Cognitive Neuroscience for AI Developers (CNAID)

SS 2023

Week 8, Brain Structure, Functional Systems, Lesion Studies, Brain Lateralization, Auditory System

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Multiple Choice Exercise

(Please mark the right answer with a cross. Only one answer is correct!)

Q1: Which statement on the human nervous system is **not** correct?

- The autonomous nervous system mainly controls smooth muscles of the intestines, e.g. the heart and glands
- The autonomous system can be divided is sympathicus and parasympathicus
- The sympathicus is responsible for stress related responses of the body and accelerates the heart rate
- The parasympathicus increases its activity when a threat is perceived
- The central nervous system consists of spinal cord and the brain (including brainstem)

Q2: Which statement on the brainstem and the cerebellum is **not** correct?

- The brainstem is evolutionary older than the cortex
- Damage to the brainstem is life threatening in most cases
- The cerebellum is the brain structure that contains approximately two thirds of all brain neurons
- The pons is a substructure of the cerebellum
- The brainstem consists of medulla, pons, midbrain (mesencephalon)

Q3: Which statement on the thalamus is **not** correct?

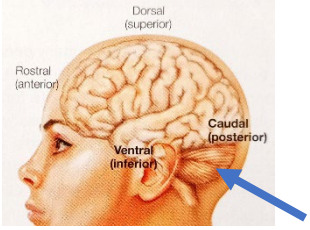
- The thalamus is the 'gate to consciousness'
- The thalamus filters out 'irrelevant' information
- The hypothalamus has very similar functions as the thalamus
- All sensory input (except olfactory input) has to pass through the thalamus
- The thalamus consists of several nuclei (e.g., lateral geniculate body, medial geniculate body)

Q4: Which statement on the cerebral cortex is true?

- The cerebral cortex consists of approx. 100,000 neurons
- Gyri are indentations (valleys) and sulci are the elevations (mountains) of the cortex
- The cortex contains the highest number of neurons of all brain parts
- The cortex can be structured and classified based on function, anatomy and cytoarchitecture
- The cortex consists exclusively of neuronal axons (white matter)

Q5: The arrow points to which brain structure in the image below?

- Medulla oblongata
- Cerebral cortex
- Hippocampus
- Cerebellum
- Basal Ganglia



Q5: Which statement on lesion studies is true?

- For transcranial direct current stimulations (TDCS) a coil is used to create a transient magnetic field to induce a transient brain lesion
- Brain lesions in lesion studies are always generated by a physician
- Phineas Gage was an important neuroscientist
- Stroke is a vascular disorder
- To treat epilepsy the brainstem (including medulla) is removed

Q6: Which statement on lesion studies is **not** true?

- Phineas Gage is a famous example for a person with an unwanted brain lesion, which caused changes of the personality
- Broca's area is important for word understanding and has nothing to do with speech production
- Wernicke are is important for language understanding and is placed posterior to the Broca's area (temporal)
- Cortical blindness is caused by lesions in the occipital lobe
- People suffering from cortical blindness sometimes behave as they have seen the presented objects, but are not aware of the fact that they have seen the objects (potentially due to several different ancient visual pathways)

Q7: Which statement on lateralization of brain function is true?

- Both brain hemispheres are anatomically exactly identical
- Both brain hemispheres are functionally exactly identical
- Wernicke's area is on the right side of the brain
- The right brain hemisphere (cortex) is optimized to process small details and is specialized for maths, programming, and language processing
- The right cortex hemisphere is important to process the prosody (rhythm) of speech

Q8: Which statement on the auditory system is true?

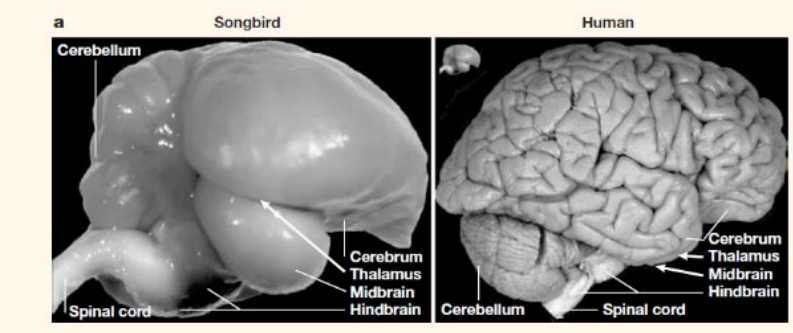
- The outer ear contains the sensory cells (hair cells) that transduce the sound (air pressure fluctuations) to a chemical signal
- The 7 ossicles in the middle ear are responsible for an impedance adaptation, in order to prevent the sound to be reflected on the border between air and fluid
- The pinna of the outer ear has no effect on directional hearing and is therefore just a symmetrical funnel collecting sound waves
- The cochlea contains the inner hair cells, which transduce the mechanical signal to a chemical signal (inner hair cells = sensory cells)
- The cochlea contains the outer hair cells, which are more efficient sensory cells than the inner hair cells.

Q9: Which statement on the mechanisms within the auditory system is **not** true?

