Dr. Abdelhamid BENAZZOUZ

Speaker	Dr. Abdelhamid BENAZZOUZ
Talk Title	Deep brain stimulationin Parkinson's disease: from bench to bedside
Institution	University of Bordeaux
Department	Neurodegenerative diseases institute, CNRS UMR 5293
E-mail	Abdelhamid.benazzouz@u-bordeaux.fr
Webpage	https://www.imn-bordeaux.org/en/teams/neurochemistry-deep-brain-stimulation-and-parkinsons-disease/

Brief Biography

Abdelhamid Benazzouz is a Neurophysiologist Researcher employed by the Inserm Institute working in Bordeaux University. He is expert in the field of Neuroscience and especially in Parkinson's disease. After completing a Master degree in Morocco, he went to Bordeaux to prepare his PhD diploma in the field of Neuroscience and Pharmacology. Dr. Benazzouz was the first to develop high frequency stimulation (HFS), named also deep brain stimulation (DBS), of the subthalamic nucleus (STN) as a therapeutical approach of Parkinson's disease. Based on the spectacular improvement of motor symptoms obtained in Monkeys rendered parkinsonians by MPTP, he proposed the transfer of this neurosurgical approach to patients. He joined as a Neurophysiologist Research Fellow the Inserm unit of Professor Alim-Louis Benabid in Grenoble to participate in transfering this approach to parkinsonian patients, with a success that has never failed since. In parallel with his hospital activity as a Neurophysiologist performing the electrophysiological mapping during surgery, he was the head of a research team in the Inserm unit investigating the functional mechanisms of this approach in animal models. In 1998 he was appointed to Inserm position as a permanent position researcher. In 2001, he came back to Bordeaux as a Principal Investigator in the CNRS unit of Professor Bernard Bioulac. In 2005 he was promoted to Research Director position. Since 2011, he is the leader of the Team "Neurochemistry, Deep Brain Stimulation & Parkinson's disease" in the Institute of Neurodegenerative diseases in Bordeaux University, in which he is investigating the respective role of monoamines in the pathophysiology of motor and non-motor symptoms of Parkinson's disease. He has published more than 110

research papers in peer-reviewed journals and 25 chapters in scientific books as well as more than 70 research contributions at international conferences, international Neuroscience Schools and Universities. Internationally ranked among distinguished scholars, his publications are cited more than 17 thousand times and received 57 degrees on the global H-Index (Google Scholar).

Awards and Prizes: He obtained the National Academy of Medicine award in 2003 and the Academy of Science award in 2007. In 2010, He obtained the distinction of Scientific Excellence delivered by Inserm.

List of Representative Publications

111) Charles K.A, Naudet F., Bouali-Benazzouz R. De Deurwaerdère P., Landry M., Fossat P*. and Benazzouz A*. Alteration of nociceptive integration in the spinal cord of a rat model of Parkinson's disease. Mov. Disord. 2018 Jul;33(6):1010-1015. doi: 10.1002/mds.27377. (*PF & AB contributed equally)

110) Tibar H., El Bayad K., Bouhouche A., Ait Ben Haddou E.H., Benomar A., Yahyaoui M., Benazzouz A.* and Regragui W.* Non-motor symptoms of Parkinson's disease and their impact on quality of life in a cohort of Moroccan patients. Front. Neurol., 2018, April 04, 9:170. Doi: 10.3389/fneur.2018.00170. (*AB & WR contributed equally)

109) Sabbar M., Delaville C., De Deurwaerdère P., Lakhdar-Ghazal N. and Benazzouz A. Lead-induced atypical Parkinsonism in Rats: Behavioral, Electrophysiological and Neurochemical Evidence for a role of Noradrenaline depletion. Front. Neurosci. 2018, March 19, 12:173. Doi: 10.3389/fnins.2018.00173.

108) Faggiani E., Naudet F., Janssen M.L.F., Temel Y. and Benazzouz A. Serotonergic neurons mediate the anxiolytic effect of L-DOPA: neuronal correlates in the amygdala. Neurobiol. Dis. 2018, 110: 20–28, doi: 10.1016/j.nbd.2017.11.001.

107) Lagière M., Bosc M., Whitestone S., Manem J, Elboukhari H., Benazzouz A., Di Giovanni G., De Deurwaerdère P. Does the Serotonin2C receptor segregate circuits of the basal ganglia responding to cingulate cortex stimulation? CNS Neurosci Ther. 2017 Nov 15. doi: 10.1111/cns.12777.

106) Sabbar M., Dkhissi-Benyahya O., Benazzouz A. and Lakhdar-Ghazal N. Circadian clock gene expression and locomotor activity rhythm are altered after chronic exposure to lead. Front Behav Neurosci. 2017 Sep 22;11:178. doi: 10.3389/fnbeh.2017.00178.

