COGNITION AND LANGUAGE

Neuroethics

Neuroethics and Cultural Diversity

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Neuroscience of Ethics

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2.1. Introduction

Neuroethics is concerned with the relationship between neuroscientific findings and ethical concepts including free will, moral judgment, self, among others. On the one hand, it focuses on the investigation of the psychological and neural conditions of these ethical concepts and, on the other, on ethical problems arising from neuroscientific advances.

Roskies (2002) distinguishes correspondingly between the ethics of neuroscience and the neuroscience of ethics. The former deals with ethical problems arising in neuroscience, such as the validity of informed consent in psychiatric patients, enhancement of cognitive functions by neuroscientific interventions and coincidental findings in neuroimaging. The latter investigates neural mechanisms that may underlie ethical concepts such as informed consent, moral judgment and will (Figure 2.1).

The purpose of this chapter is to demonstrate the relevance of empirical findings for issues in the neuroscience of ethics and the ethics of neuroscience. While the conceptual distinction between the two holds firm, empirical reality often provides a

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more blurred picture. Three examples at the interface between neuroscience and ethics demonstrate that the line between the neuroscience of ethics and the ethics of neuroscience can become unclear, with particular relevance for psychiatry.

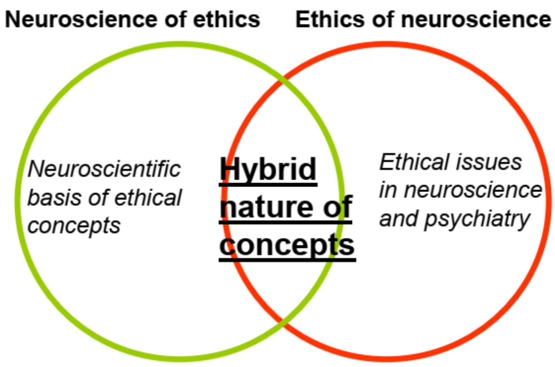

Figure 2.1. *Distinction between ethics of neuroscience and neuroscience of ethics*

Firstly, we explore how data clearly shows that the brain's neuronal activity aligns to its ecological context, implying a relational and spatio-temporal model of brains. Secondly, we examine the concept of self in a neurorelational way, on the premise that the self as the basis of agency cannot be reduced to the brain, but instead to the relationship between the external world and the brain. Thirdly, we discuss the issue of self-enhancement in the context of deep brain stimulation.

2.2. Example I: a non-reductionistic and neuro-ecological model of brains

2.2.1. *History of neuroscience – passive versus active models of brains*

The way neuroscience researchers approach the study of the brain can have a significant impact on their empirical investigations, as well as on the interpretation of their philosophical implications. One model, favored by the British neurologist Sherrington (1906), proposed that the brain and the spinal cord were primarily reflexive; that is, the brain reacts in predefined and automatic ways to sensory stimuli. Those stimuli from outside the brain, originating in either the body or the environment, are assumed to determine subsequent neural activity. The resulting activity, and more generally any neural activity in the brain, is then traced back to the stimuli to which the brain passively reacts. We may therefore speak of the passive model.

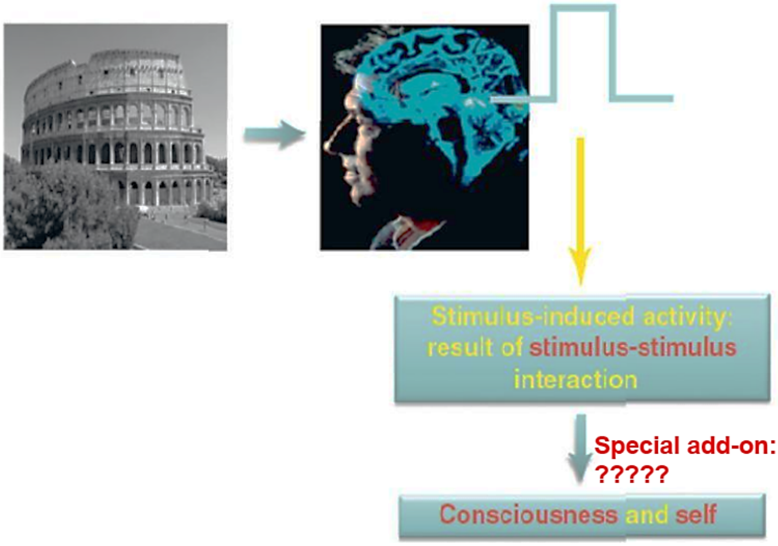

Figure 2.2a. *Passive model of the brain: Neural activity resulting sufficiently from extrinsic stimuli*

