Medical Neuroscience | Tutorial Notes

Overview of Associational Cortex

MAP TO NEUROSCIENCE CORE CONCEPTS[1]

NCC5. Intelligence arises as the brain reasons, plans, and solves problems.

NCC7. The human brain endows us with a natural curiosity to understand how the world works.

LEARNING OBJECTIVES

After study of the assigned learning materials, the student will:

1. Characterize the behaviors and corresponding neural processes that contribute to cognition.
2. Discuss the major similarities and differences in the organization of primary cortex and associational cortex.

TUTORIAL OUTLINE

I. Introduction to the neuroscience of cognition

A. lay-person's definition of cognition: the process of knowing

B. neurobiological definition: the neural processes by which the brain integrates meaningful stimuli, memory, and internal motivations producing perceptional awareness and appropriate behavior

C. **Table 1**. Neural processes that contribute to cognition

Cognitive process	Metaphor / Example	Neural Process
Attention	cognitive "search light"	modulatory influences of brainstem reticular formation, hypothalamus and basal forebrain nuclei on thalamic and cortical processes
Recognition	finding a friend's face in a crowd	coding of feature representations in primary and higher order sensory cortices
Integration	knowing that friend	integration ("association") of disparate processing streams in associational cortices
Planning	deciding to seek out that friend	processing in executive associational cortices in prefrontal cortex of frontal lobe
Selection & execution	Walking towards that friend and engage in conversation	implementation of short-term and long-term plans via somatic motor, visceral motor and emotional motor systems

[1] Visit **BrainFacts.org** for *Neuroscience Core Concepts* (©2012 Society for Neuroscience) that offer fundamental principles about the brain and nervous system, the most complex living structure known in the universe.

II. Anatomy of the Associational Cortex

A. review of cortical structure and function

1. "canonical" (i.e., standard/representative) cortical microcircuit

a. the **columnar circuit** is the fundamental unit of processing and computation in the complex circuitry of the cerebral cortex

b. within a cortical column, different types of excitatory and inhibitory neurons populate distinct cellular layers

(i) the main excitatory neurons are **pyramidal neurons**

(ii) the **inhibitory neurons** are diverse morphologically and functionally

c. each layer maintains distinct sets of inputs and outputs

(i) pyramidal neurons project:

- to other neurons in the same layer and across layers within the local column
- to other columns in the same cortical area
- to other columns in other cortical areas, including the corresponding area in the opposite cerebral hemisphere
- to subcortical targets (e.g., corticospinal tract neurons)

(ii) most inhibitory neurons project locally within their home layer and column, but some do project across cortical columns within the same area (few project to other areas; very few if any project to the other hemisphere or subcortically)

B. distribution of associational cortex (see **Figure 26.1**[2])

1. only about 25% of the cerebral mantle is comprised of primary sensory and motor cortex; the remaining 75% is termed **associational cortex**

2. with the possible exception of the occipital lobe (which is largely if not entirely devoted to increasingly complex aspects of visual processing), all other lobes contain associational cortex

3. as its name implies, the associational cortex integrates (or associates) different types of inputs, some of which come from primary and higher order sensory cortex

4. it is in the associational cortices that most of the neural processes of cognition are carried out (together with interactions among subcortical neural centers)

C. differences between associational cortex and primary cortex (see **Figure 26.4**)

1. unlike primary cortices, which receive their main input from specific sensory and motor relay nuclei of the thalamus, the associational cortex receives its most influential input from *other parts of the cortex*

[2] Figure references to Purves et al., *Neuroscience, 5th Ed.*, Sinauer Assoc., Inc., 2012. [click here]

2. associational cortex does receive input from thalamus, but it arises from thalamic nuclei (pulvinar, posterior nuclei, and mediodorsal nucleus) that are themselves driven by highly processed "feedback" projections from the cortex (rather than from "feedforward" sensory systems) (see also **Appendix BoxA**)
3. other sources of input come from brainstem modulatory systems:
    a. noradrenergic cells of the locus coeruleus
    b. serotonergic cells of the Raphe nuclei
    c. dopaminergic cells of the ventral tegmental area)
4. and from the basal forebrain:
    a. cholinergic cells in the basal nucleus of Meynert

STUDY QUESTION

Cognition is an emergent property of brain function, reflecting (as Charles Sherrington famously put it a century ago) the integrative action of the nervous system. Nevertheless, it is useful to identify and study distinct neurobiological mechanisms that support disparate functions that contribute to cognition. Which cognitive process is attributable to the functions of brainstem modulatory (biogenic amine) systems?

A. selection and execution of short and long-term plans
B. integration of disparate processing streams
C. recognition and coding of salient features
D. attentional modulation of sensory processing
E. planning appropriate behaviors