NEUROPSYCHOLOGY OPTION **Week 4 handout, Oct 24th, 2006**

Topic: Localization and the Neuropsychology of Motivation, Emotion and Social Cognition

Essay: "The principle of functional specialization which is apparent in visual cortex applies to affective states and social cognition as well." Discuss.

The issue of localization is sometimes addressed as specific to cognitive functions, visual and somatosensory perception in particular. The kind of questions about the functional specializations of different brain structures or regions can also be asked about motivation and emotion, although there may be differences of emphasis. Indeed the variety of topics addressed in brain imaging studies in recent years suggests that the original single neuron doctrine of Barlow (1972), which was formulated in the context of 'a simple correspondence between the elements of perception and unit activity' could now be expressed in terms of 'a simple correspondence between the elements of any psychological state and activity in identified neurons'. Berman et al., (2006) noted that while in 1993 fewer that 20 papers were published reporting the use of fMRI, there were nearly 1800 such papers in 2003 and the range of psychological topics studied has vastly expanded over the same period.

i. Emotion

There is not universal agreement about a clear distinction between cognitive and affective processes. Pankseep (2003) lists 6 overlapping characteristics which he argues distinguish affective states from cognitive processes: i) affective stage have valence (they are accompanied by positive or negative feelings); ii) emotional responses survive forms of brain damage that severely impair cognitive processes; because cognitive processes are heavily dependent on the cortex, whereas emotional responses are largely driven by subcortical sites; iii) emotional responses are developmentally earlier that cognitive ones; iv) cognitions are generated by a digital style of information processing, whereas emotions are influenced by analogue neurohormonal factors v) emotions but not cognitions are associated with spontaneous transcultural facial expressions; and vi) the right hemisphere is more emotional, and concentrates on negative emotions whereas the left hemisphere is linguistic and analytical yet more prone to positive emotions. Pankseep (2003) accepts that his is a minority view, and that others have argued against any distinction between cognitive and emotional processes, but there would be general agreement that the brain circuits involved in emotional regulation are distinctively different from those required by cognitive information processing (Rolls, 2000; Cardinal et al, 2002)

Broadly, emotion and motivation are dealt with by the limbic system together with associated midbrain and frontal lobe regions (see p. 4). For human brain scanning studies, orbitofrontal (sometimes called prefrontal) cortex is of particular interest. Kringlebach and Rolls (2004) proposed two distinct trends of neural activity based on a review of brain-imaging studies. The first is a distinction between medial and lateral areas, with the medial orbitofrontal areas being activated by positive or rewarding stimulus and lateral areas responding to negative or punishing outcomes. The second is a posterior-anterior difference, (within the orbitofrontal region) with more abstract outcomes (such as monetary gain or loss) being represe nted anteriorly, and more direct pleasurable outcomes such as taste or pain, posteriorly. (e.g. Small et al, 2001; Knutson et al, 2001)

However, limbic structures, such as the amygdala and cingulate gyrus, are also often detected in brain imaging studies as well as the reward pathway starting in the midbrain ventral tegmental area (often abbreviated VTA) going via the medial forebrain bundle to the nucleus accumbens in the basal ganglia (see p. 6) as well as the prefrontal emotionally sensitive areas. This reward pathway was first identified in the 1950s by investigations of self-stimulation via implanted electrodes in rats and there is continued interest in these areas because of their involvement in addiction (Berridge, 2003; Robinson and Berridge, 2003; Ikemoto and Wise, 2004; Volkow et al, 2004).

Three recent review papers include accounts of the neural structures underlying emotions.

- Kavanagh et al. (2005) present an elaborate cognitive theory of human desire, but the theory has its roots as an explanation for cravings for psychoactive substances, and it identifies the "mesocorticolimbic dopamine pathway" as important for incentives considered very generally.

- Lewis (2005) presents psychological model of self-organizing emotional interpretations based on dynamic systems theory, but also wants to identify different components of emotional appraisal — perception, evaluation, attention, memory, and planning/reflection — with different neural systems and includes several circuit diagrams of feedback circuits involving the VTA, the amygdala, orbitofrontal cortex, anterior cingulate cortex and so on.