Thomas Brown, one of Sherrington's students, advanced an alternative view, namely that neural activity in the spinal cord and brain stem is not driven and sustained by external stimuli, but by spontaneous activity originating in the brain itself. Hans Berger, who introduced the electroencephalogram (EEG), also observed spontaneous activity within the brain that remained independent of any external stimuli (Berger 1929). Other neuroscientists agreed with Brown, proposing that the brain actively generates operational–behavioral activity known as spontaneous activity (Northoff 2014a, 2014b; Raichle 2015). The idea of central activity has gained traction in neuroscience with the observation of spontaneous oscillations, as well as connectivity between different regions of the brain and what is referred to as the default-mode network DMN (Raichle et al. 2001; Greicius et al. 2003; Raichle 2015); the DMN is a network that mainly includes regions in the middle of the brain that have been shown to be related to our experience or sense of self (see below for details). These observations highlight the central role of the brain's spontaneous activity, including both resting state and stimulus-induced activity; the implication is an active model. This is well illustrated in a passage by Kurt Goldstein:

> The nervous system has often been considered as an organ at rest, in which excitation arises only as a response to stimuli. [...] It was not recognized that events that follow a definite stimulus are only an

> expression of a change of excitation in the nervous system, that they represent only a special pattern of the excitation process (Goldstein 2000, pp. 95–96).

2.2.2. *Neuroscience – passive versus active models of the brain*

The question of which model of the brain is valid has gained increased attention with the discovery of the DMN, a neural network that covers various regions in the so-called cortical midline structures (CMS) (Northoff and Bermpohl 2004; Northoff et al. 2006; Qin and Northoff 2011; Andrews-Hanna et al. 2014). The DMN shows particularly high levels of metabolism (when compared to the rest of the brain) and neural activity in the absence of any external stimuli.

The DMN's high levels of resting state activity are associated with diverse mental features, including sense or experience of self, consciousness, inner thoughts which are also described as mind wandering, episodic memory retrieval, time perception of both past and future, and random thoughts. Given this wide range of functions, the DMN's role remains unclear.

It is clear that the nature of the DMN supports the concept of an active model of the brain. Put more philosophically, the active model has been regarded as similar to Immanuel Kant's argument against a passive model of the mind (Kant 1998; Northoff 2018). David Hume proposed the opposite view, namely that impressions of external stimuli completely determined mental activity. This dispute has resurfaced in the context of theoretical neuroscience.

2.2.3. *A spectrum model – the hybrid nature of the brain's activity*

An empirically plausible model of brain activity that takes into account the relationship between spontaneous and stimulus-induced activities would be highly desirable (see Northoff (2018) for details). The brain neither generates its neural activity in a completely passive way, driven by external stimuli, nor in an exclusively active way, driven by spontaneous activity. Given the evidence, we need to accept a model of the brain that undermines the passive/active dichotomy and integrates both in a spectrum that allows for categorizing different forms of neural activity according to the degree of the brain's participation in generating that activity.

A spectrum model assumes that different sorts of neural activity involve various levels of resting state, some more active, others more passive. This is relevant when placing the brain in the context of body and environment. Neural activity is thus both intrinsic to the brain, the body and the environment – with the three usefully referred to as a "trinity" (Edelman et al. 2011).

