

From NAcc Activation Sustenance Toward Holistic Models of Anhedonia in Depression

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Abstract

The human psyche is complex. Modern descriptions of the brain call for holistic approaches, including open and closed causal-loop systems with multiple layers of closure in biological, psychological, and sociological environments. This article examines neurobiological research on anhedonia in major depressive disorder (MDD) from a holistic, biopsychosocial point of view. Heller et. al. (2009) researched causal relationships between anhedonia and the activation of specific centers in the brain in patients with MDD. After recapitulating the status quo of holistic thinking, a critical analysis identifies strengths and shortcomings of neurobiological approaches with regard to holistic understanding of cognitive phenomena. Subsequently, a biopsychosocial construction of anhedonia illustrates the gap.

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Greek philosopher Aristotle likely addressed holistic perspectives as first Western thinker. His teacher Plato had elevated form over matter. Aristotle however saw form instantiated in particular substance, taking a superposition between substance and form. After more than two millennia of Euclidian dominance, Hegel again braced being and thinking with a sense of identity, combining subject and object to an all-encompassing whole. Hegel's idealism however aimed at the resolution of the opposites. Derrida developed destruction into deconstruction to integrate forms and transcend them. Derrida's way of thinking reflects a modern, holistic understanding and found its counterpart in other disciplines (Derrida, pp. ix-lxvii).

In the early 20th century, Scientists around Wiener and Shannon invented cybernetics as an extension to control theory. Cybernetics and constructivism share with holism the non-predictability of emergent properties that transcend linear combinations (Wiener, 1965, "Introduction"). Subsequently, theories of systems emerged as a common ground. Austrian biologist Bertalanffy invented General Systems Theory to describe operationally open systems following differential trajectories (1950, p. 139-156). Chilean Biologists Maturana & Varela developed structurally determined and coupled autopoiesis (1992, pp. 31-55). Japanese sociologist Maruyama expanded on morphogenetics, emphasizing change-creating loops (1980, pp. 589-594), while Heinz von Foerster proposed a cybernetics of cybernetics (2nd order cybernetics) that includes environmental closure to introduce an observer's purpose (2003, pp. 283-286). As psychologists and medics in the 1970s argued over somatic and mental diseases in medical practice, Engel called for a holistic combination of approaches into a biopsychosocial model (2012, pp. 377-387).

Jan Smuts (1927) coined the term holism. As a significant contribution, Smuts shifted the focus from structural analysis to the dynamics of the process. He positioned holism as an

operative factor that subsequently creates new wholes. Observers' perspectives thus became re-entrant unifications of their deconstructed past. Duration and construction became two dependent concepts. Smuts proposed a genesis of physical phenomena, chemical reactions, biological organisms, mind, and personality. In this line of thought, subjects thrive on their developmental trajectory and perceive the result of their history as a dynamic, creative synthesis of instances ("now") from the most integrated point of view. Their perspectives unfold in three contexts: on top of sections of history, as participants in their environmental systems, and as trajectories toward hypothetical futures. So being continually becomes redefining one's past by creating one's future, ordered by one's intellect. Experience thus creates structure, and structure creates experience. (pp. 87-89)

Criteria for Holistic Investigation

Smut's constructional hierarchy contains biological, psychological and social factors (ibid., p. 109). For a multi-faceted investigation from the perspective of holism the following inventory is used:

1. *Subject-matter*: What is the whole whose re-entrant creation is being studied?
2. *Domain*: What longitudinal sections of history integrate into the subject-matter?
3. *Chain of Construction*: What wholes emerge along the causal chain?
4. *Environment*: In what relevant neighborhoods does the subject-matter participate?
5. *Control Theory, Closure & Trajectories*: How many levels of closure are pertinent to describe the particular developmental dynamics and what trajectories emerge on these closures?
6. *Causal Metatype*: Is the conceptualization of the system hierarchical, individualistic, homeostatic or morphogenetic?
7. *Integration*: Is the subject investigated from the most integrated point of view possible?

(Engel, 2012, pp. 377-387; Maruyama, 1980, pp. 589-594; Smuts, 1927, pp. 87-151; Wiener, 1965, "Introduction")

