WHAT THE PHILOSOPHER IMMANUEL KANT CAN TELL US ABOUT PSYCHIATRIC DISORDERS

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The early philosopher Immanuel Kant suggested that the mind’s intrinsic features are intimately linked to the extrinsic stimuli from the environment it processes. Currently, the field faces an analogous problem with regard to the brain. Kant’s ideas may provide insight into what the brain’s intrinsic features must be like in order to be linked to its neural processing of the extrinsic stimuli. Most importantly, he may prove helpful in better understanding what the various resting state abnormalities as observed in psychiatric disorders like schizophrenia and depression imply for the often rather bizarre subjective experiences and thus consciousness in those patients.
Kant’s view of the mind

The philosopher René Descartes assumed mental properties intrinsic to the mind to be distinct from the physical features of body and brain. This was countered by the Scottish philosopher David Hume, who opposed such intrinsic mental properties. Instead, Hume advocated an extrinsic view of the mind, believing that mental activity can be entirely traced back to the extrinsic features of stimuli in the world. His German successor Immanuel Kant combined both intrinsic and extrinsic views of the mind: he claimed that consciousness and self must be considered a hybrid of processes that result from an interaction between the mind’s intrinsic features and the world’s extrinsic stimuli.

In order to reveal the nature of such intrinsic-extrinsic interactions, Kant attributed various faculties (i.e., intrinsic features) to the mind, primarily described in his Critique of Pure Reason (Kant, 1998). The mind’s intrinsic features included unity of consciousness, self as ‘I think’, and various templates of spatiotemporal continuity (which were subsumed under the umbrella term ‘categories’). According to Kant, the mind uses its intrinsic features to structure and organise the effects of the extrinsic stimuli. This, in turn, allows the latter to become associated with consciousness, self, and spatiotemporal continuity. Hence, consciousness, self, and spatiotemporal continuity are based on the interaction between the mind’s intrinsic features and the environment’s extrinsic stimuli.

Extrinsic and intrinsic views of the brain

Charles Sherrington, the British neurologist working at the beginning of the 20th century, considered the brain a mere passive sensorimotor reflex apparatus. Extrinsic stimuli from the environment trigger neural activity in pathways that result in sensorimotor reflexes. This extrinsic view of the brain has been challenged by authors such as Graham Brown, Karl Lashley, and Rodolfo Llinas, based on the observation of intrinsically generated activity in the brain (Llinas 2002 for an overview).

The recent discovery of high resting state activity in a particular set of brain regions, the default-mode network (DMN), has once again raised the question of an intrinsic view of the brain’s neural activity (Raichle, 2009). Since its initial description, the functions of the DMN have been debated and associated with the self (Qin & Northoff, 2011) and consciousness (He & Raichle, 2009; Tononi & Koch, 2008; Northoff, 2013a–c). However, the exact features of resting state activity in the brain and how it yields functions such as consciousness and self remain unclear.

How does the intrinsic resting state activity of the brain interact with the extrinsic stimuli from the outside world? The relevance of such rest-stimulus interaction is supported by recent findings showing that the level of pre-stimulus resting state activity predicts the neural, phenomenal, and behavioural effects of subsequent stimuli (Northoff et al., 2010; Sadaghiani et al., 2010).

What remain unclear, however, are the exact neuronal features of the resting state itself that make possible such rest-stimulus interaction. These neuronal features must be intrinsic to the resting state while at the same time predisposing the brain to the association of its stimulus-induced activity with consciousness and self. Hence, in order to better understand our observations during rest-stimulus interaction, we may need to get a better grip on the resting state’s intrinsic features. Additionally, we must learn the neuronal features of the resting state itself make possible or predetermine that is predispose the way the stimuli can interact with the resting state, rest-stimulus interaction in such a way that the stimulus becomes associated with consciousness and self. We may thus need to develop an intrinsic-extrinsic interaction model with regard to the brain.

Kant and the brain

Kant’s view of the mind’s intrinsic features has often been interpreted within a predominantly cognitive context. Philosophers such as Brook (1994), Kitcher (1990), and Palmer & Lynch (2010), as well as neuroscientists such as Zeki (2008) associate higher-order cognitive functions with Kant’s intrinsic features of the mind. This is in line with predominantly cognitive and reflective characterizations of consciousness (as for instance ‘access consciousness’ (Block, 2005)).