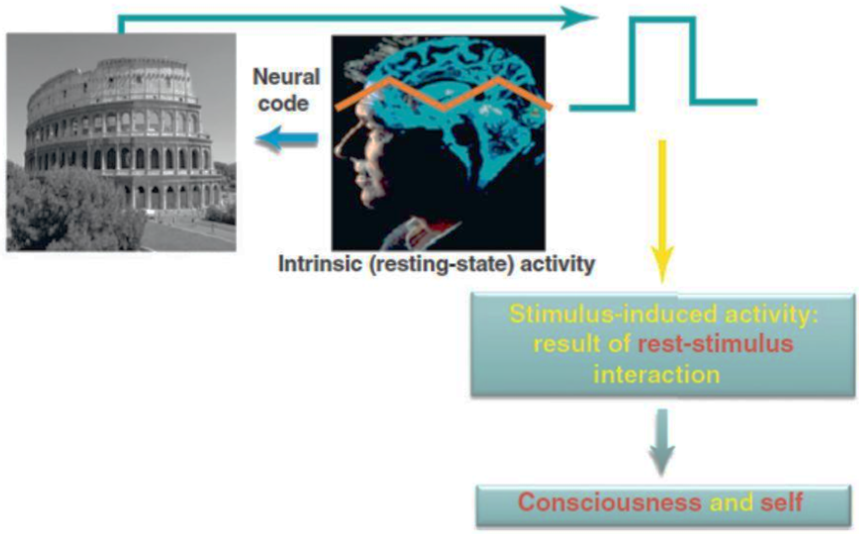

Figure 2.2b. *Spectrum model of the brain: Neural activity resulting from the interaction between intrinsic resting state activity and extrinsic stimuli*

2.2.4. *The brain's spontaneous activity – constitution of its own spatio-temporal structure on a functional level*

The brain's spontaneous activity is relevant for mental features such as consciousness and self-awareness. They also appear to relate, albeit in an ill-defined way, to the way the brain's spontaneous activity constructs its own "space–time" at a functional (rather than anatomical–structural) level (Northoff et al. 2020). On the spatial side, this concerns the constitution of a particular topography with different networks being related to each other in a hierarchical way (Golesorkhi et al. 2021). On the temporal side, the spontaneous activity of the brain can also be characterized by a complex temporal structure whose neural activity fluctuates in different bands of frequency. These are coupled; for example, slower frequency bands with higher ones. The result is that complex temporal structures in the brain's intrinsic activity relate, albeit unclearly, to spatial structures, as well as to a range of neural networks.

2.2.5. *Spontaneous activity and mental features – neuro-ecological rather than neuronal*

Spontaneous activity in the spatio-temporal structure extends beyond the brain and is aligned to the body (e.g. the heart and stomach) and to the external world (Bab-Rabello et al. 2016; Richter et al. 2017; Tallon-Baudry et al. 2018), suggesting a spatio-temporal alignment of the brain to the body (Northoff and Huang 2017; Northoff 2018). Alignment to the world is especially obvious when listening to music and dancing; that is, we align our brain's temporal features and rhythms of its neural activity (its frequencies and synchronization) to the temporal feature and rhythm of the music or, more generally, to the world (Schroder and Lakatos 2008; Schroeder et al. 2008).

The above forms of alignment are central for the state of consciousness; the better the alignment the more we can become conscious of the body and the world. We therefore posit a spatio-temporal model of both consciousness and mental features in general (Northoff 2014a, 2014b, 2018; Northoff and Huang 2017). The brain and its spatio-temporal features must be related to those of the world to make consciousness possible; if they are not related, consciousness is lost, as in disorders of unresponsive wakefulness, sleep and anesthesia. Most importantly, the extension of the spatio-temporal structure beyond the brain and body to the world signifies spontaneous activity as intrinsically neuro-ecological and relational, also entailing a non-reductionistic view of the brain. This is of utmost importance to psychiatric disorders, where the mental changes can be traced to the impact of social and developmental factors such that both neuronal and social changes cannot be separated.

2.2.6. *Psychiatric disorders – "spatio-temporal psychopathology"*

We are now ready to confront the relevance of the spectrum model in the case of psychiatric disorders. In schizophrenia and bipolar disorder (BD), for example, major changes occur in the brain's spontaneous activity (Martino et al. 2016; Northoff and Duncan 2016). This is manifested in the networks' resting states, as well as in the variability of their neural activity. At the same time, patients with these conditions react abnormally or differently in stimulus-induced or task-evoked activity. The abnormal neuronal speed of spontaneous activity in these patients, as reflected in neuronal variability, is related to the experience of abnormal consciousness of time speed which, in turn, manifests as symptoms such as abnormal speed of thought or movement, like psychomotor agitation and thought racing in manic episodes of BD (Martino et al. 2016; Northoff and Duncan 2016).