- Phelps (2006) reviews 5 topics: emotional learning, emotion and memory, emotional influences on attention, emotional effects of social stimuli, and change in emotional responses, all in terms of the functions of the human amygdale.

Much of the evidence linking the mesocorticolimbic structures to motivation and emotion is based on physiological studies with monkeys or rats, but human brain imaging experiments provide some degree of confirmation that extrapolations to humans are justified.

Bartels and Zeki (2000) and Aron et al., (2005) recruited subjects who were deeply in love, and compared fMRI scans when these subjects were looking either at pictures of their partners or control pictures of friends or familiar individuals. Bartels and Zeki (2000) found activity in the anterior cingulate cortex and in the basal ganglia associated with viewing partners. These structures have been implicated in other kinds of emotion but the precise location and pattern of activity lead the authors to suggest that a unique network was involved, and thus postulated "that the principle of functional specialization in the cortex applies to affective states as well". Aron et al found a somewhat similar pattern of activation, with anterior cingulate activity correlating with length of the romantic relationship, but they also found activation in the ventral tegmental area, with a suggestion that this is lateralized on the right, but nevertheless draw an opposing conclusion, namely "that romantic love does not use a functionally specialized brain system" because of the generic nature of the mesocorticolimbic incentive network.

ii. Social cognition and other areas of human psychology

- Amodio and Frith (2006) and Saxe (2006) offer general reviews of evidence about the braincircuits involved in social cognition, in which areas in the **frontal lobes** figure prominently.
- Goldberg et al (2006) claim a complete segregation between patterns of brain activity produced during self-reflective introspection and a sensory categorization task and Northhoff et al. (2006) review a large collection of imaging studies of the self which locate it in 'cortical midline structures'.
- Several recent studies focus on empathy and other "theory of mind" aspects of social psychology (Aventanti et al, 2005, 2006, Jackson et al., 2005, Singer et al., 2004, 2006, Heisel and Beatty. 2006), including morality (Berthoz et al, 2006; Luo et al., 2006).
- There is an extremely long list of studies of human reward circuits (e.g. Pessiglione et al., 2006; Preuschoff et al., 2006) which merge into those on decision making (Daw et al., 2006; Montague et al., (2006) and 'neuroeconomics' (Braeutigam et al. 2005; Sanfey et al., 2006; Zap. 2004)
- Special cases of human reward circuits involve brain activity related to food (Small et al., 2001; O'Doherty et al., 2006; Beaver et al., 2006), drugs of abuse (Kufahl et al., 2005; Risinger et al., 2005) and humour (Goel & Dolan, 2001; Bartolo et al., 2006)

Conclusion: there is localization of function in the brain systems that subserve motivation and emotion, and related areas of psychology such as social cognition and decision making in the sense that detailed circuits of named structures are involved and imaging studies are able to show specific patterns of activation associated with specific emotions. However, the level of detail of localization, and the current understanding of functional specializations in the areas involved, is considerably less developed than is the case for the visual system

Texts with brief relevant sections

Carlson, N. (1998) *Physiology of Behavior*. *6th edn* Allyn & Bacon: Needham Heights. "Neural control of emotional response patterns, pp. 326; "Reinforcement", pp 441-449; "Common features of addiction", pp. 565-584; (6 copies, 3-1wk & 3-3wk loan in BK library)

Gleitman, H. et al. (1999/2004) *Psychology. 5th/6th Edition*. Norton, London. p 112/p 118 "The dopamine hypothesis of reward and drug effects"

References

Abler, B., Walter, H., Erk, S., Kammerer, H., & Spitzer, M. (2006). Prediction error as a linear function of reward probability is coded in human nucleus accumbens. *Neuroimage, 31*(2), 790-795.

Amodio, D. M., & Frith, C. D. (2006). Meeting of minds: the medial frontal cortex and social cognition. *Nature Reviews Neuroscience, 7*(4), 268-277.