However, this still leaves open the question of mechanisms for the most basic forms of consciousness, i.e., phenomenal consciousness (Northoff, 2013; Block, 2005) and its phenomenal features like pre-reflective sense of self (Qin & Northoff, 2011) and spatiotemporal continuity (Northoff, 2013a–c). These basic forms of consciousness and self may be closely related to how the intrinsic features of the resting state interact with extrinsic stimuli, since they must occur prior to any cognition.

What Kant described as the mind’s intrinsic features, providing order and regularity to the extrinsic stimuli from the world, could be attributed to the
brain's resting state and its intrinsic features. More specifically, the brain's resting state activity may structure and organise stimulus-induced activity in such way that the latter can be associated with consciousness, self, and spatiotemporal continuity (Northoff, 2012a, 2012b, 2013a–c). Hence the brain itself, the resting state's intrinsic features, may provide an input yet to be explored specifically in relation to the neural processing of extrinsic stimuli.

Kant's account of the mind's intrinsic-extrinsic interaction may give us some clues about the kind of intrinsic features within the brain's resting state activity and how they interact with the extrinsic stimuli from the world. We may thus want to search for those intrinsic features that predispose the brain to associate consciousness, self, and spatiotemporal continuity with the extrinsic stimuli during subsequent rest-stimulus interactions. And it is exactly these functions such as self, consciousness, and spatiotemporal continuity that are abnormal in psychiatric patients with, for instance, depression or schizophrenia. The following section takes a more detailed look at spatiotemporal continuity.

**Intrinsic Activity and Spatiotemporal Continuity**

**Intrinsic activity and consciousness**

How does the brain's intrinsic activity relate to consciousness? The term intrinsic activity describes spontaneous activity generated inside the brain itself (see Logothetis, 2009 and Northoff, 2012a for details). Since the observation of spontaneous activity implies the absence of extrinsic stimuli and is thus mere rest, the term intrinsic activity is often used interchangeably with 'resting state activity', especially in an experimental-operational context (see also Logothetis, 2009 for a discussion on the concept of the resting state). The brain's intrinsic activity has recently also been considered a candidate mechanism of consciousness (see Lundervold, 2010 for a more technical overview as well as Northoff, 2013a, 2013c for a detailed discussion of the different theories).

One recent proposal suggests that the resting state's slow wave fluctuations in frequency ranges between 0.001–4 Hz are central in yielding consciousness (He et al., 2008; He & Raichle, 2009; Raichle, 2009). Due to the long time windows of their ongoing cycles, i.e., phase durations, these slow wave fluctuations may be particularly suited to integrating different information. Such information integration may then allow for the respective content to become associated with consciousness (see also Fingelkurts et al., 2010 for a consideration of the resting state's functional connectivity and low frequency fluctuations in the context of consciousness).

Another suggestion for the central role of the resting state in consciousness was proffered by Rudolfo Llinas (1998, 2002). Conducting MEG studies on subjects in the awake state and during sleep, Llinas observed that 40 Hz oscillations were present in both the awake and sleeping (REM sleep) states. The two states differed, however, in that a sensory stimulus could reset (and thus modulate) the 40 Hz oscillations in the awake state but not during REM sleep (in which we dream). Hence, the neural reactivity of the resting state to external stimuli seems to distinguish the awake state from REM sleep.

The same was observed in NREM sleep, which showed a similar non-reactivity to external stimuli. In addition, NREM sleep exhibited reduced amplitude in the 40 Hz oscillations, distinguishing it from REM sleep. Hence, the reactivity of the 40 Hz oscillations and their amplitude seem to distinguish REM and NREM sleep. This underlines the central importance of the resting state and especially of its interaction with stimuli, i.e., rest-stimulus interaction (see also Freeman, 2003, 2010, and Northoff et al., 2010 Volume I, Part IV, Chapter 2), in yielding consciousness.

Another theory central to connecting intrinsic activity to consciousness originates from Dehaene (Dehaene & Changeux, 2005, 2011). Depending on the timing of the stimulus relative to ongoing spontaneous phase fluctuations, the stimulus may or may not lead to the recruitment of the fronto-parietal neurons and network, which are considered of primary importance in allowing for conscious access.

