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## *Alfredo Ardila. Beyond Broca and Wernicke*

Laura Andrea León Anhuaman\*

Alfredo Ardila, one of the most renowned neuropsychologists in Colombia, dedicated more than 40 years of his life to the investigation of neuropsychological processes, mainly those associated with linguistic processes, learning, memory and language production. In addition, much of his research focused on the characterization of ontogenetic language development, including its protective variables, facilitators or possible vulnerabilities for successful language development, as well as the evaluation of mechanisms that could be associated with the deterioration of linguistic functions and associated pathologies.

As is well known, the areas and main processes of language are taught in the first semesters of psychology and in careers such as speech therapy, and all of us who have passed through those classes have heard from very early on what Broca's area in the frontal lobe and Wernicke's area in the temporal lobe are fundamentally. For example, we know that Broca's is mainly concerned with the planning of the movements necessary for the production of language, that Wernicke's is in charge of language comprehension, and that both were delimited and described by the physicians who gave them their names. We also know that their first studies were developed in the mid-18th century, and that today there is still an interest in demarcating these and other brain structures involved in this highly developed process in humans.

In the article by Ardila et al. (2016), regarding Dr. Ardila's legacy, an account is given of the areas that have been delimited as essential structures, as well as the models of language organization that they comprise. They also describe the patterns observed in the brain organization of different aspects of language production and comprehension through different neuroscientific techniques, such as tractography or magnetic resonance imaging, which allow a clearer delimitation of the different brain structures involved in language, compared to previous characterizations based on lesions in patients with language-associated pathologies.

However, Ardila and co-workers postulate that Broca's and Wernicke's, although fundamental areas, are only part of a network of connections that process language and contain other areas that are not as widely known. Using a methodology known as *meta-analytic connectivity modeling*, the authors reviewed several research meta-analyses in which participants performed language tasks while undergoing functional magnetic resonance imaging. According to the methodology used, it can be deduced that there are connections between different areas involved in various language tasks, as these are activated simultaneously while a linguistic task is being performed. The article even reviews Broadman's areas (BA) that are activated when performing linguistic tasks and that complement the functions of the previously described areas.

Finally, in the discussion of the article, a general model of the organization of the areas dedicated to language is proposed, in which three networks are identified: the first one, associated with language comprehension, which includes Wernicke's area (BA21 and BA22), but also the primary auditory area (BA41 and BA42) and the supramarginal gyrus (BA40); the second, which includes Broca's area (BA44 and BA45) and the areas BA46, BA47 and BA13; and the third, a part of the insula cortex, which may play a very important role in the communication of the other networks.

The article in general is a rigorous work of meta-analysis that allows to generate a more accurate model of the areas linked to language and that not only takes into account the damage of the structure to delimit the function of certain brain areas in a complex process such as language, but also studies brain activation in linguistic tasks performed by healthy people as a way to understand the functioning and organization of the different brain areas involved in this process.

Researchers like Alfredo Ardila leave in their readers and students the discipline and rigor as tools to build and leave knowledge at the service of society. In this way, the description of these models allows much more precise diagnoses and forms of therapy directed to specific damages.

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