Aron, A., Fisher, H., Mashek, D. J., Strong, G., Li, H. F., & Brown, L. L. (2005). Reward, motivation, and emotion systems associated with early- stage intense romantic love. *Journal of Neurophysiology, 94*(1), 327-337.

Avenanti, A., Bueti, D., Galati, G., & Aglioti, S. M. (2005). Transcranial magnetic stimulation highlights the sensorimotor side of empathy for pain. *Nature Neuroscience, 8*(7), 955-960.

Avenanti, A., Paluello, L. M., Bufalari, I., & Aglioti, S. M. (2006). Stimulus-driven modulation of motor-evoked potentials during observation of others' pain. *Neuroimage, 32*(1), 316-324.

Barlow, H.B. (1972) Single units and sensation: a neuron doctrine for perceptual psychology?. *Perception, 1*, 371-94.

Bartels, A., & Zeki, S. (2000). The neural basis of romantic love. *Neuroreport, 11*(17), 3829-3834.

Bartels, A., & Zeki, S. (2004). The neural correlates of maternal and romantic love. *Neuroimage, 21*(3), 1155-1166.

Bartolo, A., Benuzzi, F., Nocetti, L., Baraldi, P., & Nichelli, P. (2006). Humor Comprehension and Appreciation: An fMRI Study. *J. Cogn. Neurosci., 18*(11), 1789-1798.

Beaver, J. D., Lawrence, A. D., Van Ditzhuijzen, J., Davis, M. H., Woods, A., & Calder, A. J. (2006). Individual differences in reward drive predict neural responses to images of food. *Journal of Neuroscience, 26*(19), 5160-5166.

Bechara, A., Tranel, D., Damasio, H., Adolphs, R., Rockland, C., & Damasio, A. R. (1995). Double Dissociation of Conditioning and Declarative Knowledge Relative to the Amygdala and Hippocampus in Humans. *Science, 269*(5227), 1115-1118.

Beer, J. S., John, O. P., Scabini, D., & Knight, R. T. (2006). Orbitofrontal cortex and social behavior: Integrating self-monitoring and emotion-cognition interactions. *Journal of Cognitive Neuroscience, 18*(6), 871-879.

Berman, M. G., Jonides, J., & Nee, D. E. (2006). Studying mind and brain with fMRI. Social Cognitive and Affective Neuroscience, 1(2), 158-161.

Bermpohl, F., Pascual-Leone, A., Amedi, A., Merabet, L. B., Fregni, F., Gaab, N., et al. (2006). Dissociable networks for the expectancy and perception of emotional stimuli in the human brain. *Neuroimage, 30*(2), 588-600.

Berns, G. S., Chappelow, J., Cekic, M., Zink, C. F., Pagnoni, G., & Martin-Skurski, M. E. (2006). Neurobiological substrates of dread. *Science, 312*(5774), 754-758.

Berns, G. S., Chappelow, J., Zink, C. F., Pagnoni, G., Martin-Skurski, M. E., & Richards, J. (2005). Neurobiological correlates of social conformity and independence during mental rotation. *Biological Psychiatry, 58*(3), 245-253.

Berridge, K. C. (2003). Pleasures of the brain. *Brain and Cognition, 52*(1), 106-128.

Berridge, K. C., & Robinson, T. E. (2003). Parsing reward. *Trends in Neurosciences, 26*(9), 507-513.

Berthoz, S., Armony, J. L., Blair, R. J. R., & Dolan, R. J. (2002). An fMRI study of intentional and unintentional (embarrassing) violations of social norms. *Brain, 125*(8), 1696-1708.

Berthoz, S., Grezes, J., Armony, J. L., Passingham, R. E., & Dolan, R. J. (2006). Affective response to one's own moral violations. *Neuroimage, 31*(2), 945-950.

