Medical Neuroscience | Tutorial Notes

Associational Cortex of the Temporal Lobe

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. Discuss the major functions that are localized to the associational cortex of the temporal lobe.
2. Differentiate categories of human memory and discuss the relevant neuroanatomical systems.
3. Differentiate Broca's and Wernicke's aphasia.
4. Discuss dementia and relate its associated cognitive signs to associational cortex.

TUTORIAL OUTLINE

I. Temporal associational cortex

- A. visual recognition
  - 1. harbors higher order visual pathways in the ventral ("what") processing stream, in addition to associational cortex that integrates information from other sensory systems to form representations of objects (see **Figure 12.18**[2])
  - 2. damage can lead to **agnosias** ("not knowing")
    - a. in general, agnosias refer to deficits in the recognition and/or naming of specific objects, despite an awareness of their presence
    - b. e.g., **prosopagnosia** ("prosopo" Greek, = face or person): inability to recognize faces
      - i. in the inferior temporal gyrus and the lateral occipitotemporal gyrus (fusiform gyrus), there are neurons that respond selectively to (primate) faces (see **Figure 26.11** & **26.13**)
      - ii. some cells are selective for only certain views of faces (see **Figure 26.13C**& **26.14**)

[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.

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

iii. damage to the right inferior temporal lobe commonly leads to prosopagnosia

B. formation of declarative (episodic) memory

1. different categories of memory

a. declarative vs procedural (non-declarative) (see **Figure 31.1**)

b. immediate; working memory; long-term memory(see **Figure 31.2**)

2. brain systems for the acquisition and storage of memory

a. declarative memory

i. acquisition requires **hippocampal formation** and associated temporal cortex (see **Figure 31.9**)

ii. damage to the medial temporal lobe produces **amnesia** (pathological forgetting)

iii. memory storage involves widespread cortical areas that are specialized for processing particular modes of information (e.g., sensory-specific areas) (see **Figure 31.14**)

b. procedural memory (i.e., **motor learning**) (see **Figure 31.17**)

i. acquisition of motor skills involves cerebellum and the motor cortex

ii. storage involves widespread cortical regions, including premotor areas and the cerebellum

c. memory and aging (see **Figure 31.18** & **31.19**)

i. with normal aging, the brain continues to change

- overall brain sizes decreases
- synaptic density (connections) decreases
- myelination becomes less compact (efficiency of information processing likely decreases)
- but the numbers of neurons is not changing significantly (neuronal loss in pathological, not part of normal healthy aging)

ii. like most organ systems, the brain benefits from cardiovascular fitness across the lifespan

- physical exercise is the single best activity to support brain health into older adulthood
- there is less clear evidence suggesting that cognitive exercise is also beneficial
- there is no compelling evidence for the benefits of dietary supplements (assuming a balanced diet) in supporting brain health in older adulthood (caveat emptor!)

iii. dementia and Alzheimer's disease (see **Box 31D**)

- dementia is a syndrome characterized by memory deficit with at least one other cognitive deficit
- Alzheimer's disease is the most common cause of dementia
- one of the first and most severely affected brain systems is the medial temporal lobe memory system
- the cortical distribution of neuritic tangles and plaques helps to explain what aspects of cognition are afflicted with disease progression

C. language

1. the ability to associate arbitrary symbols with specific meanings, and the ability to use such symbols to report thoughts and emotions
2. linguistic abilities are localized to specific divisions of associational cortex in the temporal and frontal lobes
   a. cerebral centers devoted to language processing transcend the essential sensory and motor functions associated with hearing or reading words and speaking, signing or writing words
   b. there are separate divisions of the associational cortex devoted to the **reception** and **expression** of linguistic symbols (see **Figure 27.2**)
   c. reception of language
      i. **Wernicke's area** (posterior speech cortex) (named for the German neurologist, Carl Wernicke)
      ii. frequently located in the posterior portion of the superior temporal gyrus, but important nodes in an extended network of lateral temporal cortex may be distributed across the lateral aspect of the temporal lobe and into the inferior parietal lobule
      iii. Wernicke's "area" (network) integrates sensory information that represents language
      iv. damage results in fluent expression of language, but impaired comprehension of language (**Wernicke's aphasia**) (see **Table 27.1**)
   d. expression of language
      i. **Broca's area** (named for the French physician, Paul Broca)
      ii. located in the posterior portion of the inferior frontal gyrus
      iii. coordinates the production of language (**expression**)
      iv. "pre-motor" function for language (consistent with its position in the posterior and inferior frontal lobe; may be considered a functional component of the lateral premotor cortex)

v. damage results in normal comprehension of language, but impaired expression of language (**Broca's aphasia**) (see **Table 27.1**)

visit **BrainFacts.org** for a compelling and inspiring account of one family's coping with Broca's aphasia; click here

e. linguistic abilities are **lateralized**

i. corresponding divisions of the association cortex in the two hemispheres contribute to language processing; however, the specific contributions of the two hemisphere are different

- for approximately 95% of us, Wernicke's and Broca's areas are lateralized to the **left hemisphere**
- however, Brodmann's Areas 22 (Wernicke's) and 44/45 (Broca's) on the right side also contribute to language function (**prosody**)
  - Area 22 in the right hemisphere is involved with perceiving the emotional content of language
  - Area 44/45 in the right hemisphere can produce rudimentary words and phrases in subjects with damage to the left frontal lobe; the right hemisphere is also involved in producing the modulations of vocal tone that imbue speech with emotional content

ii. gender differences?

- lateralization of language functions appears to be less obvious in about 20% of women
- women are less likely to develop language impairments following middle cerebral artery stroke than men

STUDY QUESTIONS

Q1. What neurological problems would you expect with a patient who suffered a stroke involving branches of the **right posterior cerebral artery** that supply inferior temporal cortex?

A. profound inability to produce fluent speech
B. diminished capacity to infuse emotional content into speech
C. profound difficulty understanding the semantic content of speech
D. diminished capacity to appreciate emotional nuance in speech
E. loss of ability to read
F. profound difficulty naming familiar faces
G. profound difficulty perceiving the movement of objects and people in the visual world
H. profound amnesia
I. profound difficulty recalling events from childhood

Q2. What neurological problems would you expect with a patient who suffered a stroke involving inferior branches of the **right middle cerebral artery** that supply lateral temporal cortex?

A. profound inability to produce fluent speech
B. diminished capacity to infuse emotional content into speech
C. profound difficulty understanding the semantic content of speech
D. diminished capacity to appreciate emotional nuance in speech
E. loss of ability to read
F. profound difficulty naming familiar faces
G. profound difficulty perceiving the movement of objects and people in the visual world
H. profound amnesia
I. profound difficulty recalling events from childhood