

Brain bases for language and logic and their clinical relevance

Keynote lecture

Yosef Grodzinsky

Neurolinguistic Laboratory, Hebrew University of Jerusalem

We use language for communication; we also use it for reasoning: when I (truthfully) tell you that *my dogs are big and brown*, you are in a position to infer that (i) to my knowledge, there exists a plurality of dogs; (ii) I own (at least some of) these dogs; (iii) all the dogs that I own are big; (iv) all of them are brown. The information you can extract from this sentence goes way beyond the lexical meaning of the 6 words it contains. But you can only extract it if you possess grammatical and logical tools – knowledge resources stored in your brain/mind. What is the nature of this knowledge and the mechanisms that put it to use? Can we separate knowledge of language and knowledge of logic? Are we the only fortunate species to have these resources at our disposal? These questions have long intrigued logicians, linguists and evolutionists.

I will address some of these questions by providing experimental arguments for the neural separability of logical and linguistic operations. These arguments come from experiments on the processing of a basic logical operation – negation – in the brain. Negation is central to reasoning as it reverses the direction of logical entailments: from the sentence *there are children in the room* you can infer that *there are humans in the room*, but when negated, the entailment direction is reversed: *there are no humans in the room* entails *there are no children in the room*. Yet isolating negation experimentally is not easy. I will review a series of behavioral and neuroimaging experiments, in which we used linguistic and logical tools to isolate effects of negation behaviorally. We then localized the neural basis of negation in the anterior part of the left insula, distinct from, but adjacent to, the language areas. A corresponding well-delineated cytoarchitectonic region was subsequently identified, and its properties were studied. I will then show how these results have clinical relevance, mainly in awake neurosurgery.

I will discuss what these results tell us about the boundary between language and logic and argue that they mark the line at which language stops and logic begins. I will then offer some speculations on why logical operations are located in the anterior insula and not elsewhere. I will, in short, use an emerging picture from neurolinguistics to reflect on what it is to be human, and on how studies of language and logic may help us to understand ourselves a bit better. Clinical and therapeutic perspectives will also be discussed.