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Non-Reductive Neurophilosophy – What Is It and How It Can Contribute To Philosophy

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Abstract

What is neurophilosophy? Different variants of connecting neuroscience and philosophy emerged in recent years. Besides reductive, parallelistic, and neurophenomenological variants, we here focus on Non-Reductive Neurophilosophy (NRNP) as introduced by the author of this paper. NRNP can methodologically be characterized by the inclusion of multiple domains (ontological, epistemological, empirical, etc.) and various methodological strategies (like logical-conceptual and observational-experimental) – this amounts to domain pluralism and method pluralism. That is combined with an iterative methodological movement between the different domains and, specifically conceptual and empirical domains resulting in concept-fact iterativity. Such non-reductive neurophilosophical approach can make major contributions to both neuroscience and philosophy. Concerning the latter, we demonstrate how a non-reductive neurophilosophical approach allows taking into view a deeper neuro-ecological and spatiotemporal layer of Martin Heidegger's Fundamental ontology and its "being in the world". This may also require a more fundamental approach to consciousness in both its phenomenological features and neural basis – this has recently been proposed in the "Temporo-spatial theory of consciousness" (TTC). In sum, due to its particular methodological strategy, NRNP allows providing a broader more comprehensive framework to philosophical problems like subjectivity, consciousness, and mind-body problem (and various others). Moreover, NRNP may provide a novel deeper framing and reading of historical authors (like Kant, Heidegger, Whitehead, etc.) which may allow to connect them to current and systematic philosophical and even neuroscientific issues.

Key Words: neurophilosophy, neurophenomenology, non-reductive neurophilosophy, temporo-spatial theory of consciousness, mind-body problem, Merleau-Ponty

Introduction

Neurophilosophy – an abbreviated history

Recent neuroscientific progress has led to the extension of neuroscience to apply and include also concepts like consciousness, free will, self, etc. that were originally discussed in philosophy. This has led to the recent emergence of a new field, neurophilosophy. The term "neurophilosophy" is often used either implicitly or explicitly for the characterization of an investigation of philosophical theories in relation to neuroscientific hypothesis. According to Breidbach, "neurophilosophy" has already been implicitly practiced at the turn of last century by, for example W. Wundt (Bredibach, 1997; p.393-4). Another neurophilosopher though not named as

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such was the 19th century philosopher Arthur Schopenhauer (1788-1860) who was probably the first philosopher to introduce the concept of the brain in the philosophical context; he formulated the "brain paradox" which points out that the brain is both subject and object of our cognition.

The French 20th century phenomenological philosopher Maurice Merleau-Ponty (1908-1961) may also be considered a neurophilosopher since in his books 'The structure of behavior' and 'Phenomenology of perception' he explicitly introduces the brain and its neural organisation and links it to perception and other originally philosophical concepts. He paves the way for what in our times is featured as 'neurophenomenology' (Varela, 1992; Thompson, 2007). Other important developments in this regard were the paper about naturalized epistemology by Willard Van Orman Quine (1969) and the book about the self and its brain by Karl Popper and John Carew Eccles (1989). Though these approaches differ widely, they at least share the presupposition that the brain may be important to consider in explaining our possible knowledge and the concept of mind.

Yet, it was the Canadian-American philosopher Patricia Churchland who explicitly introduced the term "neurophilosophy" (Churchland, 1986). Her concept of neurophilosophy set a certain standard in defining neurophilosophy by possible reduction and elimination of originally philosophical concepts by neuroscientific concepts and facts. She thus did not only consider the brain to be relevant for knowledge but claimed much stronger that the mind including philosophy as whole can be reduced to the brain and thus to neuroscience. This had important implications since then the term neurophilosophy is almost exclusively reserved for reductive-eliminative approaches. Neurophilosophy in this sense is considered to be the "application of neuroscientific concepts to traditional philosophical questions" (Bickle, 2006). Since "neurophilosophy" in this sense aims at revealing the neural correlates of originally philosophical terms (like, for example, free will, personal identity, consciousness, etc.), one may also speak of a "neuroscience of philosophy" or "Empirical Neurophilosophy" (Northoff, 2004; 2014; 2018). "Empirical Neurophilosophy" focuses on the investigation of the neural (and psychological) conditions of originally philosophical concepts like free will, self, action, consciousness, etc.