The spectrum model can thus be invoked when linking spontaneous and task-evoked activities to mental features (see Figure 2.2(c)).

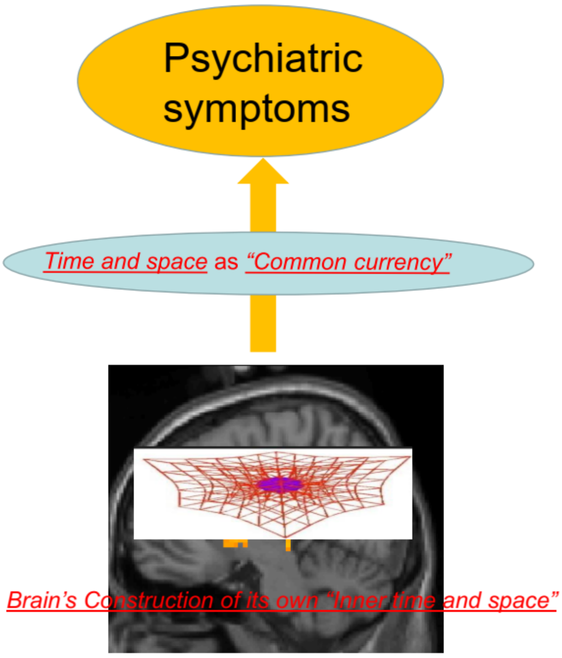

Figure 2.2c. *Spatio-temporal psychopathology*

2.3. Example II: from the neural basis of sense of self to relational agency

2.3.1. *Neuroscience of the self – mapping distinct aspects of the self onto different brain regions*

The question for the constitution of self-awareness has been one of the most salient problems in philosophy, psychology and neuroscience. William James distinguished between three selves: physical, mental and spiritual; similar concepts of self have been discussed by neuroscientists (Northoff and Panksepp 2008). Panksepp (1998) and Damasio (1999), among others, suggest that what has been referred to as the "proto-self" in sensory and motor domains, resembles James's account of the physical self. Similarly, what has been termed as the "minimal self" (Gallagher 2005) or "core or mental self" (Damasio 1998) may correspond to James's concept of mental self. Finally, Damasio's (1998) "autobiographical self" and Gallagher's (2005) "narrative self" strongly rely on linking past, present and future, and is akin to James' spiritual self.

These selves are related to activity in distinct brain regions. For instance, the "proto-self", outlining our body in emotional and sensory-motor terms, is associated with subcortical regions like the peri-aqueductal gray matter (PAG), colliculi and tectum (Northoff and Panksepp 2008), and the "core or mental self" building on the "proto-self", with the thalamus and cortical regions, such as the ventromedial prefrontal cortex (see for instance Northoff and Panksepp 2008). Finally, the "autobiographical or extended self" is associated with cortical regions such as the hippocampus and cingulate gyrus.

Neuro-imaging studies reveal that various cortical regions, especially midline structures, integrated with subcortical regions like the thalamus, are involved in self-related processing (SRP) to yield an integrated subcortical–cortical midline system (SCMS). The assumed existence of this system is consistent with research findings that show that core self-related functioning involves both cortical and subcortical regions.