Britton, J. C., Phan, K. L., Taylor, S. F., Welsh, R. C., Berridge, K. C., & Liberzon, I. (2006). Neural correlates of social and nonsocial emotions: An fMRI study. *Neuroimage, 31*(1), 397-409.

Cardinal, R. N., & Everitt, B. J. (2004). Neural and psychological mechanisms underlying appetitive learning: links to drug addiction. *Current Opinion in Neurobiology, 14*(2), 156-162.

Cardinal, R. N., Parkinson, J. A., Hall, J., & Everitt, B. J. (2002). Emotion and motivation: the role of the amygdala, ventral striatum, and prefrontal cortex. *Neuroscience and Biobehavioral Reviews, 26*(3), 321-352.

Critchley, H. D., Mathias, C. J., Josephs, O., O'Doherty, J., Zanini, S., Dewar, B.-K., Cipolotti, L., Shallice, T., & Dolan, R. J. (2003). Human cingulate cortex and autonomic control: converging neuroimaging and clinical evidence. *Brain, 126*(10), 2139-2152.

Daw, N. D., O'Doherty, J. P., Dayan, P., Seymour, B., & Dolan, R. J. (2006). Cortical substrates for exploratory decisions in humans. *Nature, 441*(7095), 876-879.

Depue, R. A., & Morrone-Strupinsky, J. V. (2005). A neurobehavioral model of affiliative bonding: Implications for conceptualizing a human trait of affiliation. *Behavioral and Brain Sciences, 28*(3), 313-+.

Everitt, B. J., Dickinson, A., & Robbins, T. W. (2001). The neuropsychological basis of addictive behaviour. *Brain Research Reviews, 36*(2-3), 129-138.

Fadiga, L., Craighero, L., & Olivier, E. (2005). Human motor cortex excitability during the perception of others' action. *Current Opinion in Neurobiology, 15*(2), 213-218.

Fischer, H., Andersson, J. L. R., Furmark, T., & Fredrikson, M. (1998). Brain correlates of an unexpected panic attack: a human positron emission tomographic study. *Neuroscience Letters, 251*(2), 137-140.

George, M. S., Anton, R. F., Bloomer, C., Teneback, C., Drobes, D. J., Lorberbaum, J. P., Nahas, Z., & Vincent, D. J. (2001). Activation of prefrontal cortex and anterior thalamus in alcoholic subjects on exposure to alcohol-specific cues. *Archives of General Psychiatry, 58*(4), 345-352.

Goel, V., & Dolan, R. J. (2001). The functional anatomy of humor: segregating cognitive and affective components. *Nature Neuroscience, 4*(3), 237-238.

Goldberg, II, Harel, M., & Malach, R. (2006). When the brain loses its self: Prefrontal inactivation during sensorimotor processing. *Neuron, 50*(2), 329-339.

Goldin, P. R., Hutcherson, C. A. C., Ochsner, K. N., Glover, G. H., Gabrieli, J. D. E., & Gross, J. J. (2005). The neural bases of amusement and sadness: A comparison of block contrast and subject-specific emotion intensity regression approaches. *Neuroimage, 27*(1), 26-36.

Hampton, A. N., Bossaerts, P., & O'Doherty, J. P. (2006). The role of the ventromedial prefrontal cortex in abstract state-based inference during decision making in humans. *Journal of Neuroscience, 26*(32), 8360-8367.

Heatherton, T. F., Wyland, C. L., Macrae, C. N., Demos, K. E., Denny, B. T., & Kelley, W. M. (2006). Medial prefrontal activity differentiates self from close others. *Social Cognitive and Affective Neuroscience*, 1(1), 18-25.

Heisel, A. D., & Beatty, M. J. (2006). Are cognitive representations of friends' request refusals implemented in the orbitofrontal and dorsolateral prefrontal cortices? A cognitive neuroscience approach to 'theory of mind' in relationships. *Journal of Social and Personal Relationships, 23*(2), 249-265.