Neurophilosophy – Current landscape of methodological approaches

The current intersection of philosophy and neuroscience can, roughly, be described by four different methodological approaches (Northoff, 2004; 2014; 2018). First, there is reductive Neurophilosophy which, following the line of Churchland, reduces if not replaces philosophy including the mind to/by the brain and thus to neuroscience. This is predominant in the Anglo-American world. Second, there is parallelism of neuroscience and philosophy where both are conceived as distinct non-overlapping realms or domains, i.e., conceptual and empirical. The brain is empirical while the mind falls into the conceptual domain. Such parallelism is advanced by Bennet and Hacker (Bennett, 2003) who largely follow the late Wittgenstein in their methodological approach.

Thirdly, there is neurophenomenology which strongly builds on Merleau-Ponty when aiming to link first-person experience, as described in phenomenology, to the third-person neural features of the brain, i.e., neuroscience. Unlike in the reductive approach, the mind is here not reduced to the brain but rather conceived in the context of the latter's embodiment – body and body-brain relation thus play a key role here (Verela, 1992; Thompson, 2007).

Non-reductive Neurophilosophy

Finally and fourth, there is non-reductive neurophilosophy (Northoff, 2004; 2014; 2018) which is the main focus in this paper. Unlike reductive neurophilosophy, the non-reductive approach does not reduce or replace philosophy by neuroscience. Instead of such unilateralism, the non-reductive approach opts for bilateral iterative exchange of conceptual, epistemological, ethical, and ontological domains (philosophy) with the empirical domain (neuroscience).

Specifically, the domain in question is investigated with regard to the degree to which it presupposes the respective others. While the other domains are searched for their implications for the domain in question. While this sounds logically and methodologically circular, NRNP argues that that is not the case: the domain in question is enriched by the implications it receives from the others and vice versa. We will see further down present a concrete example of those presuppositions and implications. Hence, it is rather an open-looped iterative than closed-looped circular methodological movement.

Such bilateral iterative approach also stands square to the parallelism of conceptual and empirical domains: the distinction of these domains is purely methodological and, at best, epistemological but not ontological. This makes it possible to search for overlap, connection, and linkages between empirical and conceptual (and epistemological and ontological and ethical) domains. For that, the non-reductive approach proposes particular methodological strategies, concept-fact linkage and iterative (rather than circular) procedure. These shall be explained in the first part of this paper.

Given its bilateral movement between philosophical and neuroscientific domains, the non-reductive neurophilosophical approach can operate within both fields, neuroscience and philosophy. Drawing on philosophical theories and concepts, it can link them to specific neuronal mechanisms which can be probed empirically. As we will see this requires somewhat of a translation (rather than reduction) of philosophical concepts within the empirical realm of neuroscience. This has been made fruitful for originally philosophical concepts like self and consciousness (Northoff, 2014; 2017; 2022a; 2022b). Importantly, the non-reductive approach also allows to proceed in the reverse direction, that is, from neuroscience to philosophy: neuroscientific insights are considered in extending particular philosophical framework of for instance historical philosophers as well as to tackle some philosophical problems like the mind-body problem. We will demonstrate this latter direction from neuroscience to philosophy in the second part of this paper.

Finally, it shall be added here that historically such consideration of empirical data from the sciences in philosophical theories was the "norm" (consider, for instance, Aristotle, Descartes, Leibniz, Hume, and even Kant) rather than the exception. Only in 20th century there is clear divide of philosophy and science which discourages the use of empirical data in the conceptual analyses of philosophy. Non-reductive Neurophilosophy aims to overcome such methodological myopia and put philosophy back into a more comprehensive framework that includes both conceptual (and ontological, etc.) and empirical domains.

