer to events whose meanings include more motion features relative to concrete objects. In our study we showed that the most likely candidate to drive verb specificity in the brain is predication: a core lexical feature involved in binding constituent arguments (e.g. *boy*, *candies*) into a unified syntactic-semantic structure (e.g. *the boy likes the candies)*. We used functional neuroimaging to test whether the intrinsic predicative function of verbs is what drives the verb-noun distinction in the brain. We first identified verb-selective regions with a localizer experiment including verbs and nouns. Then, we examined whether these regions were sensitive to a word's predicative function – valence – as indexed by the tendency of a verb to select for a direct object. We controlled for other verb-specific dimensions. Those dimensions were telicity, dynamicity, and subject agentivity. Telicity refers to the extent to which an action entails a natural endpoint: telic verbs such as *arrive* - someone is now at a location where she was not before, vs. atelic verbs such as *march* - it only describes a way of walking without specifying any natural point at which there is a transition from walking to not walking; dynamicity refers to unfolding over time: dynamic verbs such as *watch vs.* state verbs such as *exist;* agentivity refers to an action intentionally performed by the subject: *agentive* verbs such as *kill* - the subject decides to perform the action, vs. non-agentive verbs such as *like* - the subject involuntarily experiences the action. Neural activity in the left posterior middle temporal and inferior frontal gyri correlated with valence, indicating sensitivity to predication. This suggests that grammatical class preference in the brain is driven by a word's predicative function. Following the rationale that verbs' fundamental role is that of predication whereas nouns lack this property, we conclude that verb-selectivity in these regions is driven by this syntactic-semantic function. These results represent the first positive evidence on the question of what grammatical class distinctions are captured in the brain, and have been published in Journal of Cognitive Neuroscience. We expect this publication to have a strong impact on the field and to represent a new basis for future research on the neural representation of actions/verbs and objects/nouns.

Hernández M., Fairhall S.L., Lenci A., Baroni M., & Caramazza A. (2014). Predication drives verb cortical signatures. *Journal of Cognitive Neuroscience*, 26 (8), 1829–1839. doi:10.1162/jocn_a_00598

For a schematic illustration of the results of the present study see attachment "Predication_SchemiaticIllustration".

2. What is the role of the primary motor cortex in action-language understanding?

Current research on the role of the motor cortex in action-language processing recurrently shows what it is already known: action-language processing activates the motor cortex in a somatotopic way. However, whether this activation reflects that the motor cortex is functionally involved in the semantic processing of action-language or not has been long a controversial debate.

In the second part of this Action Concept project present project we aimed at determining **whether the recruitment of the motor cortex is epiphenomenal to action-language processing, or rather it reveals a functional role in conceptual representation.** Showing that primary brain structures (such as the motor cortex) get involved in high-level cognitive processes (such as language) sounds attractive, counterintuitive and provocative – where primary brain structure is understood as one involved in low-level information processing, as opposed to higher-order associative brain structures. Therefore, most studies on this topic to date have repeatedly shown that action-language processing incurs in activity in the motor cortex. However, it is still a mystery what this activity in the motor cortex means: should this brain structure be considered part of the lexical-semantic system for action-language processing? If so, many classical and widely adopted theories in the field of language production and comprehension should be revisited and reviewed to accommodate the functional role of the motor cortex and sensorimotor experiences in conceptual representation. Note that although the present project focuses on action language, the embodied versus disembodied debate is equally applicable to any sensory process other than action and motion (e.g. color, shape, emotion …). That is, concluding that a primary such as the motor cortex is functionally involved in action-language understanding would also suggest that all primary structures through which we get any type of sensory information would be probably involved in the semantic processing of our diverse concepts. Therefore, the current theories of lexical-semantic processing will necessarily have to acknowledge and incorporate the role of the sensorimotor processing for the semantic representation of all motor actions and concrete objects, and wonder about the role of those sensorimotor experiences in the conceptual representation of more abstract words.

Therefore, in this study we addressed the fundamental question of whether any conceptual information is represented in the motor cortex or not. To answer this question, we will conduct a functional neuroimaging experiment with healthy participants using the Representational Similarity Analysismethod **(RSA;** Kriegeskorte et al. 2008). RSA is one of the most advanced methods in the field of neuroimaging, which allows for causal inferences at a highly specific and sensitive neural level. This method makes it possible to compare the regional patterns of neural responses elicited by action phrases and the behavioral ratings reflecting conceptual processing of the same action phrases.

Our hypothesis is that if the motor cortex is involved in the lexical-semantic processing of action concepts, the pattern of neural activity in the motor cortex should correlate with the pattern of behavioral ratings measuring the lexical-semantic processing of those concepts.

At the moment this study is in phase of data analyses.