

SECONDARY SOMATOSENSORY AREA (S2)

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SECONDARY SOMATOSENSORY AREA (S2)

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1. Core Definition and Location

The Secondary Somatosensory Area, commonly abbreviated as **S2**, represents a crucial area of the cerebral cortex dedicated to the higher-order processing and integration of tactile and somatosensory information. Anatomically, S2 is situated primarily within the parietal lobe, specifically located deep within the lateral sulcus (also known as the **Sylvian fissure**), residing in the parietal operculum, which is the cortical tissue forming the upper lip of this fissure. While the **Primary Somatosensory Cortex (S1)** handles the initial registration of simple sensory data such as intensity and location, S2 is responsible for the complex analysis required for object recognition through touch, often called **stereognosis**. Its functional definition is based on electrophysiological studies demonstrating responsiveness to peripheral tactile stimulation, complementing the map established in S1.

Functionally, S2 serves as a secondary receiving area for sensibility to touch stimulation originating from the skin. It synthesizes information regarding complex sensory features, including texture, size, and shape, and is vital for integrating sensory input from both sides of the body. Unlike S1, which is rigidly somatotopically organized and largely contralateral, S2 exhibits bilateral receptive fields, meaning neurons in this area can respond to stimuli applied to either the left or the right side of the body. This bilateral representation is essential for coordinated motor actions involving both hands and for maintaining a holistic, integrated body schema.

2. Historical Identification and Mapping

The identification of the Secondary Somatosensory Area followed the extensive mapping of S1, largely through classical neurophysiological techniques involving electrical stimulation and recording in both primates and humans. Early research, particularly in the mid-20th century, used surface electrodes to record evoked potentials following peripheral nerve stimulation. These studies consistently demonstrated a second, smaller, and less precise representation of the body surface located lateral and inferior to the main S1 area, leading to its designation as S2. The pioneering work often involved defining cortical regions based on their responsiveness to tactile stimuli across various body parts, confirming that S2 processed somatosensory input distinct from S1.

Further confirmation of S2's existence and function was provided by cytoarchitectonic studies, which analyze the cellular structure of cortical areas. While S1 corresponds largely to Brodmann Areas 1, 2, and 3, the region associated with S2 often includes portions of the parietal operculum

and the adjacent insular cortex, though its precise borders vary across species. The identification techniques relied heavily on the difference in response properties between S1 and S2 neurons; specifically, the discovery that S2 neurons often possess larger receptive fields and respond to a broader class of stimuli, indicating a higher level of sensory integration compared to the fine discriminative input handled by S1. This historical progression marked S2 as a critical node in the hierarchical flow of somatosensory processing.

3. Afferent Connections: Input Pathways

The connectivity of the Secondary Somatosensory Area is hierarchically structured, positioning it as a major recipient of processed information from the primary sensory regions. The most significant afferent pathway originates from the **Primary Somatosensory Cortex (S1)**. Neuronal projections travel directly from S1--specifically from areas involved in tactile processing--to S2, carrying refined, highly localized, and temporally precise sensory data. This direct projection ensures that S2 receives a high-fidelity input stream necessary for complex interpretive functions. The integrity of this S1-to-S2 pathway is considered fundamental for the sequential organization of somatosensory perception.

In addition to the corticocortical input from S1, S2 also receives projections directly from the **thalamus**, bypassing S1 entirely, although these pathways are typically less dominant. These thalamic inputs primarily originate from the Ventral Posterior Lateral (VPL) and Ventral Posterior Medial (VPM) nuclei, which relay sensory information from the body and face, respectively. This dual input mechanism--receiving both primary processed information (via S1) and raw, direct information (via the thalamus)--allows S2 to perform parallel processing, contributing to its role in sensory integration and modulation. Furthermore, S2 receives indirect, modulatory input from other areas, including association cortices and possibly certain limbic structures, highlighting its role beyond mere sensory relay.

4. Efferent Connections: Output and Projections

The efferent projections of S2 are extensive and diverse, underscoring its pivotal role in linking somatosensation to motor planning, spatial awareness, and limbic functions. The information processed in S2 is crucial for guiding interaction with the environment and is distributed to several key cortical and subcortical regions. One major destination is the **lateral parietal cortex**, which integrates somatosensory data with visual and auditory information to create a coherent sense of space and body position. This connection is vital for spatial orientation and the planning of complex reaching or navigational movements.