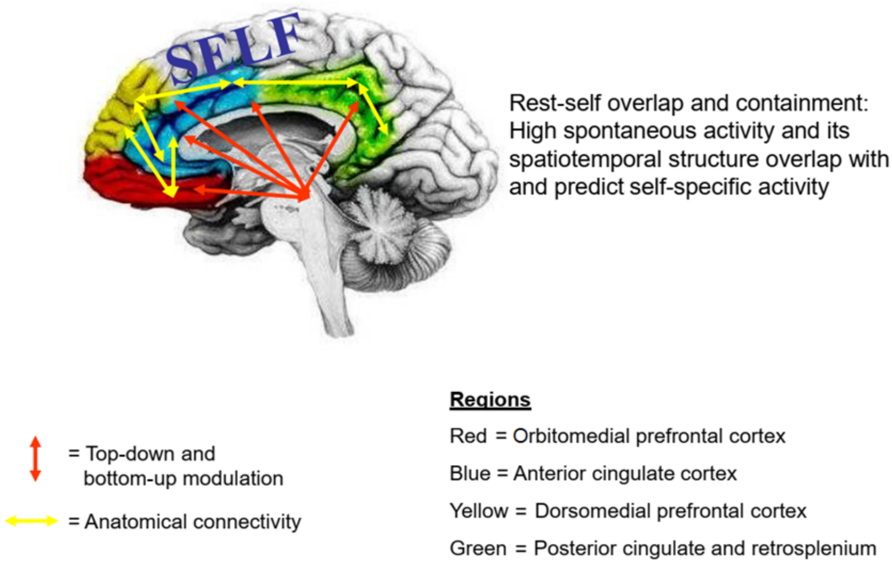

Figure 2.3. *Cortical and subcortical midline structures*

Cortical regions have been studied in particular since cognitive components, including evaluative judgments, are involved (see Northoff and Bermpohl 2004;

Northoff et al. 2006); this is reflected in the experimental paradigms of most imaging studies of the self, which compare the evaluation of self-related and non-self-related stimuli. This raises the question of whether neural activity in the SCMS is associated with the cognitive functions implicated in the evaluation of stimuli as self-related, or in the self-relatedness of the stimuli themselves.

2.3.2. *Self and brain – agency is ecological and relational*

The data have major implications for ethical concepts like agency (e.g. the ability to voluntarily initiate an action) and moral responsibility, since both are based on the sense of self. If that same self is based on the brain's spontaneous activity and its spatio-temporal structure, the two concepts need to be defined in a spatio-temporal rather than cognitive content-based way. Consequently, agency and responsibility are not about specific content generated by cognition, but about spatio-temporal features and scales, offering a novel line of study for ethicists and philosophers. The closer a person's self is to the spatio-temporal, the more robust their agency and responsibility. Furthermore, since the self is strongly based on spontaneous activity, it is more appropriately viewed as neuro-ecological, rather than being located in the brain and its neuronal activity. The same applies to agency and moral responsibility.

Assuming a sense of moral responsibility is ecological in nature, an individual is only the symptom bearer, and not the cause, of moral failure. Analogously, the same can be said for the brain and its neuronal activity, which is associated with agency and moral responsibility. That, in turn, is relevant in the case of psychiatric disorders, which are relational and neuro-ecological, and thus spatio-temporal disorders of the world–brain relation (Northoff 2018). Given a patient's altered relationship with the world, and sense of self, they may manifest a changed sense of agency and moral responsibility. Psychiatrists therefore should not impose their values onto their patients. Instead, we may want to try to understand the world as perceived by the patient. This is important since what we need to treat are not the objective symptoms, as diagnosed by the psychiatrist, but the subjective experiences and perception of the patients themselves: it is because of the latter that they suffer and come to the psychiatrist, not because of the former. For instance, it is possible that subjects with delusions and hallucination function perfectly well and do not subjectively experience any suffering. Accordingly, experience and symptoms may dissociate from each other for which reason it is important to consider both.

2.4. Example III: enhancement of self – deep brain stimulation

Deep brain stimulation (DBS) is a potential form of treatment for severe forms of conditions such as anorexia nervosa, major depression and obsessive-compulsive disorder (Lozano and Lipsman 2013). Whether and how DBS impacts the self in terms of effectiveness and unwarranted side effects generates ethical concerns. Gilbert et al. (2017) discuss different notions of self in the context of DBS, like a predominant definition of the self in terms of cognitive contents rather than in terms of relation. Gilbert and Goering observe a relationship between the pre-operative effects of the disease on self and post-operative effects on self-estrangement.

We may then set up a specific hypothesis that the pre-operative spontaneous activity's CMS and their fluctuations in different frequencies including the association between slow and fast frequencies predict effects of DBS on self. Clinically, there is the possible option of measuring the power spectrum in the brain's spontaneous activity (via functional MRI and EEG) in relation to the self, in order to predict the risk of the DBS-induced experience of being estranged from the own self.

