Windows to the Brain:
Introduction to Circuits

Cortical Association
Prefrontal-Subcortical
Papez
Brainstem

Katherine Taber, PhD, FANPA
MIRECC Assistant Director - Education
Research Health Scientist
W.G. “Bill” Hefner VAMC, Salisbury NC
Research Professor, Div Biomedical Sci
Edward Via College of Osteopathic Medicine

Robin Hurley, MD, FANPA
Associate Director - Education
ACOS/Research and Education Service Line
W.G. “Bill” Hefner VAMC, Salisbury NC
Professor, Psychiatry and Radiology
Wake Forest University School of Medicine

revised July 2011
Use of text, images and other content are subject to the following terms and conditions:

Fair Use Is Permitted

Fair use of copyrighted material includes the use for non-commercial educational purposes, such as teaching, scholarship, research, criticism, commentary, news reporting, and other content. Unless otherwise noted, users who wish to download or print text and image files from this Web site for such uses may do so without the VISN 6 MIRECC’s express permission, provided that they comply with the following conditions:

The content may only be used for personal, educational or non-commercial purposes;

Users must always specifically cite the author(s) and source of the content every time the material is used, as they would for material from any printed work;

None of the content may be altered or modified.

Warranty

By downloading, printing, or otherwise using text and image files from this website, users agree and warrant that they will limit their use of such files to fair use.
Brief guide to neuropsychiatric symptoms associated with injury to tract.

**superior fronto-occipital (subcallosal) fasciculus**
orbital & medial prefrontal cortex ↔ parietal cortex

- akinetic mutism; disordered initiation & preparation of speech movements; transcortical motor aphasia; anomia & reduction of spontaneous speech with normal articulation

**cingulum**
cingulate cortex ↔ fronto-occipital & temporal cortex

- Anterior - lack of emotional affective response to pain; anxiety; OCD; depression; panic; akinetic mutism
- Posterior - impaired integration of visuospatial & memory processing

**superior longitudinal (arcuate) fasciculus**
frontal cortex ↔ parietal, occipital & temporal cortex

- R - left hemispatial neglect; L - conduction aphasia (fluent aphasia with impaired repetition, mostly preserved language comprehension); ideational apraxia (can’t carry out skilled movements and/or commands); depression; speech arrest; anomia
- Posterior - transcortical sensory aphasia (impaired auditory comprehension, intact repetition & fluent speech)

**uncinate fasciculus**
orbital & polar prefrontal cortex ↔ anterior temporal cortex

- deficits in retrieval of past information: R - episodic context-dependent memory, personal experiences, autobiographical; L - context-free memory, general knowledge of facts

**inferior fronto-occipital fasciculus**
ventrolateral & dorsolateral prefrontal cortex ↔ posterior temporal & occipital cortex

- R>L - impaired orienting of attention; visual recognition abnormalities
- R+L - impaired pursuit eye movements; inaccurate reaching under visual guidance; impaired motion perception
- R or R+L - impaired seeing/selecting in crowds; impaired spatial relations; visual agnosia & poor visual memory; impaired recognition of places & directions to get there; getting lost

**inferior longitudinal fasciculus**
temporal pole ↔ occipital cortex

- disorders in recognition (visual agnosia) impaired visual recent memory; R or R+L - impaired face recognition (prosopagnosia), visual object agnosia, visual hypoemotionality if cue presented visually
- R+L or L>R - contralateral deficit in color vision (hemiachromatopsia); L-bilateral misnaming of objects presented by touch (tactoverbal dysfunction)

In psychiatry, the prefrontal cortex is generally divided into three principal areas. Each area has reciprocal connections with subcortical structures that form cortico-subcortical circuits.*

**Dorsolateral circuit**
mediates executive functions such as organization, planning & attention

**Orbitofrontal circuit**
mediates socially appropriate behavior, impulse control & empathy

**Anterior cingulate circuit**
produces motivation by balancing the inhibitory input of the supplemental motor area with its own stimulus that supports wakefulness & arousal

---

In psychiatry, the prefrontal cortex is generally divided into three principal areas. Each area has reciprocal connections with subcortical structures that form cortico-subcortical circuits. These prefrontal-subcortical circuits are formed by chains of neurons with cell bodies in gray matter structures (both cortical and subcortical) connected by the axons which form the white matter. Recently, the evidence supporting a similar reciprocal circuit to the cerebellum has strengthened, although its functions are still controversial.

**Major Prefrontal - Subcortical Circuits**

- **Dorsolateral circuit** mediates executive functions such as organization, planning, and attention.
- **Orbitofrontal circuit** mediates socially appropriate behavior, impulse control, and empathy.
- **Anterior Cingulate circuit** produces motivation by balancing the inhibitory input of the supplemental motor area with its own stimulus that supports wakefulness and arousal.

**Cortex**

- Dorsolateral prefrontal
- Orbitofrontal
- Anterior cingulate

**Basal Ganglia**

- Dorsolateral caudate
- Ventromedial caudate
- Dorsomedial globus pallidus
- Substantia nigra
- Rostromedial globus pallidus
- Ventral globus pallidus

**Thalamus**

- Ventral anterior
- Dorsomedial
- Anterior

**Pons**

- Pontine nuclei

**Cerebellum**

- Crus I & II
- Dentate nucleus
- Vermis
- Fastigial nucleus

**Midline Medial (Parasagittal)**

**Lateral**

**Inferior (Bottom)**
A schematic diagram of the emotion and memory circuit of Papez is color-coded to match the summary of subcortical structures and the sectional atlases. The location and extent of the Anterior Cingulate cortex (light gold), fornix and mammillary body are indicated on a midline sagittal magnetic resonance image. The locations of the remaining structures are shown on a coronal magnetic resonance image.
Brainstem - Amine Neurotransmitters

These small brainstem nuclei project very widely in the brain. They provide essential modulation of the brain systems that subserve multiple functions including behavior, cognition and mood. The approximate locations and extents of nuclei that are important sources for a particular neurotransmitter are color-coded onto a sagittal magnetic resonance image.*

Neurotransmitters: 
- dopamine
- acetylcholine
- serotonin
- norepinephrine