The prime aims of non-reductive neurophilosophy within the context of philosophy are thus three-fold: (i) develop a systematic methodological strategy to connect or link the different domains of philosophy and neuroscience; (ii) extending historical philosophers in their arguments and theories; and (iii) apply neuroscientific insights to empirically support and re-frame conceptual (or ontological, etc.) arguments and theories in philosophy with their consecutive empirical plausibility for, for instance, consciousness-brain relationship. This will allow to provide a deeper and more fundamental framing and reading of historical authors including their connection to domains beyond their original ones like the link to empirical domains. That, in turn, may provide us with novel insights for more systematic and

transdisciplinary problems like the questions for consciousness and mind-brain relationship. My goal in this paper is to briefly demonstrate that by showing some examples.

Part I: Methodical strategy of Non-reductive neurophilosophy

Distinction of Domain and method – What vs how

We traditionally conceive different disciplines like philosophy and neuroscience in terms of their content and method. For instance, philosophy concerns metaphysical, epistemological or ethical contents which is investigated in a logical-conceptual way by rational arguments. While science including neuroscience focuses more on empirical contents investigated by observation and experimentation. There is thus a connection of content and method: certain contents require a particular methodological strategy for their investigation which defines both philosophy and neuroscience.

This connection of content, the "what" of our investigation, and method, the "how" of our investigation, is no longer taken for granted in non-reductive neurophilosophy (NRNP). There are different contents like metaphysical, epistemological, ethical and empirical – NRNP speaks of different domains of contents. The concept of domain comes from the Latin terms 'domus', dominium', and 'dominus' which refer to master, lord and owner with domus standing for house. The latter meaning is the one picked by NRNP: different contents can be described as distinct domains, that is, 'different houses feature distinct contents'. NRNP henceforth speaks of metaphysical, epistemological, ethical and empirical domains. The concept of domain is thus not limited to philosophy, it rather describes the contents as what of different disciplines in a trans- or cross-disciplinary way across the boundary of neuroscience and philosophy. Note though that the concept of domain can be identified with the one of content: the same content like the brain can be investigated in different domains like ontological, empirical, and epistemological.

Domains have to be distinguished from the method which we use to investigate the content of the former. Philosophy, for instance, uses the logical-conceptual method when relying on rational arguments to investigate its metaphysical, epistemological or ethical domains. While neuroscience is based on the observational-experimental method. These different methods reflect the different way how we as investigators approach and deal with the content, the what of our investigation. We usually associate a particular methodological strategy with specific contents, how and what are seemingly intimately linked. There is almost one-to-one relation of domain and method, i.e., what and how – methodological monism and domain monism go hand in hand.

Domain pluralism converges with method pluralism

Methodological monism and domain monism are put into doubt by NRNP. One and the same domain can be associated with more than one method in the same way two or more domains can be investigated with the same method. For instance, NRNP postulates that the ontological domain can be combined not only with logical-conceptual investigation but also with observational-experimental strategies. For instance, the brain can be investigated with both the observational-experimental and the logical-conceptual method. This transcends traditional disciplinary boundaries where the brain is restricted to the observational-logical method but not considered subject to the logical-conceptual method of philosophy. The same applies conversely to the mind.

Moreover, NRNP does not restrict itself do the traditional domains of philosophy and neuroscience: it considers the empirical domain in addition to the ontological, epistemological etc. domains while, unlike neuroscience, it goes beyond the empirical

domain. NRNP can thus be characterized by domain pluralism rather than domain monism as the traditional disciplines of philosophy and neuroscience. Importantly, unlike in the reductive variant of neurophilosophy that gives predominance to the empirical domain, NRNP does not claim for a hierarchical weighting of the different domains – they all stand side-by-side without any hierarchy or weighting.

The claim for domain pluralism in NRNP is accompanied by an analogous method pluralism. Different methods including logical-conceptual and observational-experimental can be used and easily combined with respect to for instance the same domain like the ontological or empirical domain. The ontological presuppositions of empirical contents can be investigated with both observation and rational argument as we will demonstrate below. The combination of different methodological strategies, i.e., method pluralism, with the domain pluralism is THE hallmark feature of the non-reductive nature of NRNP which distinguishes it from the other variant of neurophilosophy (reductive, parallelism, neurophenomenology).