105) Miguelez C., Benazzouz A., Ugedo L. and De Deurwaerdere P. Impairment of the serotonergic transmission by the antiparkinsonian drug L-DOPA: mechanisms and clinical implications. Front Cell Neurosci. 2017 Sep 12;11:274. doi: 10.3389/fncel.2017.00274.

104) Faggiani E, Benazzouz A. Deep brain stimulation of the subthalamic nucleus in Parkinson's disease: From history to the interaction with the monoaminergic systems. Prog Neurobiol. 2017, 151:139-156. doi: 10.1016/j.pneurobio.2016.07.003. Review

103) Benazzouz A. Twenty-four years of deep brain stimulation of the subthalamic nucleus. Rev. Neurol. (Paris), 2017, 173(3):103-105. doi: 10.1016/j.neurol.2016.12.001. Editorial

102) Janssen ML.F., Temel Y., Delaville C ., Zwartjes D.G.M., Heida T., De Deurwaerdère P., Visser-Vandewalle V. and Benazzouz A. Cortico-subthalamic inputs from the motor, limbic and associative areas in normal and dopamine-depleted rats are not fully segregated. Brain Struct Funct. 2017 Aug;222(6):2473-2485. doi: 10.1007/s00429-016-1351-5.

101) Benazzouz A., Gross C., Bioulac B. Non-Human Primate: An Essential Building Brick in the Discovery of the Subthalamic Deep Brain Stimulation Therapy. Front Aging Neurosci. 2016 Jan 12;7:252. doi: 10.3389/fnagi.2015.00252. Commentary

100) Bouabid S., Tinakoua A., Lakhdar-Ghazal N. and Benazzouz A.. Manganese Neurotoxicity: behavioral disorders associated with dysfunctions in the basal ganglia and neurochemical transmission. J. Neurochem., 2016, 136:677–691. doi: 10.1111/jnc.13442. Review

99) Kölbl F., N'kaoua G., Naudet F., Berthier F., Faggiani E., Renaud S., Benazzouz A., Lewis N. A New Embedded Deep Brain Stimulator for Chronic Experiments in Freely Moving Rodents. IEEE Transactions on Biomedical Circuits and Systems. 2016, 10(1):72-84. doi: 10.1109/TBCAS.2014.2368788. Epub 2014 Dec 23.

98) Bouabid S., Fifel K., Benazzouz A. and Lakhdar-Ghazal N. Consequences of manganese intoxication on the daily and circadian rest-activity rhythms in the rat. Neuroscience, 2016, 331:13-23.

97) Miguelez C., Navailles S., Delaville C., Marquis L., Lagière M., Benazzouz A. Ugedo L. and De Deurwaerdère P. L-DOPA elicits non-vesicular releases of serotonin and dopamine in hemiparkinsonian rats in vivo. Eur Neuropsychopharmacol. 2016, 26(8):1297-309. doi: 10.1016/j.euroneuro.2016.05.004. Epub 2016 May 24.

96) van Dijk KJ, Janssen MLF, Zwartjes DGM, Temel Y, Visser-Vandewalle V, Veltink PH, Benazzouz A and Heida T. Spatial Localization of Sources in the Rat Subthalamic Motor Region Using an Inverse Current Source Density Method. Front. Neural Circuits, 2016, 10:87. doi: 10.3389/fncir.2016.00087.

95) Faggiani E, Delaville C, Benazzouz A. The combined depletion of monoamines alters the effectiveness of subthalamic deep brain stimulation. Neurobiol. Dis. 2015, 82:342-348. doi: 10.1016/j.nbd.2015.07.010.

94) Mamad O., Delaville C., Benjelloun W. and Benazzouz A. Dopaminergic control of the globus pallidus through activation of D2 receptors and its impact on the electrical activity of subthalamic nucleus and substantia nigra reticulata neurons. PlosOne 2015, 10(3):e0119152. doi: 10.1371/journal.pone.0119152. eCollection 2015.

93) Tinakoua A, Bouabid S, Faggiani E, De Deurwaerdère P, Lakhdar-Ghazal N and Benazzouz A. The impact of combined administration of Paraquat and Maneb on motor and non-motor functions in the rat. Neuroscience, 2015, 311:118-129. doi:

10.1016/j.neuroscience.2015.10.021.

92) Bouabid S., Delaville C., De Deurwaerdère, P., Lakhdar-Ghazal N. and Benazzouz A. Manganese-induced parkinsonian-like motor and non motor deficits associated with changes in basal ganglia neuronal activity in the rat. PLoS ONE, 2014, 9(6): e98952. doi:10.1371/journal.pone.0098952.