- The outer hair cells further enhance the amplitude of and sharpen the travelling wave in the inner ear.
- Lateral inhibition is an important mechanism in the auditory system (lateral inhibition: active neurons inhibits neighboring neurons)
- The brainstem is important for sound localization and gets input from both ears.
- Subjective tinnitus is an illness which is always characterized by a hypersensitivity against mild sounds (hyperacusis), chronic pain, and impairments of the visual system.
- Potentially tinnitus could be explained by the so-called stochastic resonance model or central noise model (intrinsically generated neural noise is the neural correlate of tinnitus)

Discussion Exercise

Birds



"On the basis of this new understanding of avian brain organization and its evolutionary relationships, we estimate that, as in mammals, the adult avian pallium comprises about 75% of the telencephalic volume (FIG. 1c; calculated from sagittal series of pigeon and zebra finch brain sections). This realization of a relatively large and well developed avian pallium that processes information in a similar manner to mammalian sensory and motor cortices sets the stage for a re-evaluation of the cognitive abilities of birds, which, since the 1950s, have been increasingly appreciated as far more complex than was originally presumed[91,92]." (Jarvis et al 2005)

"So, although the avian pallium is not organized cytoarchitectonically into layers, its nuclear subdivisions bear marked similarities in connectivity and molecular profile to different layers of the mammalian neocortex." (Jarvis et al., 2005)

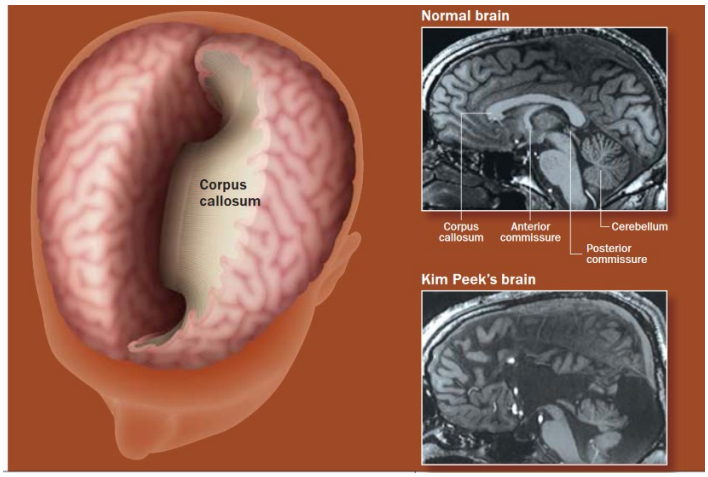
"Apes, corvids, and pigeons differ in their pallial/cortical neuron numbers, with apes ranking first and pigeons third. Do cognitive performances rank accordingly? If they would do, cognitive performance could be explained at a mechanistic level by computational capacity provided by neuron numbers. We discuss five areas of cognition (short-term memory, object permanence, abstract numerical competence, orthographic processing, self-recognition) in which apes, corvids, and pigeons have been tested with highly similar procedures. In all tests apes and corvids were on par, but also pigeons reached identical achievement levels in three tests. We suggest that higher neuron numbers are poor predictors of absolute cognitive ability, but better predict learning speed and the ability to flexibly transfer rules to novel situations." (Güntürkün, 2017); "Corvids have 6 times less pallial neurons than chimps but 6-17 times more than pigeons." (Güntürkün, 2017); "Birds have small brains but much more neurons per pallial mass than primates." (Güntürkün, 2017)

Jarvis, E. D., Güntürkün, O., Bruce, L., Csillag, A., Karten, H., Kuenzel, W., ... & Butler, A. B. (2005). Avian brains and a new understanding of vertebrate brain evolution. Nature Reviews Neuroscience, 6(2), 151-159.

Güntürkün, O., Ströckens, F., Scarf, D., & Colombo, M. (2017). Apes, feathered apes, and pigeons: differences and similarities. Current Opinion in Behavioral Sciences, 16, 35-40.

1) **Is it necessary to have a layered cortex to fulfill higher cognitive tasks?**
2) **Does a bigger brain always mean higher intelligence?**
3) **Why are bird brains smaller than brains of apes? Why could neurons be networked more efficiently in birds?**

Savant Syndrome



Treffert, D. A., & Christensen, D. D. (2006). Inside the mind of a savant. *Scientific American Mind*, *17*(3), 50-55.

This is the brain of Kim Peek. He has some brain damages from birth. His cerebellum is too small and he has no corpus callosum since his birth. However, he has a big head and a big brain (in the 99th percentiles) (Treffert and Christensen, 2006).

"Peek's brain shows abnormalities in the left hemisphere, a pattern found in many savants. What is more, left hemisphere damage has been invoked as an explanation of why males are much more likely than females to display not only savantism but also dyslexia, stuttering, delayed speech, and autism. Also supporting the role of left hemisphere damage are the many reported cases of "acquired savant syndrome," in which older children and adults suddenly develop savant skills after damage to the left hemisphere" (Treffert and Christensen, 2006).

"But phenomenal memory is itself the skill in a 54-year-old man named Kim Peek. His friends call him "Kim-puter." He can, indeed, pull a fact from his mental library as fast as a search engine can mine the Internet. Peek began memorizing books at the age of 18 months, as they were read to him. He has learned 9,000 books by heart so far. He reads a page in eight to 10 seconds and places the memorized book upside down on the shelf to signify that it is now on his mental "hard drive."" (Treffert and Christensen, 2006).

"Peek underwent psychological testing in 1988. His overall IQ score was 87, but the verbal and performance subtests varied greatly, with some scores falling in the superior range of intelligence and others in the mentally retarded range. The psychological report concluded, therefore, that "Kim's IQ classification is not a valid description of his intellectual ability."" (Treffert and Christensen, 2006).

1) **What is a savant syndrome?**
2) **What do we learn about intelligence from people with savant syndrome?**

References:
Treffert, D. A., & Christensen, D. D. (2006). Inside the mind of a savant. Scientific American Mind, 17(3), 50-55.
Treffert, D. A. (2009). The savant syndrome: an extraordinary condition. A synopsis: past, present, future. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1522), 1351-1357.
Treffert, D. (2010). Kim Peek 1951-2009. Wisconsin Medical Journal, 109(2), 61.