Concept-fact iterativity

One may next be concerned that such pluralism in both domain and method lead invariably to parallelism: we combine domains but do not provide any connection between the different domains. This is countered by a particular methodological strategy NRNP describes as 'concept-fact iterativity'. Concept-fact iterativity describes that we go beyond the mere parallel use of both logical-conceptual and observational-experimental methods relying on concepts and facts respectively. We intimately link these methods through the contents. One and the same content like the brain can be conceived and investigated using different methods, i.e., logical-conceptual and observational-experimental. We can then search for similarities and differences in the determination of the brain using these different methodological strategies.

For instance, we can then take into view how much empirical and ontological determinations of the brain align to or dissociate from each other. As ontology concerns existence and reality in the natural world, an ontological determination of the brain must include reference to the natural world (and its existence and reality. That, in contrast, is not necessary in the case of the observational-experimental investigation of the brain that can remain restricted to the brain independent of the natural world. We will see further down that that leads us to a neuro-ecological rather than purely neuronal determination of the brain. This implies that any ontological or epistemological approach to mind, brain or otherwise, is not reduced to the brain itself, i.e., brain-reduced, as in the reductive variant of neurophilosophy. Instead, the brain is considered in a larger wider more comprehensive context, the world or knowledge – this renders NRNP a brain-based (rather than brain-reductive) approach to the mind (and even to the brain itself).

NRNP focuses on the similarities and differences with respect to one and the same content when it is conceived in distinct domains (like ontological and empirical) and/or different methods (like logical-conceptual and observational-experimental). The same can be considered in the converse way when conceiving different contents with the same method like using the logical-conceptual method for both brain and mind. The pluralism of both method and domain thus provides the opportunity to take into view and establish novel hitherto neglected connections between contents between or across different domains and method.

NRNP speaks here of an iterative (rather than circular) methodological strategy as one and the same content is conceived in distinct contexts (like distinct domains and/or methods): the brain as one particular is conceived in both empirical and ontological domains which is made possible by applying both logical-conceptual and observational-experimental methods to the brain. The concept of brain is linked to the facts of the brain in a step-wise iterative procedure – this amounts to concept-fact iterativity. The stepwise methodological procedure across different domains

distinguish NRNP from the other neurophilosophical approaches that, even if considering different domains, do not combine and converge the distinct methodological approaches across the different domains in such iterative way, i.e., concept-fact iterativity.

Part II: Brain and self in the empirical domain – Scale-freeness and Long-range temporal correlation

Subjectivity in philosophy and neuroscience – Paradigmatic example of a non-reductive neurophilosophical approach

How can we demonstrate the methodological approach of NRNP? For that I turn to subjectivity. Subjectivity is a key feature which has long been discussed in philosophy with Kant's transcendental self and Heidegger's existential self featured by 'being in the world' representing historical examples. In our times, subjectivity in both philosophy and neuroscience is often associated with the self. For instance, phenomenology conceives the subjectivity in terms of pre-reflective self-consciousness in phenomenology (Zahavi, 2005; Gallagher, 2019) while the more analytical philosophy of mind often characterizes subjectivity by a point of view (PV) as for instance in the famous "what it is like to be a bat" by Thomas Nagel (Nagel, 1974).

At the same time, neuroscience searches for the neural correlates of various cognitive processes associated with the self, like self-esteem, self-recognition, self-monitoring, and self-referential processing are investigated and debated (Northoff, 2016; Sui, 2015; Gallagher, 2018). How can we link both philosophical and neuroscientific lines of subjectivity? And what kind of implications does that link carry for our philosophical view of subjectivity? This provides a paradigmatic example of a non-reductive neurophilosophical approach.

Scale-freeness – Brain and self-operate across different timescales with long-range temporal correlations

The brain's spontaneous neural activity can be characterized by different frequencies ranging from infraslow (0.01–0.1 Hz), over slow (0.1–1 Hz), fast (1 – 40 Hz) to ultrafast (40-180 Hz) (Buszaki, 2006). Power is strongest in the infraslow range and decreases across the slow, fast and ultrafast ranges following a power law distribution (Buszaki, 2006; He *et al.,* 2010; Huang *et al.,* 2016; Linkenkaer *et al.,* 2001; He, 2014). Together, the different frequencies and their distinct degrees of power constitute a complex temporal structure in the brain's spontaneous activity which, in large parts, can be featured by the balance between infraslow, slow, and faster frequencies.