If for instance the spontaneous firing activity in the fronto-parietal network is too strong and continuous, it can block and thus prevent ignition by an external stimulus. Since Dehaene and Changeux assume the fronto-parietal network to be a global neuronal workspace that is necessary for consciousness, the stimulus may consequently be 'denied' conscious access and thus remain unconscious, i.e., pre-conscious (see also Kleinschmidt et al., 2012 for the relevance of pre-stimulus resting state activity).

Taken together, these proposals provide support for a central role for the brain's intrinsic activity in consciousness. They leave open, however, the question as to why and how intrinsic activity—the brain's input—can create the tendency or predisposition to generate consciousness. Without intrinsic activ-
ity, consciousness, with its special subjective and phenomenal-qualitative features, would not even be possible. Hence, intrinsic activity is indispensable for the possibility of consciousness, although it is (usually) not sufficient in itself to generate actual consciousness.

Intrinsic activity seems to add a special feature to the neural processing of extrinsic stimuli that predisposes their possible association with consciousness in the ‘right’ circumstances. To better understand what this feature is, it is necessary to grasp the temporal and spatial organisation of the brain’s intrinsic activity in more detail. This is the focus of the following sections.

**Intrinsic activity and temporal continuity**

There appears to be quite an elaborate temporal structure to the brain’s intrinsic activity, based on the fluctuations of intrinsic activity in different frequency ranges. Spontaneous fluctuations of neural activity in the resting state are often observed, especially in the default-mode network (DMN) where they are characterized predominantly by low frequencies (< 0.1 Hz).

However, low (and high) frequency fluctuations in neural activity can also be observed in regions other than the DMN such as the sensory cortices, motor cortex, insula, and subcortical regions like the basal ganglia and thalamus (see Freeman, 2003; Shulman et al., 2004, 2009; Buckner et al., 2008; Wang et al., 2007; Hunter et al., 2005; Zuo et al., 2010). Rather than being specific to the DMN, low frequency fluctuations appear to be a hallmark feature of neural activity in general.

Further support for spontaneous resting state activity across the whole brain comes from electrophysiological studies showing spontaneous neuronal oscillations and synchronizations in various parts of the brain including the hippocampus and visual cortex (Buzsaki, 2006; Buzsaki & Draguhn, 2004; Arieli et al., 1996; Llinas, 1988; Singer, 2003; Fries et al., 2001, 2007). This suggests that spontaneous fluctuations—and thus intrinsic activity—may be prevalent throughout the whole brain in both humans and animals, and not limited to the DMN.

To be more specific, spontaneous BOLD fluctuations as observed in fMRI are to be found in lower frequency ranges including the delta band (1–4 Hz), up- and down-states (0.8 Hz) and infra-slow fluctuations (ISFs) (0.001–0.1 Hz). The slow frequency fluctuations observed in fMRI have been assumed to correspond to what is measured as slow cortical potentials (SCPs) in EEG (Khader et al., 2008; He & Raichle, 2009).

These SCPs are not easy to obtain in EEG because they are subject to artefacts caused by sweating, movements, and electrode drift; their measurement therefore requires a more direct approach by so-called DC (direct current) recording. There is some evidence that what is measured as SCP in EEG corresponds to, or is even identical to the low frequency fluctuations obtained in fMRI (see He & Raichle, 2009 as well as Khader et al., 2008 for reviews).

In addition to such low frequency fluctuations, there are also higher frequency fluctuations in the brain’s resting state activity. These cover 1 Hz and higher, thus including delta (1–4 Hz), theta (4–8 Hz), alpha (8–12 Hz), beta (12–30 Hz), and gamma (> 30 Hz) (see Mantini et al., 2007; Sadaghiani et al., 2010).

This raises the question of how low and high frequencies are related to each other in the brain’s resting state (see also the recent reviews by Fries, 2009; Canolty & Knight, 2010; Sauseng & Klimesch, 2008; Fell & Axmacher, 2011). For instance, Vanhatalo et al. (2004) conducted an EEG study of healthy and epileptic subjects during sleep and thus during rest where, using DC-EEG, low frequency oscillations were recorded. All subjects showed infraslow oscillations (0.02–0.2 Hz); these were detected across all electrodes—and thus the whole brain—without any specific, visually obvious spatial distribution evident.

