Dopamine: Go/No-Go motivation vs. switching.

Robert D. Oades

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Biopsychology Group, University Clinic of Child and Adolescent Psychiatry, Virchowstr. 174, 45147 Essen, Germany. Email: oades@uni-essen.de

Commentary on Depue & Collins
"Neurobiology of the Structure of Personality: Dopamine, Facilitation of Incentive Motivation and Extraversion"
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Abstract:
Sensitivity to incentive motivation has a formative influence on extraversion. Meso-amygdaloid dopamine (DA) activity may, at one level, act as a micro-gate permitting an incentive to influence behavioral organization - 'Go/No-Go' in this scheme. However data on function elsewhere in the mesocorticolimbic DA system is taken to support this particular function. At another level of analysis, the data in this review by D&C along with that on the rest of the VTA system may fit better with a "switching" function in information processing. This link is supported by correlations between measures of extraversion, learned inattention and overall DA activity. The point is extended to the novelty-seeking feature of the extraverted personality.

Commentary:

The neurotransmitter dopamine (DA), in areas innervated by the VTA, is undoubtedly an important part of the substrate for motor activation and responses to novelty, as expressed in the mesolimbic and modulated by the mesocortical system. Thus, via activation and impulsivity (D&C's terms), modulation by DA of limbic and neocortical activity in the expression of extraversion is not in contention. We support this in the animal model with psychostimulants (rearing, head-turning, and orienting-movements, Oades et al. 1985; 1986) as well as normal young adult humans, where ratings of 'outgoing-behavior' correlated with the levels of DA excreted (n = 29, Spearman r = +0.5, p = 0.015, data in Oades et al. 1996a).

What is in dispute is the exclusive role of the VTA-DA projection system in 'incentive motivation'. D&C section 3.3 specifically state that the approach of a rewarding goal is the essence of incentive motivation and this is facilitated by VTA-DA activity. They then qualify this (section 4.1) by saying that this facilitation does not consist of mediation (the strong version of the postulate) but instead should be seen as modulation. This 'weak' version flies in the face of the 'strong' version promulgated by Schultz and colleagues (e.g., 1995b) whom they so willingly cite in section 4.2, (the titles alone illustrate the point). Both versions are a kind of Go/No-Go theory to explain the extraversion/ introversion conflict over signals of reward and punishment described in section 2.4. A more widely applicable and more parsimonious alternative lies in selective information processing.

D&C draw on this interpretation (Oades 1985) without resorting to the underlying idea. The proposal was and remains that an increase of DA activity in a DA-innervated nucleus increases the likelihood that the current control of the output of this nucleus is switched to the influence of another input. This makes particular sense for the nodes innervated by the VTA where there is a huge convergence of input, described by Oades and Halliday (1987: e.g. VTA, prefrontal cortex, entorhinal cortex, septum, nucleus accumbens, and habenula). This point is selectively used (for the VTA) at the start of section 4.6. An argument can also be made for the basolateral amygdala being one of the nodes innervated by the VTA (see section 4.3.1). But this is only one branch of the system, albeit especially relevant for motivational matters: other branches are relevant too, for example, motor responsiveness and heteromodal processing. Thus, in the example cited above (Oades et al. 1996a), the ability of normal young adults not to attend to a new conditioned stimulus while still learning about another - a selective attention ability called conditioned blocking - correlates with the general background level of DA utilization. Blocking measures an ability to select stimuli for processing and learning: as the learning and the blocked stimuli have the same consequences, attention for the one over the other reflect a selective strategy relatively unsullied by questions of incentive motivation.

To be sure, Oades et al. (1996a, b) found that 'outgoing personality features' correlated with improved blocking. This might be predicted as extraversion (in part) reflects this sort of 'decisive' information-processing service, provided by the mesolimbic accumbens and fronto-cortical VTA-DA projection system (structures shown to influence blocking in animal studies e.g. Oades et al. 1987) - a bottom-up argument. The top-down argument of D&C requires that the large limbic and cortical modules that put extraversion together require this sort of processing, and thus incentive motivation is the label they feel attaches best to the (part) of the VTA activity that is coincident.