The relationship between these frequencies is maintained across different temporal scales and can therefore be characterized by what is described as "scale-free dynamics" (Buszaki, 2006; He *et al.,* 2010; Huang *et al.,* 2016; Linkenkaer *et al.,* 2001; He, 2014). Roughly, scale-free activity describes the fractal (i.e., self-similar) organisation and thus temporal nestedness in the relationship between power and the different frequency ranges: the longer and more powerful slower frequencies nest and contain the shorter and less powerful faster frequencies - this amounts to long-range temporal correlation (LRTC) which operates across different time scales or frequencies providing temporal continuity over time (Buszaki, 2006; He *et al.,* 2010; Huang *et al.,* 2016; Linkenkaer *et al.,* 2001; He, 2014). This makes it clear that we here understand scale-freeness in explicitly temporal terms, that is, in terms of frequencies and their power spectrum.

The brain's scale-freeness with its LRTC is relevant for our self. Recent studies have shown that the brain's scale-free activity is related to mental features such as the self (Huang *et al.,* 2016; Scalabrini, 2017; 2019; Wolff, 2019). These studies show

that the degree of scale-free activity directly predicts: (i) the degree of self-consciousness (as operationalized by the Self-consciousness scale (Huang *et al.,* 2016, Kolvoort *et al.,* 2020); (ii) task-related activity during self-specific stimuli (like animate versus inanimate touch (Scalabrini, 2017; 2019); and (iii) the degree of temporal integration on a psychological level of self-specificity as measured by a matching task where subjects have to associate the own self, non-self or celebrity with a particular geometric shape (Kolvoort *et al.,* 2020).

Given that in all these studies it is the resting state's scale-free activity that correlates with different psychological tasks all probing for self-specificity, we assume that the resting state "scale-freeness" seems to be central in mediating self-specificity and thus, more generally, subjectivity which can thus be featured by LRTC and their temporal continuity.

Neuro-ecological shaping of scale-freeness of brain and self – Point of view

Where and how is the scale-freeness of both brain and self-shaped and constituted? Various studies show that the brain's LRTC are strongly shaped by their respective environmental context. For instance, traumatic life events disrupt the scale-free temporal structure of the brain by decreasing LRTC (Nakao *et al.,* 2013; Duncan *et al.,* 2015). This also affects the self as for instance early traumatic childhood events reduce the LRTC of the self (Scalabrini *et al.,* 2017; 2019; Nakao *et al.,* 2013). This suggests a neuro-ecological background layer with an intimate connection of brain and world to operate as basis and fundament for the scale-freeness of brain and self.

Where and how is such neuro-ecological shaping and background layer possible? One of the most interesting aspects of scale-free activity is its universality. Scale-free activity is not unique to the brain; rather, it is ubiquitous in nature, evident across systems as varied as climate, seismic activity, magnetic fields, and stock markets (He et al., 2010; He, 2014). Basically, wherever irregular fluctuations in activity are observed, LRTC and scale-free activity may provide structure to what initially appears to be random noise.

There is "structure to irregularity," and that seems to be a unifying principle and key feature of nature, that is, of the existence and reality in the natural world. The brain is thus integrated and embedded within the natural world through the share scale-freeness with LRTC: like a smaller Russian doll is integrated within the next larger ones, the brain is embedded and thus nested within the wider and larger world. There is thus an intimate relation of world and brain through their shared scale-freeness with LRTC – this, in turn, provides the neuro-ecological background layer for the self and its subjectivity.

Without being able to fully explicate it, such anchoring of the self within the natural world through its shared scale-freeness and LRTC with the brain provides the basis for the point of view (PV) as put forward by Thomas Nagel: the PV provides us with a vantage point from which we take into view the world while, at the same time, being part of that very same world (Northoff, 2014). Using Nagel's concept of PV, we can now complement it by the empirical characterization namely by its scale-freeness and LRTC as based on the neuro-ecological background layer.