Most interestingly, Vanhatalo et al. (2004) observed phase-locking or phase-synchronization between the slow (0.02–0.2 Hz) oscillations and the amplitudes of the faster (1–10 Hz) oscillations: the amplitudes of the higher frequency oscillations (1–10 Hz) were highest during the negative deflection of the slow oscillations (0.02–0.2 Hz). Even the higher-frequency K-complexes that are characteristic of sleep, as well as interictal epileptiform events, were phase-locked to the slow oscillations in that the former occurred preferentially in the negative deflection phases of the latter.

An analogous phase-locking of high frequency oscillations’ power to the phases of lower ones can also be described as phase-power coupling, with phase-phase and power-power coupling also being possible (see Canolty & Knight, 2010 as well as Sauseng & Klimesch, 2008 for excellent reviews). Such low-high frequency entrainment may occur not only during the resting state as described in the above-mentioned study but also during rest-stimulus interaction (Northoff et al., 2010), where it may be central to integrating and embedding the stimuli (and their respective contents) into the ongoing temporal structure of the brain’s intrinsic activity.
Figure 1

The figure illustrates schematically the constitution of the supposed generation of temporal (1a) and spatial (1b) continuity by the brain's intrinsic activity.

1a: The brain shows intrinsic activity independent of the extrinsic stimuli from the environment. The intrinsic activity shows fluctuations in different frequency ranges ranging from infraslow to fast (000.1–60 Hz) (red lines). High and low frequency fluctuations are connected to each other via their phases and power (yellow lines). For instance, the phases of low frequency fluctuations align themselves to the power of higher ones resulting in phase shifting and phase-power coupling. This makes it possible for the intrinsic activity to bridge the temporal gaps between the neural activities at different discrete points in physical time within the brain itself. There is consequently continuity of neural activity across different time points, a neuro-temporal continuity as one may say, as constituted by the brain's intrinsic activity itself.

1b: The brain shows intrinsic activity independent of the extrinsic stimuli from the environment. The neural activities at different regions, reflecting different discrete points in physical space, are linked and connected to each other via functional connectivity as illustrated by the red arrows. This allows to bridge the spatial gaps between the neural activities at different discrete points in physical space, i.e., regions, within the brain itself. There is consequently continuity of neural activity across different regions, a neuro-spatial continuity as one may say, as constituted by the brain's intrinsic activity itself.
It is apparent, then, that there is a complex temporal structure and organisation to the brain’s intrinsic activity. Most importantly, this temporal structure seems to bridge the temporal gaps between different discrete points in time. By linking together neural activities at different points in time, a certain degree of temporal continuity in the brain’s intrinsic activity is constituted. Before addressing the question of how this intrinsic activity’s temporal continuity is related to the above-described temporal continuity of consciousness, it is necessary to briefly explore the constitution of spatial continuity in the brain’s intrinsic activity.

**Intrinsic activity and spatial continuity**

Resting state activity can be characterized by both spatial and temporal dimensions. This is reflected in functional connectivity and low frequency fluctuations (see above, as well as Raichle, 2009; Northoff, 2012a). Functional connectivity describes the linkage between the neural activities of different regions across the space of the brain (see also Fingelkurts et al., 2004, 2005, 2010 for a discussion of this issue), while low frequency fluctuations concern the fluctuations in neural activity across time. Most importantly, both functional connectivity and low frequency fluctuations reflect neural activity across different discrete points in time and space rather than corresponding directly to the individual points themselves.

Spatially, the brain’s intrinsic activity can be characterized by different neural networks such as the default-mode network (DMN), the cognitive-executive network (CEN), and the salience network (SN) (see Raichle et al., 2001; Menon, 2011; Raichle, 2009). The DMN concerns mainly cortical midline regions and the bilateral posterior parietal cortex (Buckner et al., 2008; Raichle et al., 2001). These regions seem to show high resting state activity, dense functional connectivity, and strong low frequency fluctuations (0.001–0.1 Hz) in the resting state. The executive network comprises the lateral prefrontal cortex, the supragenual anterior cingulate, and posterior lateral cortical regions as core regions, as these are involved in higher-order cognitive and executive functions. Finally, the salience network includes regions like the insula, the ventral striatum, and the dorsal anterior cingulate cortex, which are associated with reward, empathy, intero/exteroception and other processes involving salience (see Menon, 2011; Wiebking et al., 2011; Yan et al., 2011).