Gilbert et al. (2017) argue correctly that DBS is no different from other forms of treatment, such as psychotropic medications and psychological therapies, in that all of them change the spatio-temporal structure and, in turn, the self. The interaction possibly restores the self rather than replacing it. My colleagues and I have shown that inserting fetal cells when transplanting the brain tissue in Parkinson's disease does not adversely affect the patient's sense of self. On the contrary, the fetal tissue improves abnormal movement, and also restores their original sense of self and personal identity. Specifically, we asked subjects for the subjective experience of their identity before and after the fetal cell implantation (Northoff 1999). None of the five patients experienced any changes in their personal identity, that is, the experienced temporal continuity of their own self after the implantation relative to before. This may be explained by the fact that the fetal cells only impacted those regions related to movements, that is, dopaminergic cells in basal ganglia and motor cortex, but not those networks like the default-mode network and its cortical midline structure that are key for constituting the experience of self-continuity (Northoff 2017).

2.4.1. *Deep brain stimulation – its application in bipolar disorder*

Goering et al. (2017) point out how DBS potentially affects the self. They suggest that it registers neural activity and delivers stimulation when the neural activity related to the target symptom occurs. Although Goering et al. welcome the introduction of DBS, they are careful, if not skeptical, about its potential effects on the self, and specifically agency. They believe these effects may be mitigated by the support of family and friends, leading to their concept of “relational agency”.

Can neuroscience, in tandem with neuro-philosophy, contribute to better understand the mechanisms and effects of DBS? We need to be clear about the neuronal mechanisms underlying specific psychopathological symptoms. For example, fMRI studies in BD (26) demonstrate elevated neuronal activity and variability in the resting state in the somatomotor cortex in manic patients. These findings may be associated with a hallmark of manic BD, namely spontaneous initiation of movement and subsequent psychomotor agitation. The opposite pattern is observed in depressed BD patients manifesting psychomotor retardation (see Northoff et al. (2018) for the latter).

2.4.2. *Effects of DBS on the self – a quest for neuronal mechanisms*

What about the effects of DBS on the self? There should be none since only motor cortical activity is altered. However, as mentioned earlier, DMN neural variability changes occur that are the opposite of those in the motor network; namely depressed patients show increased neural variability, whereas in manic patients neural variability declines.

What do these findings imply for a potential influence of DBS on the self and agency? First, “normalization” of motor neuronal variability should also re-balance its relationship to DMN/CMS; this, in turn, should “normalize” the self. We know that if we do not move, ruminations can develop and we can get “stuck” in our self. In contrast, if we are overactive, our sense of self can evaporate. In short, psychomotor behavior and self are closely linked. That is, DBS may restore the “original self” by replacing the “disease self”. However, the findings may also be reversed. There may be self-estrangement from the own self, as indicated by Gilbert. This may be related to the fact that the restoration of the movement, including their subcortical–cortical motor circuit, may affect their relation to the default-mode network/cortical midline structure that mediates self-awareness in a negative way: for instance, functional connectivity between subcortical–cortical motor circuit and DMN/CMS may decrease after DBS, which, in turn, may be manifested in the experience of self-estrangement, that is, the movements are no longer properly related to the self. This is further supported by the fact that DBS may also affect agency.

DBS may also affect agency (Goering et al. 2017). Thus, movements either initiated or suppressed by external stimulation may depend on the degree to which the effects of DBS are integrated with the brain's spontaneous activity. The more effective the response to the stimulation, the more likely it is to be attributed to the self rather than to an external agent. However, we have to be aware that it is a continuum between the internal self and external environment – this may be shifted towards either end with both increased self-awareness and self-estrangement. Albeit hypothetically, this continuum of internal self-awareness and self-estrangement may be mediated by the functional connectivity between different neural networks in the brain like between the DMN/CMS (self) and sensory regions (non-self). That remains speculative though.