Methodological interlude – Where are we in our iterative neurophilosophical loop?

The neuro-ecological characterization of PV through scale-freeness and LRTC carries major philosophical implications for the notion of subjectivity. We so far conceived the brain and self in most exclusively the empirical domain relying on the observational-experimental method. In other terms, we remained within the bounds of neuroscience. This changes now.

In order to take into view the ontological implications of these empirical findings for subjectivity, we need to shift to the ontological domain: we take into view the scale-

freeness of brain and self no longer within the empirical domain but within the context of the ontological domain. This will be made possible by applying the logical-conceptual method. Hence, one and the same content, i.e., scale-freeness of brain and self, is conceived in the context of different domains, i.e., ontological and empirical, and methods, i.e., logical-conceptual and observational-experimental. This yields a stepwise procedure allowing to connect concepts and fact as outlined in concept-fact iterativity. That shall be demonstrated in the following by the example of subjectivity which is conceived in a non-reductive neurophilosophical way.

Part IV: From the brain's scale-freeness to Heidegger's 'Being in the world' – World-vs subjectivity-based ontology of self

Ontological basis of subjectivity: From Kant over Husserl to Heidegger

Kant introduced a deeper background layer of the subject when distinguishing transcendental and empirical self-consciousness. The transcendental subject was determined mainly in conceptual-logical terms entailing what can be described as "reflective self-consciousness." Husserl went beyond Kant by replacing the latter's transcendental level of the subject by focusing on consciousness and its phenomenal level. The subject could now be determined phenomenally rather than in conceptual-logical terms – this shifted the focus from reflective self-consciousness to pre-reflective self-consciousness (Zahavi, 2005).

We now extend Husserl from the pre-reflective self-consciousness to an even more basic notion of the pre-phenomenal self (Northoff, 2004; 2014; 2018). That is possible by introducing the ecological background layer in addition to the pre-reflective surface layer of the point of view (PV).

The ecological background layer of PV makes it possible to situate and emplace pre-reflective self-consciousness within the context of the world in a necessary (a posteriori) and intrinsic way. Since that is ontologically mediated by the scale-free world-brain relation, this marks the self and its subjectivity as intrinsically neuro-ecological (Northoff, 2018). Importantly, the neuro-ecological character is not experienced as such but provides the necessary condition or predisposition for any possible experience of the self in terms of pre-reflective self-consciousness (which, phenomenologically, is also often described as the minimal self (Zahavi, 2005). For this reason, we designate the neuro-ecological layer of self and its subjectivity as pre-phenomenal rather than either non-phenomenal or pre-reflective. Let us explicate that.

Going deeper and beyond Heidegger's "Fundamental ontology"

Our main claim is that the neuro-ecological layer of self provides the capacity or predisposition for its possible experience in terms of pre-reflective self-consciousness as distinguished from the latter's actual realization. This means that the neuro-ecological level cannot be described by pre-reflective self-consciousness itself, as that would confuse the necessary conditions or predisposition of its possible realization with the sufficient conditions of the self's actual realization. This extends Husserl's phenomenological notion of pre-reflective self-consciousness to an ontological level, namely to a pre-phenomenal self-based on the neuro-ecological background layer of PV and its scale-free nature which, ontologically, is ultimately based on the spatiotemporal features of the world-brain relation.

The presupposed neuro-ecological and ontological level is even deeper and more fundamental than what Heidegger described as *"Fundamental Ontology"* (Heidegger, 1927). Unlike Heidegger, the present approach no longer infers the self from the phenomenological level and its existential extensions like Dasein and Being-in-the-world. Rather than taking the self as the point of departure for characterizing its role and place in the world, the present approach takes a reverse stance: it describes the

world in spatiotemporal and ontological terms which serves as a basis for exploring the ontological similarities between the world and self which, as we postulate, can be found in the temporo-spatial and scale-free features of the point of view and its basis on the world-brain relation.

