Neuroanatomy Reflection Corner

The Insula

Reetika Dikshit[1]

[1]*Resident Doctor, Department of Psychiatry, Lokmanya Tilak Municipal Medical College, Mumbai.*
E-mail – reetikadikshit@yahoo.com

INTRODUCTION

First described by Johann Christian Reil in the eighteenth century (1809), the insula has "long been a *terra incognita* for anatomists".

The insula is the fifth lobe of the brain and it is the least known.In each hemisphere of the mammalian brain the insular cortex (often called insula, insulary cortex or insular lobe) is a portion of the cerebral cortex folded deep within the lateral sulcus (the fissure separating the temporal lobe from the parietal and frontal lobes). It is completely covered by its neighboring cortical structures, the frontal, the parietal and the temporal operculum. Macroscopically, the central sulcus of the insula divides it into an anterior and a posterior part. The anterior part includes three short gyri, the anterior, middle and posterior short gyrus as well as an additional accessory gyrus on the ventral margin of the anterior part of the insula. The posterior part has two long gyri, an anterior and a posterior long gyrus.

Development

The insular cortex is considered a separate lobe of the telencephalon by some authorities. Other sources see the insula as a part of the lobe. It is also sometimes grouped with limbic structures deep in the brain into a limbic lobe. As a paralimbic cortex, the insular cortex is considered to be a relatively old structure.

Cytoarchitecture

Distinguishable cortical areas have been described in the insula, depending on the pattern of lamination or myelination. Based on the degree of granularity, a tripartition into an anterior agranular cortex, an intermediate dysgranular and a posterior granular cortex is commonly referred to in modern descriptions of the insula.

Neurophysiology

(1) Interoceptive awareness

The spindle neurons in right insular cortex are involved in cognitive-emotional processes, such as empathy and self-aware emotional feelings. This is supported by functional imaging results showing that the structure and function of the right frontal insula are correlated with the ability to feel one's own heartbeat, or to empathize with the pain of others. It is the role of the insula in conveying homeostatic information toconsciousness.The right anterior insula aids interoceptive awareness of body states, such as the ability to time one's own heartbeat. Moreover, greater right anterior insular gray matter volume correlates with increased accuracy in this subjective sense of

the inner body, and with negative emotional experience. It is also involved in the control of blood pressure, in particular during and after exercise, and its activity varies with the amount of effort a person believes he/she is exerting. The insular cortex also is where the sensation of pain is judged as to its degree. Those with irritable bowel syndrome have abnormal processing of visceral pain in the insular cortex related to dysfunctional inhibition of pain within the brain.Another perception of the right anterior insula is the degree of nonpainful warmthor nonpainful coldness of a skin sensation. Other internal sensations processed by the insula include stomach or gastric distension.A full bladder also activates the insular cortex.Other non-interoceptive perceptions include passive listening to music,laughter, and crying, empathy and compassion and language.

(2) Motor control

In motor control, it contributes to hand-and-eye motor movement,swallowing,gastric motility,speech articulation. It has been identified as a "central command" centrethat ensures that heart rate and blood pressureincrease at the onset of exercise. It is also involved in motor learningand has been identified as playing a role in the motor recovery from stroke.

(3) Homeostasis

It plays a role in a variety of homeostatic functions related to basic survival needs, such as taste, visceral sensation, and autonomic control. The insula controls autonomic functions through the regulation of the sympathetic and parasympathetic systems. It has a role in regulating the immune system.

(4) Self

It has been identified as playing a role in the experience of bodily self-awareness,sense of agency and sense body ownership.

(5) Social emotions

The anterior insula processes a person's sense of disgust both to smellsand to the sight of contamination and mutilation even when just imagining the experience. This associates with a mirror neuron-like link between external and internal experiences. In social experience, it is involved in the processing of norm violations, emotional processing, empathy and orgasms.

(6) Emotions

The insular cortex, in particular its most anterior portion, is considered a limbic-related cortex. The insula has an important role in pain experience and the experience of a number of basic emotions, including anger, fear, disgust, happiness, and sadness. The anterior insular cortex (AIC) is believed to be responsible for emotional feelings, including maternal and romantic love, anger, fear, sadness, happiness, sexual arousal, disgust, aversion, unfairness, inequity, indignation, uncertainty, disbelief, social exclusion, trust, empathy, sculptural beauty, a 'state of union with God', and hallucinogenic state.. The insula is well-situated for the integration of information relating to bodily states into higher-order cognitive and emotional processes.

(7) Salience

Interoceptive information processing that links interoception with emotional salience to generate a subjective representation of the body. This involves, first, the anterior insular cortex with the pregenual anterior cingulate cortex (Brodmann area 33) and the anterior and posterior mid-cingulate cortices, and, second, a general salience system concerned with environmental monitoring, response selection, and skeletomotor body orientation that involves all of the insular cortex and the mid-cingulate cortex.An alternative or perhaps complementary proposal is that the right anterior insular regulates the interaction between the salience of the selective attention created to achieve a task (the dorsal attention system) and the salience of arousal created to keep focused upon the relevant part of the environment (ventral attention system).

Clinical correlates

(1) Progressive non-fluent aphasia

Progressive non-fluent aphasia is the deterioration of normal language function that causes individuals to lose the ability to communicate fluently while still being able to comprehend single words and intact other non-linguistic cognition. It is found in a variety of degenerative neurological conditions including Pick's disease, motor neuron disease, corticobasal degeneration, frontotemporal dementia, and Alzheimer's disease. It is associated with hypometabolism and atrophy of the left anterior insular cortex.

(2) Addiction

The insular cortex is activated when drug abusers are exposed to environmental cues that trigger cravings. This has been shown for a variety of drugs, including cocaine, alcohol, opiates, and nicotine. Disruption of addiction was evidenced by self-reported behavior changes such as quitting smoking less than one day after the brain injury, quitting smoking with great ease, not smoking again after quitting, and having no urge to resume smoking since quitting. This suggests a significant role for the insular cortex in the neurological mechanisms underlying addiction to nicotine and other drugs, and would make this area of the brain a possible target for novel anti-addiction medication. In addition, this finding suggests that functions mediated by the insula, especially conscious feelings, may be particularly important for maintaining drug addiction.The insula may play a role in memory for the pleasurable interoceptive effects of past drug use, anticipation of these effects in the future, or both. Such a representation may give rise to conscious urges that feel as if they arise from within the body. This may make addicts feel as if their bodies need to use a drug, and may result in persons with lesions in the insula reporting that their bodies have forgotten the urge to use.

(3) Other clinical conditions

The insular cortex has been suggested to have a role in anxiety disorders, and emotion dysregulation.

Figure – The Insula – location and position in the brain