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REPORT CARD



INSULA AND AUDITORY SYSTEM: WHAT IS THE CONNECTION?

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Our newsletter this month will be about a very interesting structure called the insula. The word insula derives from the Latin "island" and, unfortunately, there is still little information about this structure. But what do we know about the insula so far?

The insula is located internally in the cortex, more specifically, below the lateral sulcus. In order to access it, it is necessary to remove some parts of the frontal, parietal, and temporal lobes (see Figures 1 and 2).

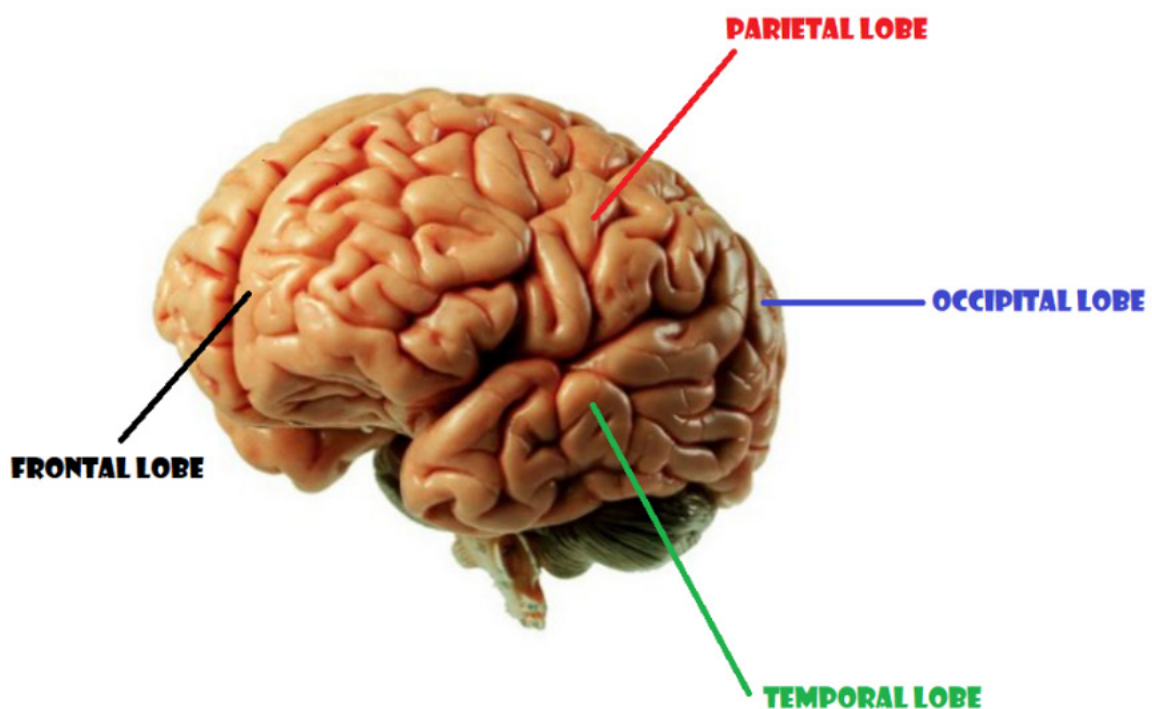


Figure 1: Location of the cortical lobes.
Image from Donadon et al. (2019)