91) Benazzouz A., Mamad O., Abedi P., Bouali-Benazzouz R., Chetrit J. Involvement of dopamine loss in extrastriatal basal ganglia nuclei in the pathophysiology of Parkinson's disease. Front. Aging Neurosci., 2014, May 13, 6:87. eCollection 2014, doi: 10.3389/fnagi.2014.00087. Review

90) Caire F, Guehl D, Burbaud P, Benazzouz A, Cuny E. Intraoperative 3D imaging control during subthalamic Deep Brain Stimulation procedures using O-arm(®) technology: Experience in 15 patients. Neurochirurgie. 2014 Dec;60(6):276-82. doi: 10.1016/j.neuchi.2014.05.005.

89) Chetrit J.*, Taupignon A.*, Froux L., Morin S., Bouali-Benazzouz R., Naudet F., Kadiri N., Gross CE., Bioulac B. and Benazzouz A. Inhibiting constitutive activity of subthalamic D5 receptors reverses motor impairment in a rat model of parkinsonism. J. Neurosci., 2013, 33:14840-14849. (*These authors contributed equally)

88) Abedi P.M., Delaville C., De Deurwaerdère P., Benjelloun W. and Benazzouz A. Intrapallidal administration of 6-hydroxydopamine mimics in large part the electrophysiological and behavioral consequences of major dopamine depletion in the rat. Neuroscience, 2013, 236:289–297. DOI: 10.1016/j.neuroscience.2013.01.043.

87) Zbrzeski A., Lewis N., Rummens F., Jung R., N'Kaoua G., Benazzouz A., Renaud S. Low-Gain, low-noise integrated neuronal amplifier for implantable artifact-reduction recording System. Journal of Low Power Electronics and Applications (JLPEA), 2013, 3 :279-299. DOI:10.3390/jlpea3030279.

86) Kolbl F., Sabatier J., N'Kaoua, G., Naudet F., Faggiani E., Benazzouz A. Renaud S. and Lewis N. Characterization of a Non Linear Fractional Model of Electrode-Tissue Impedance for Neuronal Stimulation. IEEE Biomedical Circuits and Systems Conference (BIOCAS). 2013, 338-341.

85) Delaville C., Chetrit J., Abdallah K., Morin S., Cardoit L., De Deurwaerdère P. and Benazzouz A. Emerging dysfunctions consequent to combined monoaminergic depletions in parkinsonism. Neurobiol. Dis. 2012, 45:763-73.

84) Delaville C., Zapata J., Cardoit L. and Benazzouz A. Activation of subthalamic alpha 2 noradrenergic receptors induces motor deficits as a consequence of neuronal burst firing. Neurobiol. Dis., 2012, 47:322-330.

83) Delaville C., Navailles S. and Benazzouz A. Effects of noradrenaline and serotonin depletions on the neuronal activity of globus pallidus and substantia nigra pars reticulata in experimental parkinsonism. Neuroscience, 2012, 202:424-433.

82) Vlamings R., Benazzouz A., Chetrit J., Janssen M., Kozan R., Visser-Vandewalle V., Steinbusch H.W.M., von Hörsten S. and Temel Y. Metabolic and electrophysiological changes in the basal ganglia of a transgenic rat model for Huntington's disease. Neurobiol. Dis., 2012, 48:488-494.

81) Syed E.*, Benazzouz A.*, Taillade M., Baufreton J., Champeaux K., Falgairolle M., Bioulac B., Gross C. and Boraud T. Oscillatory entrainment of subthalamic nucleus neurons and behavioural consequences in rodents and primates. Eur. J. Neurosci., 2012, 36:3246-3257. (* Equal contribution).

80) Sabbar M., Delaville C., De Deurwaerdère P., Benazzouz A.* and Lakhdar-Ghazal N.* Lead intoxication induces noradrenaline depletion, motor and non-motor disabilities and changes in the firing pattern of subthalamic nucleus neurons. Neuroscience, 2012, 210:375-383. DOI:10.1016/j.neuroscience.2012.02.026. (* Equal contribution)

79) Aouizerate B., Cuny E., J.Y. Rotgé, Martin-Guehl C., Doumy O., Benazzouz A., Allard M., Rougier A., Fabrigoule C, Bioulac B, Tignol J, Guehl D. and Burbaud P. Is Deep Brain Stimulation able to make antidepressants effective in resistant for Obssesive Compulsive Disorder ? Biol. Psychiatry., 2012 Jun 1;71(11):e43-4. DOI:10.1016/j.biopsych.2011.10.013.