All three neural networks, the DMN, CEN, and SN, show strong intrinsic functional connectivity among their respective regions, while the functional connectivity to regions extrinsic to the respective network are usually much weaker while in the resting state. This can change, however, during stimulus-induced activity when the relationship and thus the functional connectivity between the three networks is rebalanced (see Menon, 2011).

Most importantly, none of the neural networks acts in an isolated way during either resting state or stimulus-induced activity. Instead, all three are mutually dependent in their level of neural activity and intrinsic functional connectivity via their functional connectivity to extrinsic regions in the respective other networks (See Menon et al., 2011). See Figure 1b on page 8.

Taken together, this characterization of the spatial structure of the brain’s intrinsic activity may provide a neuronal mechanism for the constitution of spatial continuity that allows transitions (or, metaphorically speaking, glue) between different discrete points in physical space. Hence, although the exact mechanisms remain unclear, the brain’s intrinsic activity seems to constitute both spatial and temporal continuity, thereby bridging the gaps between different discrete points in time and space.

**Spatiotemporal continuity and consciousness**

**Spatiotemporal continuity in consciousness**

Experience of contents in consciousness presupposes a dynamic and continuous flow of time extending from the past over the present to the future, all of which are crystallized and condensed in the present moment. This is what W. James (1890) described as ‘spacious present’ or dynamic flow. The organisation of time is conceived through this notion as a continuum rather than as a discontinuum in consciousness. This leads to the experience of what James described as the ‘stream of consciousness’, a continuous temporal flow analogous to the flow of water in a river.

Put simply, any content we experience in consciousness becomes integrated and embedded within this dynamic flow of time and becomes thereby a part of the ongoing stream of consciousness. Consciousness of contents can thus be compared to a boat in a river: just as the boat could not function as a boat without the flowing water of the river, contents cannot become conscious without an underlying dynamic flow, i.e., the stream of consciousness.
Figure 2

The figure illustrates schematically the constitution of spatiotemporal continuity in consciousness (2a) and its relation to neuronal features in the intrinsic activity (b, c).

(a) The upper part of the figure shows the occurrence of different stimuli (vertical lines) at different discrete points in physical time and space. Middle part: Independent of the respective stimuli themselves, consciousness seems to be based on the extraction of their purely spatial and temporal points linking and connecting them. A spatiotemporal grid, template, or matrix is generated thereby resulting in spatiotemporal continuity. Phenomenally, this is manifest in the occurrence of ‘inner time and space consciousness’. Lower part: Following their occurrence in space and time, the different stimuli are linked to objects, events or persons which as appear as contents (upper dashed green lines) in consciousness. Most importantly, these contents are integrated and embedded into the spatiotemporal grid or continuity (lower blue dashed line) which makes possible their association with consciousness.

(b) The x-axis shows the temporal durations as experienced in ‘inner time consciousness’. While the y-axis stands for the phase durations of the strong low frequency fluctuations dominating in the intrinsic activity. The longer the phase durations during the intrinsic activity, the longer the temporal durations subjects can experience in ‘inner time consciousness’.

The x-axis shows the temporal durations during the experience of stimulus-related contents in consciousness. While the y-axis stands for the coupling between the intrinsic activities’ low frequency phases and the stimulus-induced high frequency power. The better the low-high frequency coupling, the longer the phase durations, and the longer subjects can experience the stimulus-related contents in consciousness.
To put this in another perspective, the contents themselves occur at specific discrete points in physical time. At most they may last for a few fleeting seconds, after which they are replaced by others. One element of content goes and the next one comes, each occupying its own position in time. Yet despite their occurrence at different discrete points in physical time, we experience a temporal continuum, a transition, between the different contents.

This temporal continuum in consciousness does not seem to obey the laws of physical time with its discrete points. Instead, it constitutes a continuum between the different discrete points in physical time, and thus what phenomenally is described as dynamic flow (James) or ‘phenomenal time’ (E. Husserl) as distinct from physical time.