Hennenlotter, A., Schroeder, U., Erhard, P., Castrop, F., Haslinger, B., Stoecker, D., Lange, K. W., & Ceballos-Baumann, A. O. (2005). A common neural basis for receptive and expressive communication of pleasant facial affect. *Neuroimage, 26*(2), 581-591.

Hunter, M. D., Griffiths, T. D., Farrow, T. F. D., Zheng, Y., Wilkinson, I. D., Hegde, N., Woods, W., Spence, S. A., & Woodruff, P. W. R. (2003). A neural basis for the perception of voices in external auditory space. *Brain, 126*, 161-169.

Husted, D. S., Shapira, N. A., & Goodman, W. K. (2006). The neurocircuitry of obsessive-compulsive disorder and disgust. *Progress in Neuro-Psychopharmacology & Biological Psychiatry, 30*(3), 389-399.

Ikemoto, S., & Panksepp, J. (1999). The role of nucleus accumbens dopamine in motivated behavior: a unifying interpretation with special reference to reward-seeking. *Brain Research Reviews, 31*(1), 6-41.

Ikemoto, S., & Wise, R. A. (2004). Mapping of chemical trigger zones for reward. *Neuropharmacology, 47*(Supplement 1), 190-201.

Jackson, P. L., Meltzoff, A. N., & Decety, J. (2005). How do we perceive the pain of others? A window into the neural processes involved in empathy. *NeuroImage, 24*(3), 771-779.

Jackson, P. L., Brunet, E., Meltzoff, A. N., & Decety, J. (2006). Empathy examined through the neural mechanisms involved in imagining how I feel versus how you feel pain. *Neuropsychologia, 44*(5), 752-761.

Johnson, S. C., Baxter, L. C., Wilder, L. S., Pipe, J. G., Heiserman, J. E., & Prigatano, G. P. (2002). Neural correlates of self-reflection. *Brain, 125*(8), 1808-1814.

Kavanagh, D. J., Andrade, J., & May, J. (2005). Imaginary relish and exquisite torture: The elaborated intrusion theory of desire. *Psychological Review, 112*(2), 446-467.

Kim, H., Shimojo, S., & O'Doherty, J. P. (2006). Is avoiding an aversive outcome rewarding? Neural substrates of avoidance learning in the human brain. *Plos Biology, 4*(8), 1453-1461.

Knutson, B., Adams, C. M., Fong, G. W., & Hommer, D. (2001). Anticipation of increasing monetary reward selectively recruits nucleus accumbens. *Journal of Neuroscience, 21*(16), art. no.-RC159.

Knutson, B., Taylor, J., Kaufman, M., Peterson, R., & Glover, G. (2005). Distributed neural representation of expected value. *Journal of Neuroscience, 25*(19), 4806-4812.

Koelsch, S., Fritz, T., Von Cramon, D. Y., Muller, K., & Friederici, A. D. (2006). Investigating emotion with music: An fMRI study. *Human Brain Mapping, 27*(3), 239-250.

Kranz, F., & Ishai, A. (2006). Face perception is modulated by sexual preference. *Current Biology, 16*(1), 63-68.

Kringelbach, M. L., & Rolls, E. T. (2004). The functional neuroanatomy of the human orbitofrontal cortex: evidence from neuroimaging and neuropsychology. *Progress in Neurobiology, 72*(5), 341-372.

Kufahl, P. R., Li, Z., Risinger, R. C., Rainey, C. J., Wu, G. H., Bloom, A. S., et al. (2005). Neural responses to acute cocaine administration in the human brain detected by fMRI. *Neuroimage, 28*(4), 904-914.

LaBar, K. S., & Cabeza, R. (2006). Cognitive neuroscience of emotional memory. *Nature Reviews Neuroscience, 7*(1), 54-64.

Lewis, M. D. (2005). Bridging emotion theory and neurobiology through dynamic systems modeling. *Behavioral and Brain Sciences, 28*(2), 169-+.

Luo, Q. A., Nakic, M., Wheatley, T., Richell, R., Martin, A., & Blair, R. J. R. (2006). The neural basis of implicit moral attitude - An IAT study using event-related fMRI. *Neuroimage, 30*(4), 1449-1457.