78) Delaville C., De Deurwaerdère P. and Benazzouz A. Noradrenaline and Parkinson's disease, Front. Syst. Neurosci. 2011, 5:31. Doi: 10.3389/fnsys.2011.00031. Epub 2011 May 18. Review

77) Zbrzeski A., Lewis N., Syed E., Boraud T., Benazzouz A. and Renaud S. A Tunable Integrated Device for LFP Tracking. Proceedings in the 26th Conference on Design of Circuits and Integrated Systems, DCIS, 2011, 439-442.

2010

76) Navailles S., Benazzouz A., Bioulac B., Gross C., De Deurwaerdère P. High-frequency stimulation of the subthalamic nucleus and L-DOPA inhibit in vivo serotonin release in the prefrontal cortex and hippocampus in a rat model of Parkinson's disease. J. Neurosci. 2010, 30(6):2356-2364.

75) Chetrit J., Ballion B., Laquitaine S., Belujon P., Morin S., Taupignon A., Bioulac, B Gross C. and Benazzouz A. Involvement of basal ganglia network in motor disabilities induced by typical antipsychotics. PLoS One. 2009 Jul 9;4(7):e6208.

74) Bouali-Benazzouz R., Tai C.H. Chetrit J. and Benazzouz A. Intrapallidal injection of 6-OHDA induced changes in dopamine innervation and neuronal activity of globus pallidus. Neuroscience, 2009, 164(2):588-596.

73) Vidailhet M, Yelnik J, Lagrange C, Fraix V, Grabli D, Thobois S, Burbaud P, Welter ML, Xie-Brustolin J, Braga MC, Ardouin C, Czernecki V, Klinger H, Chabardes S, Seigneuret E, Mertens P, Cuny E, Navarro S, Cornu P, Benabid AL, Le Bas JF, Dormont D, Hermier M, Dujardin K, Blond S, Krystkowiak P, Destée A, Bardinet E, Agid Y, Krack P,

Broussolle E, Pollak P; French SPIDY-2 Study Group (A. Benazzouz is a member of the group). Bilateral pallidal deep brain stimulation for the treatment of patients with dystonia-choreoathetosis cerebral palsy: a prospective pilot study. Lancet Neurol. 2009, 8:709-717.

72) Guehl D., Benazzouz A., Aouizerate B., Cuny E., Rougier A., Tignol J., Bioulac B. and Burbaud P. Neuronal correlates of obsessions in the caudate nucleus. Biological Psychiatry, 2008, 63:557-562.

71) Belujon P., Bezard E., Bioulac B.H., Taupignon A.I. and Benazzouz A. Noradrenergic modulation of subthalamic nucleus activity: behavioral and electrophysiological evidence. J. Neurosci. 2007, 27:9595-9606.

70) Meissner W., Guigoni C., Cirilli L., Garret M., Bioulac B.H., Gross C.E., Bezard E. and A. Benazzouz. Impact of chronic subthalamic high frequency stimulation on metabolic basal ganglia activity: a 2-deoxyglucose uptake and cytochrome oxidase mRNA study in a macaque model of Parkinson's disease. Eur. J. Neurosci., 2007, 25:1492-1500.

69) Breit S., R. Bouali-Benazzouz, R.C. Popa, T. Gasser, A.L. Benabid, Benazzouz A. Effects of 6-hydroxydopamine-induced severe or partial lesion of the nigrostriatal pathway on the neuronal activity of pallido-subthalamic network in the rat. Exp. Neurol., 2007, 205:36-47.

68) Guehl D., Cuny E., Tison F., Benazzouz A., Bardinet E., Sibon Y., Ghorayeb I., Yelnick J. Rougier A., Bioulac B., Burbaud P. Deep brain pallidal stimulation for movement disorders in neuroacanthocytosis. Neurology 2007, 68:160-161.

67) Vercueil L, Houeto JL, Krystkowiak P, Lagrange C, Cassim F, Benazzouz A, Pidoux B, Destée A, Agid Y, Cornu P, Blond S, Benabid AL, Pollak P, Vidailhet M; and the Spidy GROUP (French Pallidal stimulation Group for dystonia). Effects of pulse width variations in pallidal stimulation for primary generalized dystonia. J Neurol. 2007, 254:1533-1537

66) Damier P, Thobois S, Witjas T, Cuny E, Derost P, Raoul S, Mertens P, Peragut JC, Lemaire JJ, Burbaud P, Nguyen JM, Llorca PM, Rascol O; French Stimulation for Tardive Dyskinesia (STARDYS) Study Group (A. Benazzouz is a member of the group). Bilateral deep brain stimulation of the globus pallidus to treat tardive dyskinesia. Arch Gen Psychiatry. 2007 Feb;64(2):170-6.