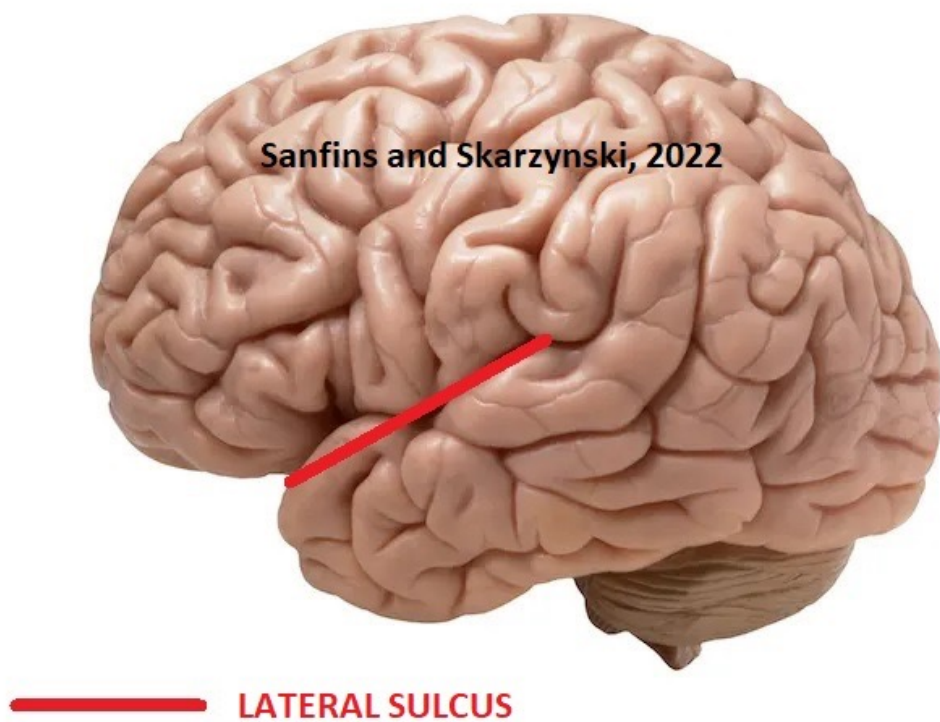


Figure 2: Position of the lateral sulcus.
Image developed by the authors

An important aspect of the insula is that this structure exchanges much information with the structures around it. It has important bidirectional connections with the following areas:

**(A) orbitofrontal cortex (OFC),
(B) anterior cingulate cortex (ACC),
(C) supplementary motor areas, parietal (primary and secondary somatosensory areas),
(D) temporal cortex,
(E) subcortical structures (amygdala, globus pallidus, and thalamus).**

The functional role of the insula is directly linked to feelings such as pain, cognition, anxiety, mood, threat recognition, and conscious impulses. The insula is involved in the

integration of a wide variety of sensations and is fundamental in the process of perception, recognition, and working memory.

Understanding this, the initial question about the connection between the insula and the auditory system now begins to make sense. The insular cortex is essential for the recognition of many senses, including auditory perception. When we have an auditory experience, auditory learning will occur and so auditory memories will be formed and archived. Thus, the insular cortex plays a critical evolutionary role in humans.

The connection between the insula and hearing is gaining more attention, since there is functional evidence that supports the hypothesis that our hearing ability, and the experience acquired with a spoken language (or even a sign language), may affect the anatomy of the insula.

This is because the insula has extensive connections with the primary and secondary auditory regions of the temporal lobe and with speech areas of the frontal lobe. In deaf individuals the use of sign language activates areas related to language, as well as other regions including the posterior insula.

The insula, protected within the cortex, also plays an important role in aspects of decision-making, since auditory stimuli processed in the insula can involve somatic markers of feelings in the body, such as an increase in heart rate in response to emotions

aroused when listening to music (Figure 3).

Two people can have completely different feelings when listening to the same melody (Figure 4).

This difference in feelings when listening to the same sound may be due to the trajectory of the sound within the insular cortex. The primary signals arrive in the posterior insula where low-level sensory processing is performed; subsequently, the information is directed to the anterior insula where the signals are processed and integrated into emotional, cognitive, and motivational systems.