Crucially, S2 projects strongly to both the **motor** and **premotor areas** of the frontal lobe. This connection forms the sensory-motor loop necessary for skilled motor actions. For example, when

grasping an object, S2 provides the motor system with continuous feedback regarding the object's texture, weight, and current position in the hand, allowing for precise force adjustments and successful manipulation. Without this feedback loop, fine motor skills would be severely compromised.

A particularly significant efferent pathway connects S2 to the **insular cortex**, a region deeply involved in interoception, pain perception, and emotion. Through this link, S2 contributes to the affective and cognitive aspects of touch and pain processing, helping to determine the emotional significance of sensory stimuli. Additionally, S2 sends projections to limbic structures such as the **amygdala** and **hippocampus**, suggesting its involvement in the formation of sensory memories and the emotional responses associated with specific tactile experiences.

5. Functional Roles: Touch Integration and Recognition

The primary functional role of the Secondary Somatosensory Area is the integration of simple somatosensory features into recognizable objects and surfaces. While S1 detects that something is touching the skin, S2 helps determine what that object is. This higher-level processing includes the ability to perform tactile discrimination tasks, such as differentiating between sandpaper and silk, or determining the precise size and contour of a key purely by touch. This function, known as **haptic perception**, is arguably S2's most significant contribution to daily life.

Furthermore, S2 is uniquely involved in the processing of **bilateral somatosensory information**. Because many real-world tasks (such as tying shoelaces or peeling fruit) require simultaneous or sequential sensory input from both hands, S2 acts as the convergence zone where these inputs are unified into a single perceptual experience. This bilateral integration is essential for coordinating actions that require cross-midline cooperation. Damage to S2 can severely impair the ability to recognize objects held simultaneously in both hands, even if primary sensation remains intact.

Beyond simple touch, S2 is recognized as a key component of the cortical pain matrix. It receives nociceptive (pain) signals and contributes to the evaluation of pain intensity and location, working in conjunction with the insula and anterior cingulate cortex. Its role in affective touch--the softer, emotionally resonant forms of touch often mediated by C-tactile fibers--is also a growing area of research, linking S2 to social bonding and affective experience.

6. The Somatotopic Organization of S2

Although S2 possesses a representation of the body, its somatotopy is markedly different from the highly organized and distinct homunculus found in S1. The mapping in S2 is generally described as being **crude** or **overlapping**, rather than strictly segregated. Typically, electrophysiological studies reveal two mirrored or partial representations of the body surface within the parietal

operculum, often referred to as S2 and the adjacent parietal ventral area (PV).

The key characteristic of the S2 somatotopic map is the dominance of **bilateral receptive fields**. While S1 neurons primarily respond to stimulation on the contralateral side of the body, a substantial proportion of S2 neurons respond to input from both the ipsilateral and contralateral sides. This structural feature underlies S2's functional capability for bilateral integration, making it less of a primary locator of stimuli and more of an integrator of whole-body sensory input. The representations often emphasize the parts of the body used for active interaction, such as the hands and mouth, reflecting S2's involvement in manipulation and feeding behaviors.

7. Clinical Significance and Related Syndromes

Damage or lesions affecting the Secondary Somatosensory Area, often due to stroke or trauma affecting the parietal operculum, can lead to specific deficits in tactile processing. While primary loss of sensation (anesthesia) is typically linked to S1 damage, S2 lesions can result in **tactile agnosia** or **astereognosis**--the inability to recognize objects by touch, despite having intact primary sensation (i.e., the patient can feel the object but cannot identify it). This confirms S2's role as the interpretive center for somatosensory input.

Furthermore, S2's strong connections with the pain network highlight its relevance in chronic pain conditions. Abnormal activity or reorganization within S2 has been implicated in conditions such as **phantom limb pain** and certain neuropathies. Research suggests that the maladaptive plasticity of somatosensory maps, which may involve altered S1-S2 interactions, contributes significantly to the persistence and severity of chronic pain experiences, making S2 a potential target for therapeutic interventions aimed at neuromodulation.

Further Reading

[Secondary Somatosensory Cortex \(S2\)](#)

[Somatosensory Cortex](#)

[Neuroscience: The Parietal Lobe and Spatial Cognition](#)