Mohn, A. R., Yao, W.-D., & Caron, M. G. (2004). Genetic and genomic approaches to reward and addiction. *Neuropharmacology, 47*(Supplement 1), 101-110.

Mohr, C., Binkofski, F., Erdmann, C., Buchel, C., & Helmchen, C. (2005). The anterior cingulate cortex contains distinct areas dissociating external from self-administered painful stimulation: a parametric fMRI study. *Pain, 114*(3), 347-357.

Montague, P. R., King-Casas, B., & Cohen, J. D. (2006). Imaging valuation models in human choice. *Annual Review of Neuroscience, 29*, 417-448.

Morris, J. S., & Dolan, R. J. (2004). Dissociable amygdala and orbitofrontal responses during reversal fear conditioning. *Neuroimage, 22*(1), 372-380.

Morton, G. J., Cummings, D. E., Baskin, D. G., Barsh, G. S., & Schwartz, M. W. (2006). Central nervous system control of food intake and body weight. *Nature, 443*(7109), 289-295.
Northoff, G., Heinzel, A., Greck, M., Bennpohl, F., Dobrowolny, H., & Panksepp, J. (2006). Self-referential processing in our brain - A meta-analysis of imaging studies on the self. *Neuroimage, 31*(1), 440-457.
Ochsner, K. N., & Gross, J. J. (2005). The cognitive control of emotion. *Trends in Cognitive Sciences, 9*(5), 242-249.
O'Doherty, J. P., Buchanan, T. W., Seymour, B., & Dolan, R. J. (2006). Predictive neural coding of reward preference involves dissociable responses in human ventral midbrain and ventral striatum. *Neuron, 49*(1), 157-166.
Ohman, A. (2005). The rote of the amygdala in human fear: Automatic detection of threat. *Psychoneuroendocrinology, 30*(10), 953-958.
Panksepp, J. (2003). At the interface of the affective, behavioral, and cognitive neurosciences: Decoding the emotional feelings of the brain. *Brain and Cognition, 52*(1), 4-14.
Patterson, D. W., & Schmidt, L. A. (2003). Neuroanatomy of the human affective system. *Brain and Cognition, 52*(1), 24-26.
Pessiglione, M., Seymour, B., Flandin, G., Dolan, R. J., & Frith, C. D. (2006). Dopamine-dependent prediction errors underpin reward-seeking behaviour in humans. *Nature, 442*(7106), 1042-1045.
Phelps, E. A. (2006). Emotion and cognition: Insights from studies of the human amygdala. *Annual Review of Psychology, 57*, 27-53.
Preuschoff, K., Bossaerts, P., & Quartz, S. R. (2006). Neural differentiation of expected reward and risk in human subcortical structures. *Neuron, 51*(3), 381-390.
Risinger, R. C., Salmeron, B. J., Ross, T. J., Amen, S. L., Sanfilipo, M., Hoffmann, R. G., et al. (2005). Neural correlates of high and craving during cocaine self-administration using BOLD fMRI. *Neuroimage, 26*(4), 1097-1108.
Robinson, T. E., & Berridge, K. C. (2003). Addiction. *Annual Review of Psychology, 54*, 25-53.
Robinson, T. E., & Kolb, B. (2004). Structural plasticity associated with exposure to drugs of abuse. *Neuropharmacology, 47*(Supplement 1), 33-46.
Rodriguez, P. F., Aron, A. R., & Poldrack, R. A. (2006). Ventral-striatal/nucleus-accumbens sensitivity to prediction errors during classification learning. *Human Brain Mapping, 27*(4), 306-313.
Rolls, E. T. (2000). Precis of the brain and emotion. *Behavioral and Brain Sciences, 23*(2), 177-+.
Rolls, E. T. (2004). The functions of the orbitofrontal cortex. *Brain and Cognition, 55*(1), 11-29.
Rolls, E. T., Critchley, H. D., Browning, A. S., & Inoue, K. (2006). Face-selective and auditory neurons in the primate orbitofrontal cortex. *Experimental Brain Research, 170*(1), 74-87.
Saxe, R. (2006). Uniquely human social cognition. *Current Opinion in Neurobiology, 16*(2), 235-239.
Saxe, R., & Wexler, A. (2005). Making sense of another mind: The role of the right temporo-parietal junction. *Neuropsychologia, 43*(10), 1391-1399.
Shaw, P., Lawrence, E. J., Radbourne, C., Bramham, J., Polkey, C. E., & David, A. S. (2004). The impact of early and late damage to the human amygdala on 'theory of mind' reasoning. *Brain, 127*(7), 1535-1548.
Singer, T., Kiebel, S. J., Winston, J. S., Dolan, R. J., & Frith, C. D. (2004). Brain responses to the acquired moral status of faces. *Neuron, 41*(4), 653-662.
Singer, T., Seymour, B., O'Doherty, J., Kaube, H., Dolan, R. J., & Frith, C. D. (2004). Empathy for pain involves the affective but not sensory components of pain. *Science, 303*(5661), 1157-1162.
Singer, T., Seymour, B., O'Doherty, J. P., Stephan, K. E., Dolan, R. J., & Frith, C. D. (2006). Empathic neural responses are modulated by the perceived fairness of others. *Nature, 439*(7075), 466-469.
Small, D. M., Zatorre, R. J., Dagher, A., Evans, A. C., & Jones-Gotman, M. (2001). Changes in brain activity related to eating chocolate: From pleasure to aversion. *Brain, 124*(Pt 9), 1720-33
Tobler, P. N., O'Doherty, J. P., Dolan, R. J., & Schultz, W. (2006). Human neural learning depends on reward prediction errors in the blocking paradigm. *Journal of Neurophysiology, 95*(1), 301-310.
Volkow, N. D., & Wise, R. A. (2005). How can drug addiction help us understand obesity? *Nature Neuroscience, 8*(5), 555-560.
Volkow, N. D., Fowler, J. S., & Wang, G. J. (2004). The addicted human brain viewed in the light of imaging studies: brain circuits and treatment strategies. *Neuropharmacology, 47*, 3-13.
Vuilleumier, P., Chicherio, C., Assal, F., Schwartz, S., Slosman, D., & Landis, T. (2001). Functional neuroanatomical correlates of hysterical sensorimotor loss. *Brain, 124*, 1077-1090.
Walter, H., Abler, B., Ciaramidaro, A., & Erk, S. (2005). Motivating forces of human actions - Neuroimaging reward and social interaction. *Brain Research Bulletin, 67*(5), 368-381.
Yacubian, J., Glascher, J., Schroeder, K., Sommer, T., Braus, D. F., & Buchel, C. (2006). Dissociable systems for gain- and loss-related value predictions and errors of prediction in the human brain. *Journal of Neuroscience, 26*(37), 9530-9537.