65) Breit S, Lebas JF, Koudsie A, Schulz J, Benazzouz A, Pollak P, Benabid AL. Pretargeting for the Implantation of Stimulation Electrodes into the Subthalamic Nucleus: A Comparative Study of Magnetic Resonance Imaging and Ventriculography. Neurosurgery, 2006, 58(Suppl 1):ONS83-ONS95.

64) Guehl D., Cuny E., Benazzouz A., Rougier A., Tison F., Machado S., Grabot D., Gross C, Bioulac B., Burbaud P. Side-effects of subthalamic stimulation in Parkinson's disease: clinical evolution and predictive factors. Eur. J. Neurol. 2006, 13:963-971.

63) Meissner W., Leblois A., Benazzouz A. and Boraud T. Subthalamic high-frequency stimulation drives subthalamic oscillatory activity at stimulation frequency while firing rate is reduced. Brain, 2006, 129, E60.

62) Meissner W, Leblois A, Hansel D, Bioulac B, Gross CE, Benazzouz A, Boraud T. Subthalamic high frequency stimulation resets subthalamic firing and reduces abnormal oscillations. Brain, 2005, 128:2372-2382.

61) Breit S, Lessmann L., Benazzouz A., Schulz J.B. Unilateral lesion of the pedunculopontine nucleus induces hyperactivity in the subthalamic nucleus and in the substantia nigra in the rat. Eur. J. Neurosci., 2005, 22:2283-2294.

60) Aouizerate, B., Cuny, E., Martin-Guehl, C., Guehl, D., Amieva, H., Benazzouz, A., Fabrigoule, C., Allard, M., Rougier, A., Bioulac, B., Tignol, J. and Burbaud, P. Deep brain stimulation of the ventral caudate nucleus is effective in obsessive-compulsive disorder and major depression. Médecine Science, 2005, 21:811-813.

59) Aouizerate B, Martin-Guehl C, Cuny E, Guehl D, Amieva H, Benazzouz A, Fabrigoule C, Bioulac B, Tignol J, Burbaud P. Deep Brain Stimulation for OCD and Major Depression. Am. J. Psychiatry. 2005:162:2192.

58) Vidailhet M, Vercueil L, Houeto JL, Krystkowiak P, Benabid AL, Cornu P, Lagrange C, Tézenas du Montcel S, Dormont D, Grand S, Blond S, Detante O, Pillon B, Ardouin C, Agid Y, Destée A, Pollak P; French Stimulation du Pallidum Interne dans la Dystonie (SPIDY) Study Group. Bilateral deep-brain stimulation of the globus pallidus in primary generalized dystonia. N Engl J Med 2005, 352:459-467.

57) Vercueil L, Vidailhet M; Groupe Stimulation Pallidale Interne dans la dystonie. Pallidal stimulation for primary generalized dystonia. Revue Neurologique, 2005, 161:381-383

56) Benazzouz A., Tai C.H., Meissner W., Bioulac B., Bezard B. and Gross C. High frequency stimulation of both zona incerta and subthalamic nucleus induces a normalisation of basal ganglia metabolic activity in experimental parkinsonism. FASEB Journal, 10.1096/fj.03-0576fje. Published online January 8, 2004.

55) Meissner W., Gross C.E., Harnack D., Bioulac B. and Benazzouz A. Deep brain stimulation for Parkinson's disease: potential risk of tissue damage associated with external stimulation. Annals of Neurology, 2004, 55:449-450.

54) Benazzouz A. La stimulation à haute fréquence du noyau sous-thalamique dans la thérapie de la maladie de Parkinson : état des lieux. Médecine Science, 2004, 20: 397-398.

53) Aouizerate, B., Cuny, E., Martin-Guehl, C., Guehl, D., Amieva, H., Benazzouz, A., Fabrigoule, C., Allard, M., Rougier, A., Bioulac, B., Tignol, J. and Burbaud, P. Deep brain stimulation of the ventral caudate nucleus is effective in obsessive-compulsive disorder and major depression. J. Neurosurg. 2004, 101:682-686.

52) Fraix V., Pollak P., Chabardes S, Ardouin C., Koudsie A., Benazzouz A., Krack P., Batir A., Le Bas J.F. et Benabid A.L. La stimulation cérébrale profonde dans la maladie de Parkinson. Revue Neurologique, 2004, 160:511-521.

51) Taï C.H., Boraud T., Bezard E., Bioulac B., Gross C.E. and Benazzouz A. Electrophysiological and Metabolic Evidence that High Frequency Stimulation of the

Subthalamic Nucleus Bridles Neuronal Activity in the Subthalamic Nucleus and the Substantia Nigra Reticulata. FASEB Journal, 2003, 17: 1820-1830.