The introduction of DBS for individually tailored therapy is a welcome development; as a neuroscientist, I remain wary since the neuronal mechanisms underlying psychopathological symptoms remain unknown. As a neurophilosopher, I am equally wary of DBS; I suggest a need to re-define the notion of self in spatio-temporal terms that cross boundaries between neuronal and social dimensions, and thus between the brain and the world, thereby facilitating a novel view of self.

As a clinical psychiatrist, I will judge the therapeutic effects of DBS by its ecological and social manifestations concerning the perception and behavior of the respective subjects. For that, DBS must manipulate those mechanisms that account for spatio-temporal alignment while, at the same time, provide ecological and social stimuli that activate the brain's spatio-temporal alignment. Accordingly, DBS alone is not sufficient; complimentary and individually tailored ecological and social therapies (e.g. contact with others, music therapy) are necessary to fully exploit potential benefits of DBS.

2.5. Conclusion

The convergence of neuroscience and ethics has major implications for psychiatry. Neuroethics cannot be reduced to an exclusively neuronal view of concepts, such as agency and moral responsibility. A truly neuro-ecological approach is indicated where the brain's neural activity is intrinsically related and aligned to its respective environmental (and bodily) context (Northoff 2014, 2016, 2018). Such neuro-ecological and neuro-social determination is, for instance, manifested in the shaping of both neural dynamic (Duncan et al. 2016) and psychological time perception (Wang et al. 2020) by early traumatic life events. This, in turn, may impact emotion and ultimately, depression severity (Wang et al. 2020), as well as decision-making (Nakao et al. 2013). Abnormal shaping of neural dynamics and psychological time perception by strong traumatic events may, in turn, lead to psychopathological symptoms like depression (Wang et al. 2020). Accordingly, psychiatric disorders may require a neuro-ecological rather than merely neuronal model of the brain. Finally, the history of psychiatry informs us that empirical findings and conceptual issues are inseparable and highly relevant to the future study of psychiatric disorder.

2.6. References

Andrews-Hanna, J., Smallwood, J., Spreng, R. (2014). The default network and self-generated thought: Component processes, dynamic control, and clinical relevance. *Annals of the New York Academy of Sciences*, 1316, 29–52.

Babo-Rebelo, M., Wolpert, N., Adam, C., Hasboun, D., Tallon-Baudry, C. (2016). Is the cardiac monitoring function related to the self in both the default network and right anterior insula? *Philosophical Transactions of the Royal Society B: Biological Sciences*, 371, 1708.

Berger, H. (1929) About the electroencephalogram of huamns/Über das Elektrenkephalogramm des Menschen. *Archiv für Psychiatrie und Nervenkrankheiten*, 87, 527–570.

Damasio, A. (1999). *The Feeling of What Happens. Body and Emotion in the Making of Consciousness*. Houghton Mifflin Harcourt, Boston, MA.

Gallagher, S. (2005). *How the Body Shapes the Mind*. Clarendon Press, Oxford.

Gilbert, F., Goddard, E., Viaña, J., Carter, A., Horne, M. (2017). I miss being me: Phenomenological effects of deep brain stimulation. *American Journal of Bioethics Neuroscience*, 8, 96–109.

Goering, S., Klein, E., Dougherty, D. (2017). Staying in the loop: Relational agency and identity in next generation DBS for psychiatry. *American Journal of Bioethics Neuroscience*, 8(2), 59–70.

Goldstein, K. (2000). *The Organism: A Holistic Approach to Biology Derived from Pathological Data in Man*. Zone Books/MIT Press, New York.

Greicius, M., Krasnow, B., Reiss, A., Menon, V. (2003). Functional connectivity in the resting brain: A network analysis of the default mode hypothesis. *Proceedings of the National Academy of Sciences*, 100, 253–258.

Huang, Z., Zhang, J., Wu, J., Northoff, G. (2015). Decoupled temporal variability and signal synchronization of spontaneous brain activity in loss of consciousness: An fMRI study in anesthesia. *Neuroimage*, 124, 693–703.

Kant, I. (1998). *Critique of Pure Reason*. Cambridge University Press, Cambridge [Original published in 1781].

Lozano, A.M. and Lipsman, N. (2013). Probing and regulating dysfunctional circuits using deep brain stimulation. *Neuron*, 77, 406–424.

