Prefrontal--STN projections, the highway for emotion and cognition control

Martinez-Fernandez, Raul; Castrioto, Anna; Krack, Paul

How to cite

MARTINEZ-FERNANDEZ, Raul, CASTRIOTO, Anna, KRACK, Paul. Prefrontal--STN projections, the highway for emotion and cognition control. In: Movement disorders, 2014, vol. 29, n° 3, p. 305. doi: 10.1002/mds.25760

This publication URL: https://archive-ouverte.unige.ch/unige:95945

Publication DOI: 10.1002/mds.25760

Prefrontal — STN Projections, the Highway for Emotion and Cognition Control

Haynes WIA, Haber SN. The Organization of Prefrontal-Subthalamic Inputs in Primates Provides an Anatomical Substrate for Both Functional Specificity and Integration: Implications for Basal Ganglia Models and Deep Brain Stimulation. *J Neuroscience* 2013;33:4804–4814.

Our comprehension of the functional organization of the basal ganglia has increased progressively since the first consistent models in the 80s.[1–3] These models demonstrated an anatomical and functional segregation of parallel corticobasal ganglia loops, which comprise motor, limbic and associative circuits, suggesting an important role of the subthalamic nucleus (STN) in motor, cognitive and emotional function. Nambu[4] subsequently "complemented" our knowledge of the previously described direct and indirect pathways by including in the model a hyperdirect pathway, which projects from the cortex to the STN and is thought to act as a decisional threshold for motor programs which use the direct pathway. In their recent milestone paper, Hayne and Haber shed more light on the role of the hyperdirect pathway by focusing on the hitherto grey area of its limbic and associative subdomains. By injecting viral tracers into 48 prefrontal cortical sites in monkeys, they revealed the existence of projections from the dorsal anterior cingulate cortex to the limbic part of the STN, of dorsal prefrontal cortical fibers descending to the medial half of the nucleus, i.e. the associative subregion, and of ventromedial prefrontal and orbitofrontal cortical projections terminating medially to the medial boundary of the STN, in the area corresponding to the lateral hypothalamus. These findings indicate the presence of massive hyperdirect parallel projections between the prefrontal cortex and the STN. The authors place emphasis on the strategic position of the STN in the control of nonmotor behavior, and thus provide basic evidence for the potential of STN-DBS in the treatment of neuropsychiatric conditions such as obsessive-compulsive disorder.[5] Importantly, the viral tracing technique used by the authors demonstrated a significant overlap of functional territories within the STN. Although these were anatomically organized, they were less segregated than was previously believed. This overlap may well enable the hyperdirect pathway to combine movement with both emotion and cognition, an association which is constant in involuntary or "subconscious" behaviors. It also has significant therapeutic implications, and would explain why deep brain stimulation via an electrode located in any region of the STN has an impact (either therapeutic or as a side effect) beyond the motor system in patients with Parkinson's disease. With the allure of continuous new contributions in the field, more research using original new approaches like that of Hayne and Haber is needed to further improve our understanding of the basal ganglia and optimize patient management.

Raul Martinez-Fernandez, MD, Anna Castrioto, MD, and Paul Krack, MD, PhD

Movement Disorder Unit, Department of Psychiatry and Neurology, CHU de Grenoble, Joseph Fourier University, and INSERM, Unit 836, Grenoble Institut des Neurosciences, Grenoble, France

References

1. Alexander GE, DeLong MR, Strick PL. Parallel organization of functionally segregated circuits linking basal ganglia and cortex. Annu Rev Neurosci 1986;9:357-381.
2. Albin RL, Young AB, Penney JB. The functional anatomy of basal ganglia disorders. Trends Neurosci 1989;12:366-375.
3. DeLong MR. Primate models of movement disorders of basal ganglia origin. Trends Neurosci 1990;13:281-285.
4. Nambu A, Tokuno H, Takada M. Functional significance of the cortico-subthalamo-pallidal 'hyperdirect' pathway. Neurosci Res 2002;43:111-1117.
5. Mallet L, Polosan M, Jaafari N, et al. Subthalamic nucleus stimulation in severe obsessive-compulsive disorder. N Engl J Med 2008;359:2121-2134.

Relevant conflict of interest: Nothing to report.
Full financial disclosures may be found in the online version of this article.

Published online in Wiley Online Library (wileyonlinelibrary.com). DOI: 10.1002/mds.25760