While there has been much debate about time and consciousness (see chapters 1–3 in Part I of Northoff, 2012b for details), there has been less discussion about the experience of space in consciousness. Here an analogy may be made with time. In similar fashion, the contents of consciousness are not experienced at their respective discrete points in physical space. Instead, they are embedded and integrated into a spatial continuum with multiple transitions between the different points. As in the case of time, the contents are woven into a spatial grid or template that emphasizes continuity and transition over discontinuity and segregation (see chapter 4 in Part I of Northoff, 2012b for details). See Figure 2a, page 8.

Consciousness may therefore be characterized phenomenally as an underlying temporal and spatial template or grid into which the different contents are woven. This underlying spatiotemporal grid seems to provide continuity between the different discrete points in time and space at which the contents occur. Such spatiotemporal continuity makes it possible for us to experience the different contents in consciousness in a spatially and temporally continuous and homogenous space that spans across the different discrete points in physical time and space. If, in contrast, there was no such spatiotemporal grid in our brain’s neural activity, the contents could no longer linked together spatially and temporally which would make their appearance in consciousness impossible.

The grid can thus be characterized by spatiotemporal continuity in the phenomenal realm of consciousness, as distinct from spatiotemporal discontinuity in physical time and space.

**Spatiotemporal continuity in intrinsic activity and consciousness**

The question then arises as to how the spatiotemporal continuity of intrinsic activity in the brain relates to spatiotemporal continuity on the phenomenal level, i.e., in consciousness as described above. All that has been shown so far is that intrinsic activity bridges the gaps between discrete points in time and space by low frequency fluctuations and functional connectivity. What remains to be seen is how such neuronal spatiotemporal continuity of the brain’s intrinsic activity is related to the phenomenal spatiotemporal continuity of consciousness.

It is currently not known how neuronal and phenomenal spatiotemporal continuity are linked. Yet it is possible to suggest an example of the kind of experimental data that might shed light on such a connection, from the temporal domain. Stimulus-induced higher frequency fluctuations like gamma (30–50 Hz) are aligned and entrained to the phases of the lower ones in intrinsic activity (delta: 1–4 Hz or even infraslow: 0.01–0.1 Hz). This may integrate the stimulus and its actual discrete point in time, as signified by the gamma oscillations, into a longer temporal stretch as provided by the longer phase duration of the resting state’s ongoing low frequency fluctuations. By being integrated into a longer temporal stretch, i.e., the low frequency’s phase duration, the stimulus’ discrete point in time is resolved into the intrinsic activity’s temporal continuum.

In this way a relationship may be established with consciousness. As described above, we experience stimuli in consciousness not at their discrete points in time but rather as part of an ongoing dynamic flow of time, as part of a temporal continuum. This temporal continuum in consciousness may now be traced back to the temporal continuum provided by the intrinsic activity and its low frequency phase durations.

One would consequently expect the following. First, it would be assumed that the predominant phase durations match, at least in some measure, the subjectively experienced time durations of events in consciousness. For instance, an extrinsic stimulus occurring at time x may take place at the phase onset of a predominant low frequency fluctuation in the delta/theta range of around 5 Hz. One may now assume that the consciously perceived duration of the objective time x and thus the stimulus itself may be extended in sympathy with the temporal duration of the respective phase. If so, the degree of temporal extension would likely be dependent on where the stimulus fell in terms of the positive or
negative peaks and/or the falling or rising slopes of the phase.

Secondly, one would expect the degree of phase-power coupling between low and high frequency fluctuations to determine at least in part the degree to which a particular stimulus can enter consciousness. The stimulus itself may induce higher frequency fluctuations like gamma (30–50 Hz). The power of such gamma fluctuations may now need to be aligned and thus coupled to the phases of the low frequency fluctuations in, for instance, the delta range. Only in this way would the extrinsic stimulus gain access to the brain’s intrinsic activity and its temporal and spatial structure. One would consequently expect the degree of low-high frequency phase-power coupling to predict the degree of consciousness of a particular stimulus. See Figure 2b and c, page 8.

An analogous scenario may hold in the case of the spatial dimension. The degree of spatial continuity and thus the spatial distance between different neural activities in the resting state may govern how the stimulus’ discrete point in space is integrated and embedded into the spatial context. Further investigation is needed, however, to more closely link neuronal and phenomenal measures of both spatial distance and temporal duration. If successful, this would lead to what may be described as a neurophenomenal account of consciousness (see Northoff, 2012b).

