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Parietal Lobe

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Definition

The parietal lobe is a region of the human brain defined by anatomical landmarks. Within it are brain areas that process somatosensory information, spatial attention, visual-motor transformations, numerical computations, and language, including reading.

Introduction

The aim of this entry is to provide an overview of the parietal lobe of the brain. It will cover the basic anatomy in the human and non-human primate and general neural processing, briefly highlighting the effects of lesions in the human brain and neuronal processing in the non-human primate brain.

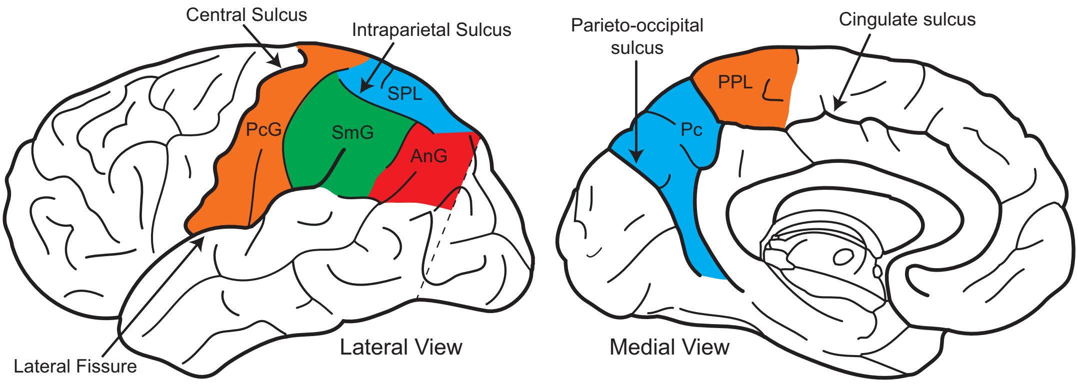
The Parietal Lobe in the Human Brain

Anatomy of the Parietal Lobe

In the human, the parietal lobe is situated posterior to the frontal lobe, anterior to the occipital lobe, and superior to the temporal lobe (Fig. 1). Several of its margins are defined by clear landmarks. On the lateral surface, it lies posterior to the central sulcus, which separates it from the frontal lobe, and superior to the lateral fissure (also called the Sylvian fissure), which separates it from the temporal lobe. On the medial surface, it lies superior to the cingulate sulcus, which separates it from the limbic lobe, and anterior to the parieto-occipital sulcus, which separates it from the occipital lobe. At the posterior end on the lateral surface, it is separated from the occipital and temporal lobes by two imaginary lines. The first runs from the tip of the parieto-occipital sulcus, which is on the medial aspect of the brain, to the preoccipital notch and separates the parietal lobe from occipital lobe (dashed line, Fig. 1). The second is an imaginary extension of the lateral fissure, which separates the parietal lobe from the temporal lobe.

Within the parietal lobe, there are six main regions: four on the lateral surface and two on the medial surface. On the lateral surface, between the central sulcus and the postcentral sulcus, is the postcentral gyrus (PcG). Poster to this, the parietal lobe is divided by the intraparietal sulcus to form the superior parietal lobule (SPL) and the inferior parietal lobule. The latter is typically divided into two regions: the supramarginal gyrus (SmG) and the angular gyrus (AnG). On the medial aspect of the brain, the postcentral gyrus is contiguous with the posterior paracentral lobule (PPL), which ends at the marginal limb of the cingulate sulcus. Posterior to the cingulate sulcus is the precuneus (Pc),

J. Vonk, T.K. Shackelford (eds.), *Encyclopedia of Animal Cognition and Behavior*,
https://doi.org/10.1007/978-3-319-47829-6_1252-1



Parietal Lobe, Fig. 1 The parietal lobe in the human brain. The extent of the parietal lobe is indicated by the colored areas, which are coded based on the regions within the lobe. *PcG* Postcentral gyrus, *SPL* superior parietal lobule, *SmG* supramarginal gyrus, *AnG* angular gyrus, *PPL* posterior paracentral lobule, *Pc* precuneus

which is an extension of the superior parietal lobule and ends at the parieto-occipital sulcus.