50) Krack P., Batir A., Van Blercom N., Chabardes S., Fraix V., Ardouin C., Koudsie A., Dowsey Limousin P., Benazzouz A., LeBas J.F., Benabid A.L., Pollak P. Five years follow-up of bilateral stimulation of the subthalamic nucleus in advanced Parkinson's disease. N. Eng J. Med., 2003;349:1925-1934.

49) Guehl, D., Tison, F., Cuny, E., Benazzouz, A., Rougier, A., Bioulac, B. and Burbaud, P. Complications and adverse effects of deep brain stimulation in Parkinson's patients. Expert Review of Neurotherapeutics, 2003, 3:811-819.

48) Benazzouz A., Breit S., Koudsie A., Pollak P., Krack P., Benabid A.L. Intraoperative microrecordings of the subthalamic nucleus in Parkinson's disease. Mov Disord. 2002, 17 (Suppl 3) : S145-149.

47) Bressand K., Dematteis M., Gao D.M., Vercueil L., Benabid A.L. and Benazzouz A. Superior colliculus firing changes after lesion or electrical stimulation of the subthalamic nucleus in the rat. Brain Res., 2002, 943 : 93-100.

46) Benabid A.L., Benazzouz A., Pollak P. Mechanisms of deep brain stimulation. Mov Disord. 2002;17 (Suppl 3) : S73-74.

45) Benabid A.L., Koudsie A., Benazzouz A., Le Bas J.F., Pollak P. Imaging of subthalamic nucleus and ventralis intermedius of the thalamus. Mov Disord. 2002;17 (Suppl 3) : S123-129.

44) Ni Z.G., Gao D.M., Bouali-Benazzouz R., Benabid A.L. and Benazzouz A. Effect of microiontophoretic application of dopamine on subthalamic nucleus neuronal activity in normal rats and in rats with unilateral lesion of the nigrostriatal pathway. Eur. J. Neurosci., 2001, 14 (2): 373-381.

43) Breit S., Bouali-Benazzouz R., Benabid A.L. and Benazzouz A. Unilateral lesion of the nigrostriatal pathway induces an increase of neuronal activity of the pedunculopontine nucleus, which is reversed by the lesion of the subthalamic nucleus in the rat. Eur. J. Neurosci., 2001, 14 (11): 1833-1842.

42) Ni Z.G., Bouali-Benazzouz R., Gao D.M., Benabid A.L. and Benazzouz A. Intrasubthalamic injection of 6-hydroxydopamine induces changes in the firing rate and pattern of subthalamic nucleus neurons in the rat. Synapse, 2001, 40 (2) : 145-153.

41) Ni Z.G., Bouali-Benazzouz R., Gao D.M., Benabid A.L. and Benazzouz A. Time-course of changes in neuronal activity of subthalamic nucleus after 6-OHDA induced dopamine depletion in rats. Brain Res., 2001, 899 (1-2) : 142-147.

40) Benabid A.L., Koudsie A., Benazzouz A., Vercueil L., Fraix V., Chabardes S., Lebas J.F. and Pollak P. Deep brain stimulation of the corpus luysi (subthalamic nucleus) and other targets in Parkinson's disease. Extension to new indications such as dystonia and epilepsy. J. Neurol., 2001, 248 (Suppl 3) : 37-47. Review

39) Vercueil L., Pollak P., Fraix V., Caputo E., Moro E., Benazzouz A., Xie J., Koudsié A. and Benabid A.L. Deep Brain Stimulation in the treatment of dystonia. J. Neurol., 2001, 248 (8): 695-700.

38) Benazzouz A., Gao DM., Ni ZG., Piallat B., Bouali-Benazzouz R. and Benabid A.L. Effect of High Frequency Stimulation of the Subthalamic Nucleus on the neuronal activities of the Substantia Nigra Pars Reticulata and ventral-lateral nucleus of the thalamus in the Rat. Neuroscience, 2000, 99 : 289-295.

37) Benazzouz A., Piallat B., Ni Z.G., Koudsié A., Pollak P, and Benabid A.L. Implication of the subthalamic nucleus in the pathophysiology and pathogenesis of Parkinson's disease. Cell Transplantation, 2000, 9 : 215-221. Review

36) Benazzouz A., Gao DM., Ni ZG. and Alim-Louis Benabid. High frequency stimulation of the STN influences the activitiy of dopamine neurons in the rat. Neuroreport, 2000, 11 : 1593-1596.

35) Ni Z.G., Gao D.M., Benabid A.L. and Benazzouz A. Unilateral lesion of the nigrostriatal pathway induces a transient decrease of firing rate with no change in the firing pattern of neurons of the parafascicular nucleus in the rat. Neuroscience, 2000, 101 : 993-999.