The assignment of consciousness to extrinsic stimuli may thus be strongly dependent on the degree and nature of interaction between the extrinsic stimulus’s spatial and temporal features on the one hand, and the intrinsic resting state’s spatiotemporal continuity on the other. It may thus be prudent to explore the exact neural mechanisms underlying the different kinds of such rest-stimulus interaction in further detail, as, for instance, whether the process is linear or non-linear (see for example Hesselmann et al., 2009; Kleinschmidt et al., 2012; Northoff, 2012a). This, though, will be a task for the future.

For now, we aim to gather further support for the link between the intrinsic activity’s spatiotemporal structure and the experience of time and space in consciousness. I propose that such a neuro-phenomenal link is strongly supported by the concomitant alterations in both intrinsic activity and consciousness in psychiatric disorders like schizophrenia and depression. This will form the focus of the following sections, albeit in a very abbreviated way.

### Spatiotemporal continuity in psychiatric disorders – Schizophrenia

In order to garner further support for our assumption that the spatial and temporal features of the brain’s intrinsic activity are central to consciousness and its spatiotemporal continuity, we here turn to psychiatric disorders where abnormalities in the spatiotemporal continuity of both intrinsic activity and consciousness have been described.

Schizophrenia is a complex disorder where patients suffer from hallucinations (mostly auditory), delusions, thought disorders, ego and identity disorders, and abnormal, mostly blunted, affect and avolition. Depressive patients, on the other hand, can be characterized by abnormal negative affect and mood, anxiety, sleeplessness, increased ruminations and cognition revolving around the self (‘increased self-focus’), and a lack of initiative and motivation. (Northoff 2007) There have been many studies on the subjective experience and thus the phenomenology of, in particular, ‘inner time consciousness’ in both disorders (see Fuchs, 2011 for an excellent summary). Rather than going into detail, I briefly summarize the main points following Fuchs (2011).

Instead of providing a grid or template of spatiotemporal continuity, ‘inner time and space consciousness’ in schizophrenia seems to be characterized by spatiotemporal fragmentation and disruption. These patients no longer experience temporal continuity and thus a dynamic flow of time (and space) in their consciousness. Instead, the stream of consciousness is disrupted and blocked with the three temporal dimensions of past, present and future being disconnected from one other.

The glue between the different discrete points in physical time seems to be missing in the consciousness of time and space. This implies that the different contents including their distinct discrete points in physical time and space can no longer be linked to each other in the consciousness; the glue and thus the spatiotemporal continuity is lost. This is very apparent, for instance, in the following quote of a schizophrenic patient in Fuchs (2011): “When I move quickly, it is a strain on me. Things go too quickly for my mind. They get blurred and it is like being blind. It’s as if you were seeing a picture one moment and another picture the next.”

The schizophrenic patient describes here that the contents of his consciousness, the different pictures, are no longer linked together. There are no longer any transitions between the different discrete points in time and space associated with the different pictures. The pictures are, as it were, experienced as
pearls without an underlying chain. Since the underlying chain—the spatiotemporal continuity—seems to be disrupted within itself, the pearls can no longer be put together, ordered, structured and organized in consciousness.

In other words, for the schizophrenic patient, both the ‘inner time and space consciousness’ and ‘consciousness of contents’ become disordered and disorganized, leading to what may be described as spatiotemporal disruption. This leads the patient to experience the contents of consciousness in an abnormal way as is manifested in many of the schizophrenic symptoms such as ego disorders, thought disorders, hallucinations and delusions.

**Spatiotemporal continuity in psychiatric disorders – Depression**

Depressive conditions may yield further insights. Major depressive disorder (MDD) is a severe psychiatric disorder in which patients suffer from excessive ruminations, increased self-focus, anhedonia, suicidal thoughts, bodily symptoms, and sleepiness (see Northoff et al., 2011; Hassler & Northoff, 2011). The nature of ‘inner time and space consciousness’ under such conditions is informative. While schizophrenia can be characterized by spatiotemporal disruption, in depression the balance between past, present and future in the spatiotemporal continuity of consciousness seems to be abnormally shifted towards the past (see Fuchs, 2011; Northoff et al., 2011; Grimm et al., 2009, 2011).