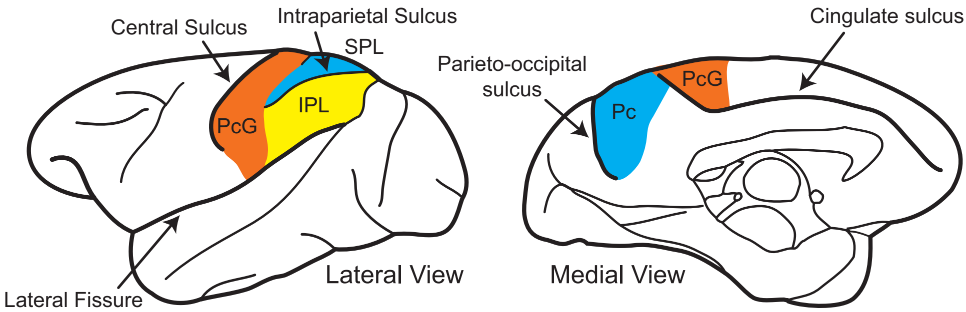
Functions of the Parietal Lobe

Primary somatosensory cortex lies in the postcentral gyrus, adjacent to the central sulcus. This is the main cortical area to receive information from the body about proprioception (information about body and limb position) and touch. The rest of the parietal lobe is composed of association areas: cortical areas that further process sensory information from one sensory source (unimodal) or from several sensory sources (multimodal). The unimodal association areas tend to be close to their respective primary sensory cortical areas. So somatosensory association areas are close to the postcentral gyrus, and visual association areas are close to the occipital lobe. The remaining areas within the parietal lobe are multimodal association areas.

The parietal lobe is one of the more lateralized lobes within the brain. Many of the multimodal association areas in the human parietal lobe have different functions on the left and right side of the brain. In most people, the left side is the *dominant hemisphere*. Together with the temporal lobe, regions of the inferior parietal lobule in the dominant hemisphere are involved in language comprehension. Lesions of this area produce *Wernicke's aphasia*: patients can have difficulty reading, comprehending speech, writing, or speaking. Deficits in writing or speaking are not motor related, but are due to an inability to put the correct words into a written or spoken sentence. Lesions around the angular gyrus can also cause computational difficulties.

More dorsal lesions, around the intraparietal sulcus, can produce deficits in visually guided movements. These can include forms of *apraxia*, in which patients have difficulty executing learned and skilled movements, and *optic ataxia*, in which the patient has difficulty in making accurate and appropriate visually guided movements, including the grasping of objects they can recognize and describe. While these deficits are usually seen after lesions of the dominant hemisphere, they can follow from lesions of the nondominant hemisphere.

Lesions in the parietal lobe of the nondominant (usually the right) hemisphere tend to have a striking effect on the awareness of space. Thought to be due to deficits in the mechanisms underlying visual attention, patients can exhibit signs of *hemispatial neglect* or *extinction*. A patient with neglect tends to ignore the spatial world on the contralateral side (usually the left side of visual space). For example, they may draw a clock with the numbers 1 to 12 all on the right side of the circle or they may draw an object, but leave out features on the left side. In severe cases, patients



Parietal Lobe, Fig. 2 The parietal lobe in the nonhuman primate brain. The extent of the parietal lobe is indicated by the colored areas, which are coded based on the regions within the lobe. *PcG* Postcentral gyrus, *SPL* superior parietal lobule, *IPL* inferior parietal lobule, *Pc* precuneus

can be unaware that the left side of their body belongs to them. Extinction is a more subtle deficit in which patients do not notice a visual or tactile stimulus on their affected side (usually the left) when simultaneously presented with a similar stimulus on their intact side, but they are able to notice it when presented alone.