Martino, M., Magioncalda, P., Huang, Z., Northoff G. (2016). Contrasting variability patterns in the default mode and sensorimotor networks balance in bipolar depression and mania. *Proceedings of the National Academy of Sciences of the United States of America*, 113, 4824–4829.

Menon, V. (2011) Large-scale brain networks and psychopathology: A unifying triple network model. *Trends in Cognitive Sciences*, 15, 483–506.

Northoff, G. (2014a). *Unlocking the Brain. Volume I: Coding.* Oxford University Press, New York.

Northoff, G. (2014b). *Unlocking the Brain. Volume II: Conciousness.* Oxford University Press, New York.

Northoff, G. (2014c). *Minding the Brain*. *A Guide to Neuroscience and Philosophy*. Palgrave MacMillan, London.

Northoff, G. (2016). *Neuro-Philosophy and the Healthy Mind*. *Learning from the Unwell Brain*. Norton, New York.

Northoff, G. (2018). *The Spontaneous Brain. From the Mind-Body Problem to the World-Brain Problem*. MIT Press, Cambridge, MA.

Northoff, G. and Bermpohl, F. (2004). Cortical midline structures and the self. *Trends in Cognitive Sciences*, 8, 102–107.

Northoff, G. and Duncan, N. (2016). How do abnormalities in the brain's spontaneous activity translate into symptoms in schizophrenia? From an overview of resting state activity findings to a proposed spatiotemporal psychopathology. *Progress in Neurobiology*, 145(146), 26–45.

Northoff, G. and Huang, Z. (2017). How do the brain's time and space mediate consciousness and its different dimensions? Temporo-spatial theory of consciousness (TTC). *Neuroscience and Biobehavioral Reviews*, 80, 630–645.

Northoff, G. and Panksepp, J. (2008). The trans-species concept of self and the subcortical-cortical midline system. *Trends in Cognitive Sciences*, 12, 259–264.

Northoff, G., Heinzel, A., de Greck, M., Bogerts, B. (2006). Self-referential processing in our brain – A meta-analysis of imaging studies on the self. *Neuroimage*, 31, 440–445.

Northoff, G., Magioncalda, P., Martino, M., Lane, T. (2018). Too fast or too slow? Time and neuronal variability in bipolar disorder – A combined theoretical and empirical investigation. *Schizophrenia Bulletin*, 44, 54–64.

Panksepp, J. (1998). *Affective Neuroscience*. Oxford University Press, Oxford.

Qin, P. and Northoff, G. (2011). How can the brain's resting state activity generate hallucinations? A "resting state hypothesis" of auditory verbal hallucinations. *Schizophrenia Research*, 127, 202–214

Raichle, M.E. (2015). The brain's default mode network. *Annual Review of Neuroscience*, 38, 433–447.

Raichle, M.E., Snyder, A.Z., Gusnard, D., Simpson, A. (2001). A default mode of brain function. *Proceedings of the National Academy of Sciences of the United States of America*, 98, 676–682.

Richter, C., Babo-Rebelo, M., Schwartz, D., Tallon-Baudry, C. (2017). Phase-amplitude coupling at the organism level: The amplitude of spontaneous alpha rhythm fluctuations varies with the phase of the infra-slow gastric basal rhythm. *Neuroimage*, 146, 951–958.

Roskies, A. (2002). Neuroethics for the new millenium. *Neuron*, 35, 21–23.

Schroeder, C.E. and Lakatos, P. (2008). Low-frequency neuronal oscillations as instruments of sensory selection. *Trends in Neurosciences*, 32, 9–18.

Schroeder, C.E., Lakatos, P., Kajikawa, Y. (2008). Neuronal oscillations and visual amplification of speech. *Trends in Cognitive Sciences*, 12, 106–113.

Sherrington, C.S. (1906). *The Integrative Action of the Nervous System.* Yale University Press, New Haven, CT.

Tallon-Baudry, C., Campana, F., Park, H., Richter, C., Babo-Rebelo, M. (2018). The neural monitoring of visceral inputs, rather than attention, accounts for first-person perspective in conscious vision. *Cortex*, 102, 139–149.