34) Ni Z.G., Bouali-Benazzouz R., Gao D.M., Benabid A.L. and Benazzouz A. Changes in the firing pattern of globus pallidus neurons after the degeneration of nigrostriatal pathwa are mediated by the subthalamic nucleus in the rat. Eur. J. Neurosci., 2000, 12 : 4338-4344.

33) Benabid A.L., Koudsie A., Benazzouz A., Fraix V., Ashraf A., Le Bas J.F., Chabardes S. and Pollak P. Subthalamic Stimulation for Parkinson's Disease. Arch. Med. Res., 2000, 31: 282-289.

32) Krack P., Limousin-Dowsey P., Benabid A.L., Acarin N., Benazzouz A., Künig G., KL Leenders, Obeso J.A., Pollak P. Ineffective subthalamic nucleus stimulation in levodopa-resistant postischemic parkinsonism. Neurology, 2000, 54 : 2182-2184.

31) Benazzouz A. and Hallett M. Mechanism of action of deep brain stimulation. Neurology, 2000, 55 (Suppl 6) : 13-16. Review

30) Benabid, A.L., Koudsié, A., Pollak P., Kahane, P., Chabardes, S., Hirsch, E., Marescaux C. and Benazzouz A. Future prospects of brain stimulation. Neurol. Res., 2000, 22 : 237-246. Review

29) Benabid A.L., Benazzouz A., Limousin P., Koudsié A., Krack P., Piallat B. and Pollak P. Dyskinesias and the subthalamic nucleus. Ann. Neurol., 2000, 47 (suppl 1) : S189-S192. Review

28) Benabid A.L., Krack P., Benazzouz A., Limousin P., Koudsié A. and Pollak P. Deep brain stimulation of the subthalamic nucleus for the treatment of Parkinson's disease. Neurology, 2000, 55 (Suppl 6) : 40-44. Review

27) Gao D.M., Benazzouz A., Piallat B., Bressand K., Ilinsky I., Kultas-Ilinsky K. and Benabid A.L. High frequency stimulation of the subthalamic nucleus suppresses rest

tremor in the Monkey. Neuroscience, 1999, 88 : 201-212.

26) Piallat B., Benazzouz A. and Benabid A.L. Neuroprotective effect of chronic inactivation of the subthalamic nucleus in a rat model of Parkinson's disease. J. Neural Transm., 1999, 55 (suppl) : 71-77.

25) Krack P., Pollak P., Limousin P., Benazzouz A., G. Deuschle and Benabid A.L. From Off-period dystonia to peak dose chorea. The clinical spectrum of varying subthalamic nucleus activity. Brain, 1999, 122 : 1133-1146.

24) Limousin-Dowsey, P. Pollak, P.Van Blercom, N. Krack, P. Benazzouz, A. Benabid, AL. Thalamic, subthalamic nucleus and internal pallidum stimulation in Parkinson's disease. J. Neurol., 1999, 246:42-45. Review

23) Krack P., Benazzouz A. Pollak P., Limousin P., Piallat B., Hoffmann D., Xie J. and Benabid A.L. Treatment of tremor in Parkinson's disease by subthalamic nucleus stimulation. Mov. Disord., 1998 13: 907-914.

22) Benabid A.L., Benazzouz A., Hoffmann D., Limousin P., Krack P. and Pollak P. Long-term electrical inhibition of deep brain targets in movement disorders. Mov. Disord., 1998, 13 (Suppl 3): 119-125.

21) Vercueil L., Benazzouz A., Deransart C., Bressand K., Marescaux C., Depaulis A. and Benabid A.L. High frequency stimulation of the subthalamic nucleus suppressed absence seizures in the rat: comparison with neurotoxic lesions. Epilep. Res., 1998, 31: 39-46.

20) Limousin P., Krack P., Pollak P., Benazzouz A., Ardouin C., Hoffmann D. and Benabid A.L. Electrical stimulation of the subthalamic nucleus in advanced Parkinson's disease. N. Eng. J. Med., 1998, 339 : 1105-1111.

19) Krack P., Pollak P., Limousin P., Hoffmann D., Benazzouz A., Le Bas JF., Koudsié A. and Benabid A.L. Opposite motor effects of pallidal stimulation in Parkinson's disease. Ann. Neurol., 1998, 43 : 180-192.

18) Krack P., Pollak P., Limousin P., Hoffmann D., Benazzouz A. and Benabid A.L. Inhibition of levodopa-effects by internal pallidal stimulation. Mov. Disord., 1998, 13 : 648-652.

