RHINAL FISSURE

Authored by

mohammad looti

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1. Core Definition

The Rhinal Fissure, alternatively known as the rhinal sulcus, is a distinct cleft or groove located on the basal (inferior) and medial surface of the brain's temporal lobe. Its position is specifically anterior, beginning near the temporal pole and extending posteriorly for a variable distance. As an essential anatomical landmark, the fissure delineates the transition zone between phylogenetically older cortical structures (paleocortex and archicortex remnants) and the surrounding six-layered neocortex. The original source confirms the bilateral presence of this structure, stating there are two rhinal fissures, one situated on the anterior medial surface of each temporal lobe.

In anatomical terms, the rhinal fissure is crucial because it marks the lateral boundary of the rhinencephalon, or "nose-brain," structures, and the medial boundary of the more lateral neocortical areas. It serves as a superior-lateral boundary for the uncus--the anterior-most portion of the parahippocampal gyrus--and the anterior medial temporal lobe cortex, which contains vital memory processing centers. Despite its relatively small size in humans compared to some other species, its location adjacent to the hippocampus and amygdala positions it at the center of critical neurobiological circuits.

Functionally, the significance of the rhinal fissure lies not in the fissure itself, but in the highly specialized cortical areas that immediately border it, collectively known as the rhinal cortex. These areas--the perirhinal and entorhinal cortices--are integral components of the medial temporal lobe memory system. The fissure provides the external neuroanatomical reference point allowing researchers and clinicians to consistently locate these underlying structures, which play fundamental roles in object recognition, spatial mapping, and the encoding of declarative memories.

2. Etymology and Historical Development

The term "rhinal" originates from the ancient Greek word *rhis*, meaning "nose." This etymology reflects the historical understanding of the structures bordering the fissure as being intimately connected to the olfactory system. In early comparative anatomy studies, particularly in non-primate mammals (like rodents), the rhinal fissure is far more prominent and is the primary anatomical division separating the olfactory bulb and associated paleocortex from the remainder of the neocortical mantle. This prominent division underscores the early evolutionary importance of olfaction and its dedicated pathway in the mammalian brain.

During the 19th and early 20th centuries, as neuroanatomists sought to map the burgeoning fields

of the human brain, the rhinal fissure was recognized as a consistent marker, though its appearance varies significantly across species. In lower mammals, the fissure separates the pyriform lobe (olfactory cortex) from the dorsal isocortex. In primates, and particularly in humans, the immense expansion of the neocortex has shifted and reduced the relative size and clarity of the rhinal fissure. This transformation led to considerable confusion in nomenclature, as the fissure became partially obscured or fused with the neighboring collateral sulcus, requiring more precise histological definitions rather than gross anatomical observation alone.

The study of the rhinal fissure gained immense importance in the mid-20th century following seminal lesion studies in non-human primates and surgical procedures in humans (such as the case of H.M.). These works demonstrated unequivocally that the cortex surrounding this fissure--the perirhinal and entorhinal areas--was essential for forming new memories. The historical development of the concept shifted the focus from the fissure merely as an olfactory boundary to its role as a critical interface for the declarative memory system, solidifying its place as a cornerstone in modern neuroscience research.

3. Key Characteristics (Anatomy and Location)

The Rhinal Fissure is characterized by its shallow nature and its typical orientation parallel to the long axis of the temporal lobe, running posteroanteriorly. It generally originates near the temporal pole and courses posteriorly, terminating before the point where the uncus transitions completely into the parahippocampal gyrus. Its exact length and depth are highly variable among individuals, and in approximately 50-70% of human brains, it is not anatomically continuous with the collateral sulcus, although the two are often closely associated and sometimes appear as a single, large sulcus.

This fissure defines the lateral border of the Entorhinal Cortex (EC) which lies medially (superiorly). The EC is a key hub for memory, located within the parahippocampal gyrus. Laterally (inferiorly) to the rhinal fissure lies the anterior portion of the temporal neocortex, often including the temporal pole and the beginning of the Perirhinal Cortex (PRC). Thus, the fissure serves as a major dividing line, separating the allocortical/periallocortical structures of the medial temporal lobe from the isocortical structures of the inferior temporal lobe.

Microscopically, the rhinal fissure is the external manifestation of a sharp transition in cortical cytoarchitecture. Medial to the fissure, the cortex exhibits characteristics of transitional cortex (periallocortex), often thinner and possessing fewer layers (or layers that are poorly defined, such as in the five-layered PRC). Lateral to the fissure, the cortex rapidly adopts the six-layered structure characteristic of the temporal neocortex. This abrupt histological change, marked by the sulcus, reflects the evolutionarily preserved boundary between the ancient olfactory and limbic systems and the later-developing sensory and associative cortices.

4. Functional Significance and Associated Structures

The functional significance of the rhinal fissure is entirely derived from the structures it demarcates: the Perirhinal Cortex (PRC) and the Entorhinal Cortex (EC). These two regions constitute the primary pathway through which highly processed sensory information enters the hippocampal formation for the process of encoding new long-term declarative memories. Therefore, damage affecting the area immediately around the rhinal fissure results in profound amnesic syndromes, particularly affecting recognition memory.