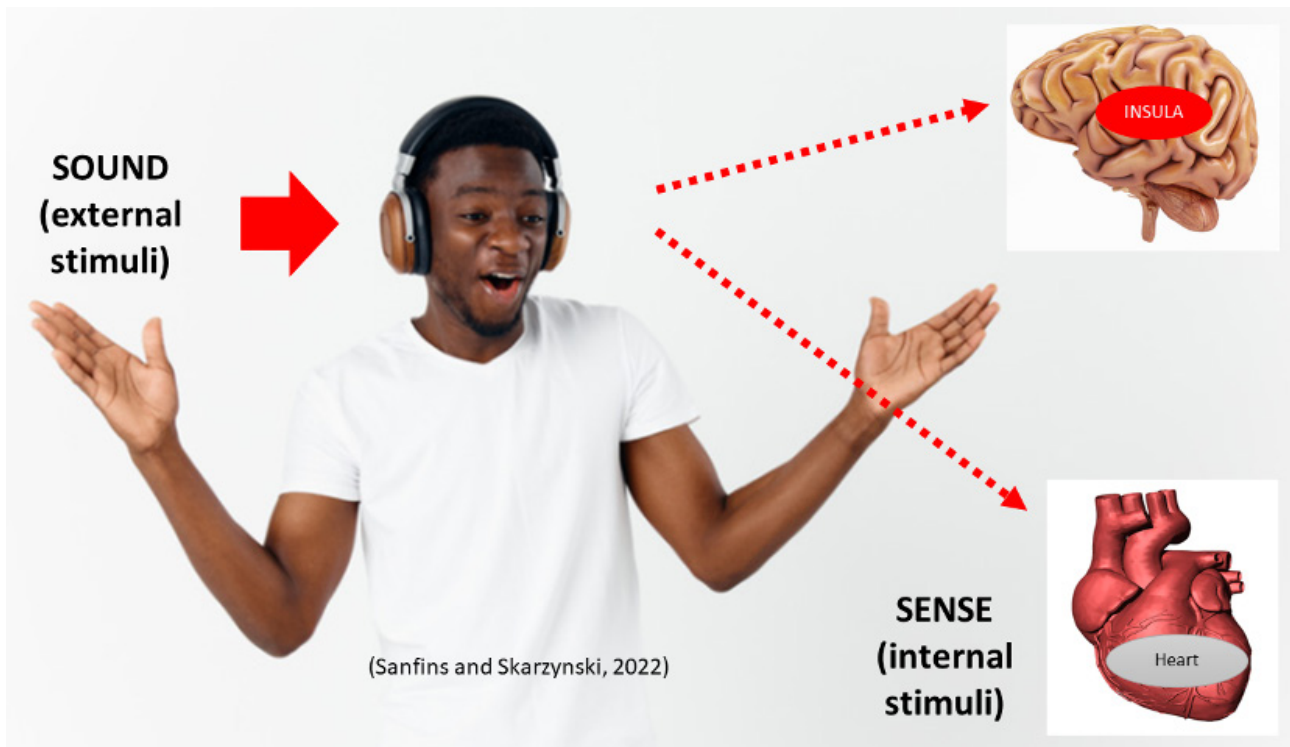


Figure 3: Integration of internal and external stimuli.
Image developed by the authors

The insula also plays an essential role in cognition. Attention is heightened when an event is important or if there is an association with feelings of pleasure, joy, pain, or sadness. For this reason, the wedding march (commonly played at weddings) can be so exciting.

The insula is involved with learning, since feeling states also influence reasoning, which contributes to the fixation of auditory information. Therefore, teachers can maximize learning by amplifying the characteristics of this very special structure, as rewarding stimuli evoke

feelings of pleasure and can improve the process of fixation and memorization of acquired information. The anatomical position of the insula allows dynamic interactions of feelings with cognition and motivation, which explains why we learn better when there is good interaction and a strong teacher-student relationship.



Figure 4: Different feelings when listening to the same melody.
Art developed by the authors

It is important here to differentiate between the functions of the two brain structures, the insula and the amygdala. The amygdala plays a fundamental role in emotional processes, but the functions are different to those performed by the insula. The amygdala acts in automatic responses, that is,

implicit knowledge, while the insula is involved in subjective experiences, that is, explicit knowledge. Briefly, the amygdala is associated with the impulsive system and the insula is more related to the reflexive system.

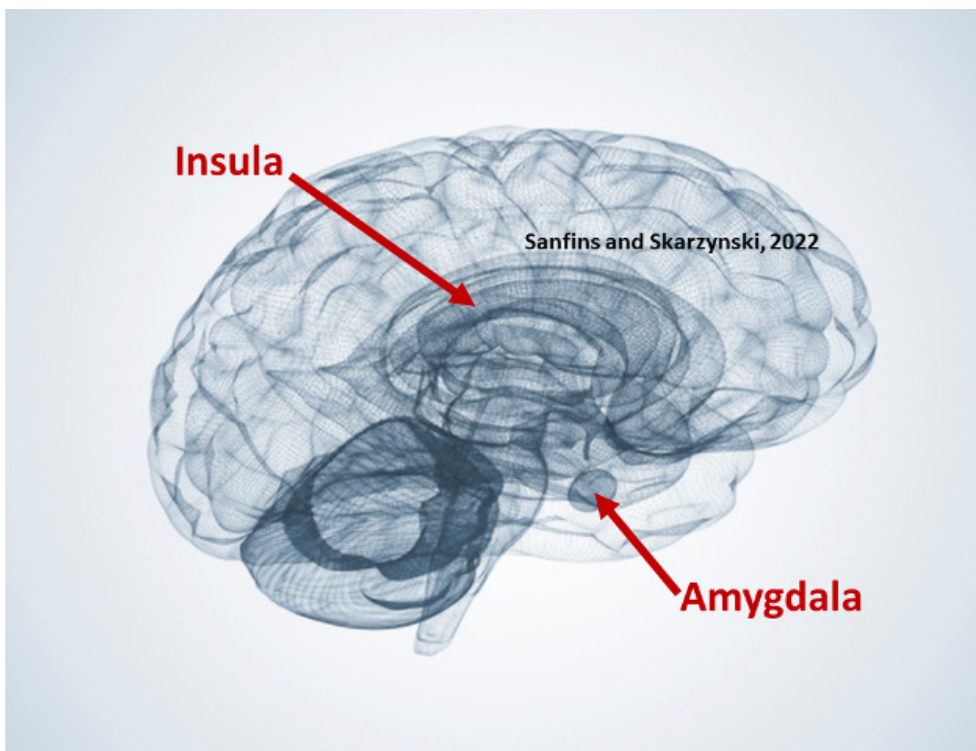


Figure 5: Anatomical positions of the insula and amygdala.
Art developed by the authors.

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