It is not surprising that 'switching' is a form of explanation also used to describe the influence of DA agents on latent inhibition, a task with some similarities to conditioned blocking (Weiner 1990). Even in simple visual discrimination learning we have seen an apparent relationship between the background DA activity and performance (Oades et al. 1997). Slower initial learning but more rapid reversal was seen in subjects with higher DA activity. Both results are consistent with an explanation in terms of switching, but only the latter in terms of incentive motivation.

An example of arguably incentive-free activity may be taken from the sensation- or novelty-seeking features of an extraverted personality. Novel stimuli do not just elicit attention, - direct and indirect, visual and auditory, reciprocal pathways (Fallon et al. 1984; Dinopoulos & Parnevelas 1991) ensure that there will be bursts of firing in DA neurons of the VTA (Schultz 1992; Horvitz et al. 1997), but elicit widespread neural responses in frontal regions inhibiting ongoing neural processes (the P3a event-related potential). These changes (or switches) are adaptive, and need no

recourse to explanations in terms of incentive motivation. [To argue this would be teleological, and an incentive would underlie any circuit that functions. Novelty is not just about stimuli that could indicate the proximity of a predator, but about seeking out new vs. old stimuli (Berlyne 1960), and that high ratings of curiosity have been related to an increased life span (Swan & Carmelli 1996)]. Hugdahl & Nordby (1994) argued that the larger P3a potential to an invalid vs. a valid cue during the covert orienting of attention should be interpreted as indicative of the attention-switch, a feature that is integral to orienting and exploring (Pribram & McGuinness 1993) and that can be enhanced by dopaminergic agents like methylphenidate (Lazzaro et al. 1997).

There need be no dispute that the amygdala is central to the orbitofrontal - hypothalamic axis controlling the appropriate application of emotional responses to sensory events in terms of physiological and behavioral indices (Downer 1962). Nor need it be disputed that the amygdala 'enhances the processing resources allocated to ambient events with high emotional or hedonic valence' (Mesulam 1998, p.1035). The norm is that incentive contributes strongly to what is learned. Meso-amygdaloid DA activity plays an important role here. This role may be a switching one, but more importantly most DA in the VTA projection system lies elsewhere involved in non-incentive guided information processing.

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Target article abstract:

Neurobiology of the structure of personality: Dopamine, facilitation of incentive motivation, and extraversion

Richard A. Depue [a1] and Paul F. Collins [a2]

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[a1] Department of Human Development, Laboratory of Neurobiology of Personality and Emotion, Cornell University, Ithaca, NY 14853 rad5@cornell.edu

[a2] Department of Psychology, University of Oregon, Eugene, OR 97403 pcollins@oregon.uoregon.edu

Abstract

Extraversion has two central characteristics: (1) *interpersonal engagement,* which consists of affiliation (enjoying and valuing close interpersonal bonds, being warm and affectionate) and agency (being socially dominant, enjoying leadership roles, being assertive, being exhibitionistic, and having a sense of potency in accomplishing goals) and (2) *impulsivity,* which emerge from the interaction of extraversion and a second, independent trait (constraint). Agency is a more general motivational disposition that includes dominance, ambition, mastery, efficacy, and achievement. Positive affect (a combination of positive feelings and motivation) is closely associated with extraversion. Extraversion is accordingly based on *positive incentive motivation.*

Parallels between extraversion (particularly its agency component) and a mammalian behavioral approach system based on positive incentive motivation implicate a neuroanatomical network and modulatory neurotransmitters in the processing of incentive motivation. A corticolimbic-striatal-thalamic network (1) integrates the salient incentive context in the medial orbital cortex, amygdala, and hippocampus; (2) encodes the intensity of incentive stimuli in a motive circuit composed of the nucleus accumbens, ventral pallidum, and ventral tegmental area dopamine projection system; and (3) creates an incentive motivational state that can be transmitted to the motor system.

Individual differences in the functioning of this network arise from functional variation in the ventral tegmental area dopamine projections, which are directly involved in coding the intensity of incentive motivation. The animal evidence suggests that there are three neurodevelopmental sources of individual differences in dopamine: genetic, "experience-expectant," and "experience-dependent." Individual differences in dopamine promote variation in the heterosynaptic plasticity that enhances the connection between incentive context and incentive motivation and behavior.

Our psychobiological threshold model explains the effects of individual differences in dopamine transmission on behavior, and their relation to personality traits is discussed.

Key Words: behavioral sensitization; dopamine; extraversion; heterosynaptic plasticity; incentive motivation; neurobiology; personality.

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