Depressed patients experience themselves as being ‘locked into the past’, while at the same time ‘seeing and experiencing no future anymore’ (Northoff 2007). This is plainly manifest in an extremely high degree of hopelessness and consequent suicidal thoughts. Hence, unlike in schizophrenic patients, the spatiotemporal continuity is not disrupted in depression. Instead it is abnormally shifted towards the past at the expense of the future, something that might be characterized as spatiotemporal dysbalance.

This spatiotemporal dysbalance is not only manifest in the abnormally past-focused ‘inner time (and space) consciousness’ in depression. It also affects the ‘consciousness of contents’ both bodily and in terms of environment. One’s own body is experienced as static and powerless while environmental contents are experienced as disconnected, very much like distant objects from the far past. Hence, in both schizophrenia and depression, the abnormal changes in the spatiotemporal continuity seem to affect the experience of both ‘inner time and space consciousness’ and ‘contents of consciousness’.

Of interest is how these phenomenal, i.e., subjective-experiential, abnormalities relate to the brain and its intrinsic activity. I have assumed a central role for the brain’s intrinsic activity in constituting spatiotemporal continuity in consciousness. This being the case, one would expect spatial and temporal abnormalities to be present in the intrinsic activity in schizophrenia and depression. This is indeed what has been found, as I discuss here briefly.

Numerous studies have recently shown resting state abnormalities in both depression (see Alcaro et al., 2010 and Northoff et al., 2011 for review) and schizophrenia (see, for instance, Northoff & Qin, 2011 for review). Findings indicate abnormal regional patterns of neural activity and altered functional connectivity. This suggests changes in the spatial continuity of the brain’s intrinsic activity. Especially in schizophrenia, changes in gamma oscillations (and low delta oscillations) have been reported (see, for instance, Jarvitt et al., 2011), indicating abnormal temporal continuity in the brain’s intrinsic activity.

Much, though, remains unclear at this point. First, the exact nature of these spatial and temporal resting state abnormalities remains to be established. Secondly, their link to the above-described phenomenal abnormalities in the consciousness of time and space in these patients is not at all clear at this time.

The extrinsic stimuli may encounter an already altered temporal and spatial continuity when interacting with the brain’s intrinsic activity. The latter’s spatial and temporal abnormalities may be imposed upon the extrinsic stimuli, which are then experienced in abnormal spatial and temporal ways in consciousness. This in turn may account for some of the characteristically difficult symptoms of sufferers of schizophrenia and depression, symptoms that could ultimately be described as abnormal spatiotemporal constellations between intrinsic activity and extrinsic stimuli—in short, abnormal rest-stimulus interaction. However, as in the case of healthy subjects, much work remains to be done to establish direct links between the neuronal and phenomenal levels in these patients.

**Conclusion: From Kant over the Brain to Psychiatric Disorders**

I have here presented an initial outline of how the philosophy of Immanuel Kant and his concept of mind can be applied to the brain, thereby illuminating something of the nature of the abnormalities in psychiatric disorders. Kant suggests an intrinsic-
extrinsic interaction model where the mind provides an active intrinsic input to the processing of extrinsic stimuli. This was put into the context of the brain, an idea which finds empirical support in recent observations of the brain’s intrinsic activity—its resting state activity. Psychiatric disorders like schizophrenia and depression indeed show major abnormalities in resting state activity, although the implications of this for the consciousness and symptoms of patients remain unclear.

It is precisely at this juncture in research where Kant and his model of the mind’s input may prove helpful when applied to the brain. The brain’s intrinsic activity may in itself provide some kind of spatiotemporal structure, a spatiotemporal continuity of its neural activity into which extrinsic stimuli are integrated. Such spatiotemporal continuity of the brain’s neural activity may on the phenomenal level of consciousness be manifest in the subjective experience of a dynamic flow or stream of consciousness of time and space across different discrete points in physical time and space.

If so, one would expect that disruptions in the resting state activity would lead to abnormal changes in subjective time and space experience. Such is what we observe in psychiatric disorders. Accordingly, Kant may have a role to play in helping us understand the implications of the brain’s neural resting state abnormalities for the subjective experience, and thus consciousness, in patients with psychiatric disorders.

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