p6. see tinyurl.com/y4cua7 and tinyurl.com/ajm5z.

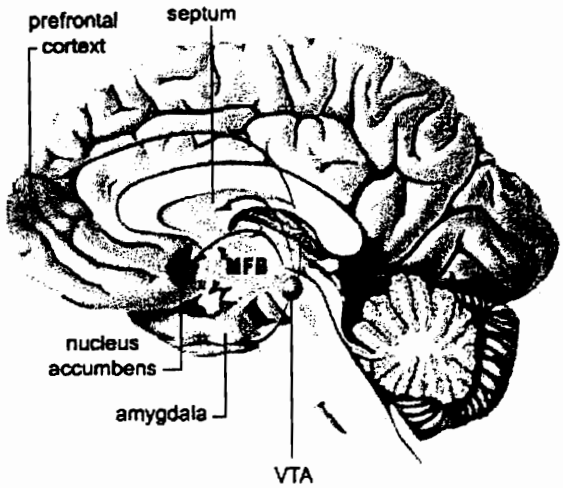
SUB-TOPICS

- Pleasure-Seeking Behaviour
- Pleasure and Drugs

THE PLEASURE CENTRES

When the cortex has received and processed a sensory stimulus indicating a reward, it sends a signal announcing this reward to a particular part of the midbrain—**the ventral tegmental area (VTA)**—whose activity then increases. The VTA then releases **dopamine** not only into the nucleus accumbens, but also into the septum, **the amygdala**, and the prefrontal cortex.