The Parietal Lobe in the Nonhuman Primate Brain

Anatomy of the Nonhuman Primate Parietal Lobe

Aspects of the parietal lobe in the nonhuman primate are quite similar to the parietal lobe in the human (Fig. 2). Laterally, the anterior boundary is the central sulcus and the inferior boundary is the lateral fissure; medially, the posterior boundary is the parieto-occipital sulcus. However, the remaining boundaries are not as well established. On the medial aspect, the cingulate sulcus in the nonhuman primate does not curve inferiorly as it does in the human, so we have defined the inferior anterior boundary of the parietal lobe based on where cingulate cortical areas, as defined functionally and cytoarchitectonicly, end and parietal cortical areas begin. Laterally, we have placed the posterior boundary of the lobe at the extension of the superior temporal sulcus. The area posterior to the superior temporal sulcus has been identified as the angular gyrus (Martin and Bowden 2000), which in humans is part of the parietal lobe. While this does appear to be the gross anatomical homologue, in terms of cortical areas, it is more homologous with the occipital lobe in the human, so we have not included it as part of the parietal lobe here.

The major regions within the parietal lobe of the nonhuman primate are similar to those in the human. Adjacent to the central sulcus is the postcentral gyrus, the intraparietal sulcus divides the superior parietal lobule from the inferior parietal lobule, and on the medial aspect posterior to the cingulate sulcus is the precuneus. Areas within the SPL and IPL are frequently described as being part of posterior parietal cortex. A key advantage of the nonhuman primate over the human is the ease with which physiological and histological mapping can be done. The regions labeled in Fig. 2 are all made up of multiple brain areas defined in these ways. In the following section, we will list some of the major and better understood brain areas with a brief note about their functions.

Functions of the Nonhuman Primate Parietal Lobe

Functionally, the nonhuman primate lacks the lateralization seen in the human parietal lobe, but the basic foundations remain. Primary somatosensory cortex is found in the postcentral gyrus along with a number of areas involved in processing somatosensory information. The superior parietal lobule is primarily composed of area 5, which itself can be broken down into a number of areas (PE, PEc, PEip, MIP) based on cytoarchitecture and connections (Pandya and Seltzer 1982). These areas all appear to play important roles in visually guided movements, including visually guided reaching (Breveglieri et al. 2006; Snyder et al. 2000). In some studies, several of these areas close to the intraparietal sulcus are grouped and termed the parietal reach region (PRR). Area AIP, which seems to have a similar function for grasping actions (Sakata et al. 1995), is found at the anterior end of the lateral/posterior wall of the intraparietal sulcus. These areas are likely to be nonhuman primate homologues of the areas that, when lesioned, create apraxia and optic ataxia.

Deep in the intraparietal sulcus is area VIP, a multimodal area which receives visual inputs, somatosensory inputs that appear to come from areas of the body with congruent receptive fields to the visual inputs, and vestibular inputs (Chen et al. 2011; Duhamel et al. 1998). Further, neurons in this area appear to encode numerosity as well. Part of the lateral/posterior bank of the intraparietal sulcus is area LIP, which is thought to be involved in the processing of visual information for the guidance of attention – both covert attention and eye movements (Bisley and Goldberg 2010). It appears to be a more specialized region within area 7, which encompasses much of the IPL. It is likely that these areas are the nonhuman homologues of the areas that, when lesioned, create neglect and extinction.

On the medial aspect of the parietal lobe are continuations of areas within the somatosensory cortex as well as area 7 and PEc. In addition, there are a number of multimodal association areas (such as V6, V6A, and LOP) that integrate visual and somatosensory information (Galletti et al. 1999a; Galletti et al. 1999b). Areas V6 and the ventral aspect of V6A appear to be high level visual processing areas providing visual information for movements. The dorsal aspect of V6A is affected more by somatosensory inputs and is thought to be more closely related to visually guided grasping movements. Each of these areas has strong connections with regions within area 5, including MIP and AIP.

Although the parietal lobe, as seen in the human, is not obviously present in species with lissencephalic brains – that is, brains that do not have prominent sulci – many primate and lower species have homologous somatosensory cortices and posterior parietal cortex areas with multimodal sensory processing to aid in driving motor commands.

Cross-References

▶ Lateral Intraparietal Region (LIP)
▶ Occipital Lobe
▶ Parieto-occipital Sulcus (POS)
▶ Primary Somatosensory (PI)
▶ Superior Parietal Lobe
▶ Superior Temporal Sulcus
▶ Temporal Lobe

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