The PRC, which lies largely adjacent to the fissure, is specialized for processing complex visual and multimodal sensory information related to specific objects and items. It is critically involved in "what" memory--the ability to recognize objects and assess their familiarity. Studies involving lesions restricted primarily to the PRC have shown highly selective deficits in recognition memory, while often sparing spatial memory. This highlights the PRC's role in detailed item representation, acting as a crucial bottleneck for object identity before memory information reaches the hippocampus.

The EC, positioned medially to the fissure, functions as the principal gateway to the hippocampus, providing the majority of its cortical input via the perforant pathway. The EC is not unitary; its lateral and medial divisions handle distinct information streams. The medial EC is famous for containing specialized neurons known as grid cells, which are fundamental to the brain's spatial navigation system, creating a cognitive map of the environment. The lateral EC primarily relays non-spatial information, including object and contextual details. The rhinal fissure visually represents the convergence point of these critical informational pathways.

The coordinated activity of the PRC and EC, separated by the rhinal fissure, is essential for Episodic Memory--the recollection of specific events, including the "what," "where," and "when." The PRC handles the item detail (the "what"), while the EC routes the spatial and contextual information (the "where" and associative links) into the hippocampus, where they are integrated and temporarily stored. The integrity of the cortical tissue surrounding the rhinal fissure is thus non-negotiable for the successful operation of the overall medial temporal lobe memory system.

5. Clinical Relevance and Disorders

The anatomy defined by the rhinal fissure holds significant clinical relevance, primarily because the adjacent cortical structures are notoriously vulnerable to neurodegenerative and neurological disorders. Perhaps most significantly, the Entorhinal Cortex is recognized as the site of initial and severe pathology in Alzheimer's disease (AD). The presence of neurofibrillary tangles, one of the pathological hallmarks of AD, is typically first detected in the transentorhinal and entorhinal cortices before spreading to the hippocampus and other neocortical areas. This early involvement explains why memory loss, particularly episodic memory impairment, is often the first symptom reported by

AD patients, directly linking the function of this region to disease progression.

Furthermore, the medial temporal lobe, encompassing the structures bordering the rhinal fissure, is the most common site of seizure initiation in patients suffering from Temporal Lobe Epilepsy (TLE). The perirhinal and entorhinal cortices exhibit a relatively low seizure threshold, and sclerosis (hardening and atrophy) of the hippocampus and surrounding tissue (known as hippocampal sclerosis) is a frequent finding in chronic TLE. The surgical treatment for intractable TLE often involves the targeted resection of the anterior medial temporal lobe, including portions of the rhinal cortex, in an effort to eliminate the seizure focus, often resulting in controlled deficits in specific aspects of recognition memory.

In cases of severe traumatic brain injury or stroke, vascular compromise affecting the anterior medial temporal lobe, supplied by branches of the posterior cerebral artery, can selectively damage the rhinal cortex. Such damage can lead to profound and isolated amnesic syndromes, providing clinical confirmation of the importance of the perirhinal and entorhinal areas. The meticulous identification of the rhinal fissure via high-resolution neuroimaging (MRI) is therefore an essential component of clinical neuroanatomical assessment, helping to localize pathology and predict resulting cognitive deficits.

6. Debates and Criticisms (Nomenclature)

The primary debate concerning the rhinal fissure centers on its precise demarcation in the human brain relative to the adjacent Collateral Sulcus (CoS). In many anatomical texts, the terms "rhinal sulcus" and "collateral sulcus" are treated somewhat interchangeably or, conversely, highly distinct, leading to inconsistency in functional mapping studies. The issue arises because, in humans, the CoS is a long, deep sulcus running more posteriorly, and the rhinal fissure is essentially its anterior, shallower extension. In a significant number of human brains, these two sulci merge into a continuous structure, making clear differentiation challenging.

Modern neuroanatomical consensus attempts to resolve this ambiguity by defining the rhinal fissure as the segment that separates the entorhinal cortex from the temporopolar cortex, residing anterior to the level of the hippocampus's head. Conversely, the collateral sulcus is defined as the segment that separates the parahippocampal gyrus (posterior to the uncus) from the fusiform gyrus. The anatomical importance of this debate is profound for lesion studies; researchers need to know precisely which cortex--entorhinal or perirhinal--is damaged versus surrounding neocortex. Mislabeling the boundary can lead to erroneous conclusions about the specific roles of these memory substructures.

Furthermore, criticisms of the term often arise from its etymological connection to olfaction, which is a less dominant function in the temporal lobe of higher primates than it is in rodents. While the rhinal cortex is clearly part of the limbic system, its primary functional role in humans is declarative

memory processing, leading some researchers to prefer purely positional or cytoarchitectural terms (e.g., area 28 for EC) over the historical term "rhinal." Nonetheless, "rhinal fissure" remains the established gross anatomical term for this critical medial temporal lobe landmark.

7. Further Reading

Wikipedia: Rhinal sulcus
Wikipedia: Temporal Lobe
ScienceDirect: Entorhinal Cortex
ScienceDirect: Perirhinal Cortex