17) Krack P., Pollak P., Limousin P., Hoffmann D., Xie J., Benazzouz A. and Benabid A.L. Subthalamic nucleus or internal pallidal stimulation in young onset Parkinson's disease. Brain, 1998, 121 : 451-457.

16) Bioulac B., Benazzouz A., Burbaud P. and Gross Ch.Chronic administration of DL-allyl-glycine into the neostriatum, effects on the electrical activity of the nigral dopaminergic neurons in the rat. Neurosci. Lett., 1997, 226 : 21-24.

15) Gao D.M., Benazzouz A., Bressand K., Piallat B. and Benabid A.L. Roles of GABA, glutamate, acetylcholine and STN stimulation on thalamic VM in rats. Neuroreport, 1997, 8 : 2601-2605.

14) Krack P., Pollak P., Limousin P., Benazzouz A. and Benabid P. Stimulation of subthalamic nucleus alleviates tremor in Parkinson's disease. The Lancet, 1997, 350 : 1675.

13) Benazzouz A., Boraud Th., Féger J., Burbaud P., Bioulac B. and Gross Ch. Alleviation of experimental hemiparkinsonism by high frequency stimulation of the subthalamic nucleus in primate: A comparison with L-dopa treatment. Mov. Disord., 1996, 11 : 627-632.

12) Benabid A.L., Pollak P., Gao D.M., Hoffmann D., Limousin P., Gay E., Payen I. and. Benazzouz A. Chronic electrical stimulation of the ventralis intermedius nucleus of the thalamus as atreatment of movement disorders. J. Neursurg., 1996, 84 : 203-214.

11) Piallat B., Benazzouz A. and Benabid A.L. Subthalamic nucleus lesion in rat prevents dopaminergic nigral neuron degeneration after striatal 6-OHDA injection : behavioral and immunohistochemical studies. Eur. J. Neurosci., 1996, 8 : 1408-1414.

10) Limousin P., Pollak P., Hoffmann D., Benazzouz A., Perret J. and Benabid P. Abnormal involuntary movements induced by subthalamic nucleus stimulation. Mov. Disord., 1996, 11 : 231-235.

9) Benazzouz A., Piallat Brigitte, Pollak P. and Benabid A.L. Responses of substantia nigra pars reticulata and globus pallidus complex to high frequency stimulation of the subthalamic nucleus in rats: electrophysiological data. Neurosci. Lett., 1995, 189 : 77-80.

8) Benazzouz A., Boraud Th., Dubédat P., Boireau A., Stutzmann J-M. and Gross Ch. Riluzole prevents MPTP-induced parkinsonism in the rhesus monkey: a pilote study. Eur. J. Pharmacol., 1995, 284 : 299-307.

7) Limousin P., Pollak P., Benazzouz A., Hoffmann D., Le Bas J.F, Broussolle E., Perret J. and Benabid A.L. Effect on parkinsonian signs and symptoms of bilateral subthalamic nucleus stimulation. The Lancet, 1995, 345 : 91-95.

6) Limousin P., Pollak P., Benazzouz A., Hoffmann D., Broussole J.E., Perret J. and Benabid P. Bilateral subthalamic nucleus stimulation for severe Parkinson's disease. Mov. Disord., 1995, 10 : 672-674.

5) Burbaud P., Gross Ch., Benazzouz A., Coussemacq M and Bioulac B. Reduction of apomorphine-induced rotational behaviour by subthalamic lesion in 6-OHDA lesioned rats is associated with a normalization of firing rate abd discharge pattern of pars reticulata neurons. Exp. Brain Res., 1995, 105 : 48-58.

4) Dousset V., Brochet B., Vital A., Gross Ch., Benazzouz A., Boullerne A., Bidabe A-M., Gin A-M. and Caillé J-M. Lysolecithin-induced demyelination in Primates: Preliminary in vivo study with MR and magnetization transfer. Am. J Neuroradiol., 1995, 16 : 225-231.

3) Benazzouz A., Gross C., Féger J., Boraud T. and Bioulac B. Reversal of rigidity and improvement in motor performance by subthalamic high frequency stimulation in MPTP-treated monkeys. Eur. J. Neurosci., 1993, 5 : 382-389.

2) Pollak P., Benabid A.L., Gross Ch., Gao D.M., Laurent A., Benazzouz A., Hoffmann D., Gentil M., and Perret J. Effets de la stimulation du noyau sous-thalamique dans la maladie de Parkinson. Rev. Neurol. (Paris), 1993, 149 : 175-176.

1) Benazzouz A., Gross Ch., Dupont J. and Bioulac B. MPTP induced hemiparkinsonism in

monkeys : behavioral mechanographic, electromyo-graphic and immunohistochemical studies. Exp. Brain Res., 1992, 90 : 116-120.