A Neural Approach to Anhedonia from a Holistic Perspective

Heller et al., refuting the explanatory principle of hedonic capacity, took a neurobiological approach to investigate the "inability to sustain positive affect across time" (2009, p. 22445). Conducting a laboratory study with 27 subjects diagnosed with MDD and a control group of 19 non-depressed persons, they examined an alternative line of reasoning that anhedonia may be caused by a failure to sustain positive emotions after an initially positive emotional response. To test their hypothesis, they instructed subjects to perform emotion regulation tasks after being presented two sets of 72 images displaying positive or negative emotion over 37-min scan sessions. The pictures were selected from the International Affective Picture System (IAPS). The subjects were asked to judge the picture's emotional content, and subsequently to either attend to the picture, "enhance or suppress their emotional response." To measure their performance, the activity of primarily the striatum, including the nucleus accumbens (NAcc), and prefrontal cortex (PFC) have been visualized via functional magnetic resonance imaging (fMRI) during the series. NAcc activation and its modulation by the PFC had been linked to the experience of positive emotion by prior studies. To summarize the results, depressed subjects showed diminished NAcc activation over time when asked to amplify positive emotional stimuli opposed to no decline with their suppression, in the control group, or for negative stimuli. The decrease was accompanied by self-reports of low intensity of positive emotion. The diminished ability to sustain positive emotion was explained by reduced prefrontal activation. (ibid., pp. 2245-2250)

Holistic Examination of the Study

The subject-matter investigated is anhedonia. The study primarily examines anhedonia in the biopsychological domain of systems of neural circuits. The study identifies two nodes in the brain's network that are considered causative to anhedonia (NAcc and PFC), and suggests a regulatory connection between the two centers.

Not much is said about the chain of construction. Gradient NAcc activity is proposed to be directly causative for excessive negative affect. This prevalence of negative affect in turn is put on a level with anhedonia. PFC up- or down-regulation is suggested as a cause for failed NAcc activity sustenance. Developmental and social histories are absent. Prior stages of construction are rooted in the brain's basic neural structure. Positive and negative emotions are apparently thought to be tightly tied to the body's anatomy as very basic phenomena of experience. From this position, a narrow systemic approach to primary brain circuits appears reasonable.

This model of anhedonia exhibits one level of closure. Environmentally, the sensorimotor system is open, but closure over time is being considered. Internal closure is necessary for the durable construction of emotion from presented pictorial stimulus. A second internal closure may be required to voluntarily up- and down-regulate emotional experience, but its causal dynamics is not investigated. This model resembles a 1st generation cybernetic system.

Primarily focusing on anhedonia, the study limits its domains to the biopsychological, ignoring social neighborhoods, e.g. the role of the inability to sustain positive affect in the cultural etiology of MDD. It remains unanswered whether the incapacity to up-regulate NAcc activity is causative in the subjects' individual, depressive history.

A control theory can be derived from Heller et al.'s direct relationship of NAcc activity and the inducement of positive emotion. Following an initial spike upon stimulus presentation, anhedonia is modeled by a decrease in NAcc activity over time under attempts at up-regulation as:

$$\frac{dA}{dt} = f(A_{NACC}, A_{PFC}),$$

where A stands for the activity in the respective neural centers and f is a regulatory function to sustain this activity. A quotient of $dA_{NACC}/dt < 0$ during prolonged efforts to reinforce positive emotion is said to characterize anhedonia, taking a differential, homeostatic stance towards emotional dynamics. People are asked to construct and rate affective phenomena during the experiment. Thus, a cognitive loop is present but its investigation remains limited to time differentials of NAcc activation. By emphasizing that prior studies found no differences in NAcc activity between group averages, accumulative approaches are dismissed.

Evaluation of Findings

Heller et al. directly correlate emotional experience with the activity of topological areas of the brain. That is both fortunate and unfortunate. Topological studies enable quantitative approaches. To connect neurobiology and emotional experience to explain anhedonia in principle may show holistic tendencies. However, the study suggests bidirectional causal effects between NAcc stimulus-response and depression, not that NAcc-activation, anhedonia, and depression emerge in a chain of wholes. (2009, p. 22447)

The ability to exhibit PFC activity appears as a coarse explanation for volitional acts. The PFC is a large structure, although specific findings refer to the left middle frontal gyrus. Explaining regulatory functions of the brain with PFC intervention reminds of an upheaval of the explanatory principle *hedonic capacity* to *PFC regulatory capacity* without further investigation of its causal laws. It remains unclear whether the observed differences may be attributed to volition. Although, to evaluate task engagement, the response times to posed questions have been measured, subjects may be differently motivated to sustain positive emotion subsequently. Similarly, the volitional effort to enhance positive emotion may exhibit medium-term fluctuations on affective experience feedback. The applied metaphors remind of a skipper who steers a ship and recruits neuronal personnel, not holistic terminology.

Heller et al.'s study is missing a vital point in holistic etiology: cognitive closure, in this case the subjective appraisal of the perceived (in-)ability to sustain positive emotion whereupon anhedonia may emerge as vicious circle. This reaffirmation is culturally biased. Positive and negative emotional contents and their display are culturally coined, cognitively modulated and show individual differences. The perceptual decomposition of positive or negative emotion in this study has been reduced to biopsychological functions and falls short of a comprehensive holistic approach. Even with perceived inability to up or down-regulate negative or positive emotions, subjects may still revert to equanimity. Western cultures cherish positive emotions, so the failure to sustain them may result in societal and cultural conflict. Some Eastern cultures promote the moderate expression of emotion. A person with such background may construct depression upon the failure to down-regulate emotional stimuli.