The nucleus accumbens then activates the individual's motor functions, while the prefrontal cortex focuses his or her attention.



These regions are connected by what is called the pleasure or reward bundle. In neuroanatomical terms, this bundle is part of the **medial forebrain bundle (MFB)**, whose activation leads to the repetition of the gratifying action to strengthen the associated pathways in the brain.

Just beside the ventral tegmental area is another part of the brain that contains a great deal of dopamine: **the substantia nigra**. The dopaminergic neurons of the substantia nigra project their axons into the corpus striatum, a region associated with the control of movement.

Essentially all of the dopamine that modulates brain activity comes from the ventral tegmental

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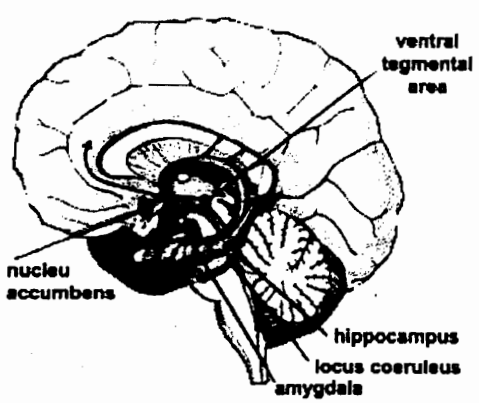
THE PLEASURE CENTRES AFFECTED BY DRUGS

The nucleus accumbens definitely plays a central role in the **reward circuit**. Its operation is based chiefly on two essential neurotransmitters: **dopamine**, which promotes desire, and **serotonin**, whose effects include satiety and inhibition. Many animal studies have shown that all drugs* increase the production of dopamine in the nucleus accumbens, while reducing that of serotonin.

* of abuse

But the nucleus accumbens does not work in isolation. It maintains close relations with other centres involved in the mechanisms of pleasure, and in particular, with the **ventral tegmental area (VTA)**.



Located in the midbrain, at the top of the brainstem, the VTA is one of the most primitive parts of the brain. It is the neurons of the VTA that synthesize dopamine, which their axons then send to the nucleus accumbens. The VTA is also influenced by endorphins whose receptors are targeted by **opiate** drugs such as heroin and morphine.

Another structure involved in pleasure mechanisms is the **prefrontal cortex**, whose role in planning and motivating action is well established. The prefrontal cortex is a significant relay in the reward circuit and also is modulated by dopamine.

The behaviours that the reward circuit drives us to repeat, as in the case of a drug dependency, can be reinforced positively or negatively.

In a **positive reinforcement**, the motivation for seeking the substance is the pleasure that it provides. In a **negative reinforcement**, the motivation is to relieve a physical discomfort, a depressive state, or social isolation.

Various theories explaining dependency behaviours posit that both types of reinforcement could be at play simultaneously to differing extents.

The locus coeruleus, an alarm centre of the brain and packed with norepinephrine, is another brain structure that plays an important role in drug addiction. When stimulated by a lack of the drug in question, the locus coeruleus drives the addict to do anything necessary to obtain a fix.

Two structures in the limbic system also play an active part in the pleasure circuit and, consequently, in drug dependency. The first is the **amygdala**, which imparts agreeable or disagreeable affective colorations to perceptions.

The second is the **hippocampus**, the foundation of memory, which preserves the agreeable memories associated with taking the drug and, by association, all of the details of the environment in which it is taken. Sometime in the future, these details may reawaken the desire to take the drug and perhaps contribute to recidivism in the patient.