The study did neither evaluate cognitive closure nor social dynamics or personal developmental trajectories and thus cannot be considered holistic in a biopsychosocial sense. The approach represents a neurobiological, reductionist, 1st order cybernetic system.

A Holistic Approach to Anhedonia

Holistic models for anhedonia including cognitive feedback may be shaped along biopsychological and psychosocial axes. To formalize wholes, George Spencer-Brown's Laws of Form are established in the social sciences. Marks (\neg) represent named domains of distinction. *J*-shaped marks symbolize re-entrant distinctions. Marks can be nested, denoting a causal chain of construction with the quality of the closure indicated below. In the following examples, closure is modeled exclusively cognitive. (Spencer-Brown, 2009, pp. 1-10, 52; Stoll, 2015)

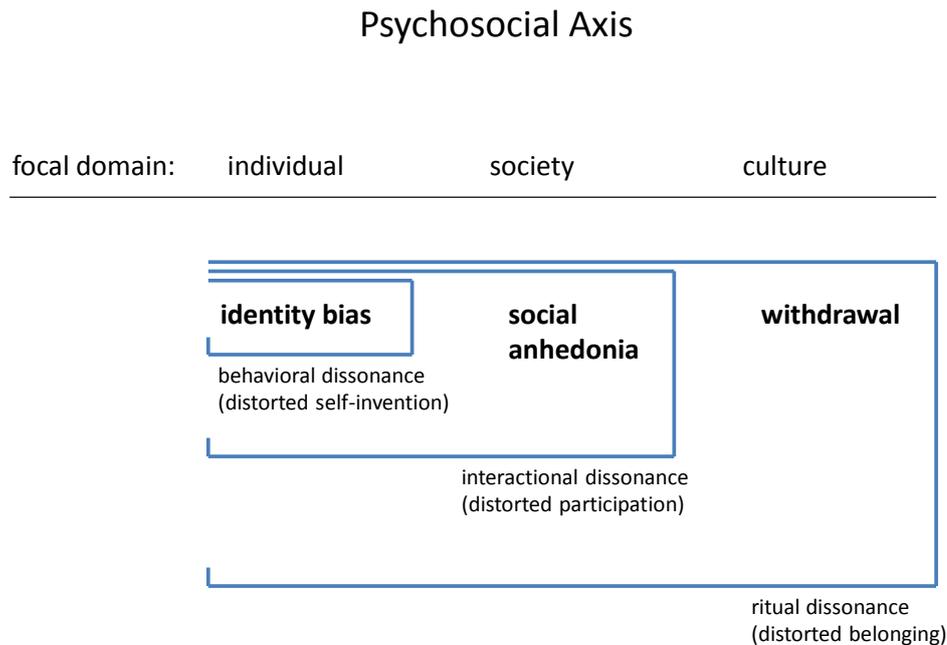


Figure 2. Formalization of sociologically rooted depression.

On the psychosocial axis, social anhedonia can be constructed from a 3rd person perspective. In the individual domain, identification fails as the discrepancy between actual own versus ought behavior leads to an overly self-critical identity bias. This bias creates dissonances in interaction from disturbed patterns of social participation. Social anhedonia can arise from negative cognitive appraisal. Extended to culture, a distorted sense of belonging may result from dissonance in ritual, resulting in withdrawal and further limiting available sensory stimuli. In the presence of exaggerated negative affect, social anxiety may form instead of anhedonia. (ibid.)

This proposition formalizes one possible 2nd generation cybernetic system with multiple internal and external closures and developmental trajectories of an observer including biological, psychological and social domains. Therefore, the attempt may be considered a holistic approach to a biopsychosocial model of anhedonia.

Conclusion

The ability to sustain positive emotion described by Heller et al. has also been termed the *outlook* dimension of emotional style by the study's co-author Richard Davidson. Such dimensions may be used to evaluate emotional experience and increase the awareness of detrimental, fossilized patterns of thinking. Although neuronal models lack the cognitive closure that is necessary to holistically explain cognitive phenomena, in introspective self-evaluation this reflection may be done by an observer. All of the dimensions proposed by Davidson can be linked with wholes in the holistic formalization above: *resilience* concerns the individual, *social intuition* the social, *sensitivity to context* the cultural, *self-awareness* the biological, *outlook* the mental, and *attention* the awareness domain. To proceed from neurobiological phenomena to holistic views, one needs to understand subject perspectives as those of observers with their steady biopsychological and socio-cultural reconstruction of self.

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