Accordingly, where Heidegger describes the world in terms of subjectivity (i.e., in existential terms), we, taking a reverse stance, describe the subjectivity of self in ecological terms of the world as featured by scale-free activity and spatiotemporal nestedness and other relationships. Converging both, we tentatively consider the scale-free nesting spatiotemporal relation of world and self through the world-brain relation as a necessary (a posteriori) condition of the kind of world-based subjectivity (i.e., Being-in-the-world) that Heidegger and Sartre describe.

World- vs subjectivity-based ontology of self

The unravelling of a deeper pre-phenomenal, temporo-spatial and neuro-ecological layer of subjectivity of self makes it possible to methodologically extend beyond Heidegger's fundamental ontology. Even though they strive for an ontology of subjectivity in the world, Heidegger still determines subjectivity in dependence on, and in terms of, the concept of subjectivity itself. Specifically, their characterization of the world is still based on the phenomenal and existential features of the self. Methodologically, this amounts to what can be described as 'subjectivity-based ontology of the self in the world'. However, that cannot avoid being methodologically circular, at least to some extent, as here the ontological account of subjectivity in the world is methodologically dependent and based upon itself (i.e., the phenomenal and existential features of subjectivity).

To avoid any such methodological circularity, we require an ontological concept of subjectivity within the world that, methodologically, remains independent of the subjectivity itself (including its phenomenal and existential features) – a 'world-based ontology of self in the world' that must unravel its pre-phenomenal and pre-existential (rather than phenomenal and existential) features.

Our triangular conceptualization of the world-brain relation, point of view, and neuro-ecological self/subjectivity serves exactly that purpose, namely to establish a truly ontological and thereby pre-existential and pre-phenomenal, world-based account of the subjectivity of self within the world. While further developments are necessary, we hope that our combined ontological-empirical non-reductive neurophilosophical approach can avoid the kind of methodological circularities that plague the concept of subjectivity in both past and current philosophy and neuroscience.

World-based ontology of self – Property- vs relation-based Ontology

How could such 'world-based ontology of self' look like? This leads us back to the neuro-ecological background layer itself and the brain's relation to the world. The empirical evidence strongly suggests that the brain is intrinsically embedded and nested within the world through linking its own inner time-space to the outer time-space of the world. This means that the brain's relation to the world is, by definition, temporo-spatial which, ontologically conceived, is based on the existence and reality of time and space within the world itself (given that the brain is part of the world). We consequently require what I recently introduced as "Spatiotemporal Ontology" (Northoff, 2014).

What is Spatiotemporal Ontology? Ontology concerns the existence and reality of the natural world (as distinguished from metaphysics that, in addition to the natural world, also aims to account for the much larger scope of the logical world of which the natural world is just but one subset; (Northoff, 2004; 2014; 2018). Various kinds of ontologies have been assumed mostly property-based ontologies with the

assumption of specific properties or substances like physical or mental. Alternatively, more on the side track of philosophy, more relational forms of ontology have been assumed like process ontology (Whitehead) or relation-based ontology (like in James or recent ontic structural realism) (Northoff, 2014).

Spatiotemporal Ontology - Fundament of "Fundamental ontology" and "Being in the world"

This raises the question whether property- or relation-based ontology are more consistent and thus in accordance with the empirical findings of the scale-freeness of brain, self and world. Given that scale-freeness featured by LRTC is determined by the relation of different frequencies, one may assume temporal relation to provide the underlying ontological substrate. Although not fully explicated here, this renders relation-based ontology more empirically plausible than property-based ontology.

How can we characterize the relation in such relation-based ontology of the natural world? This leads us to time (and space). We demonstrated the example of scale-freeness and LRTC featuring the brain itself and its relationship to the world as basis for the PV and subjectivity. This suggests that the existence and reality of brain and self are based on the existence of time and space in the natural world – we therefore assume that the existence and reality of the natural world is characterized by temporal (and spatial) relation as only those could make possible scale-freeness and LRTC (Northoff, 2014). This amounts to Spatiotemporal Ontology that can be characterized by spatiotemporal relation of different temporal (and spatial) scales, spatiotemporal nestedness with shorter time-space scales being embedded within longer ones, and spatiotemporal directedness from longer to shorter time-space scales.

We now assume that such multi-layered spatiotemporal organisation of the natural world with relation among different spatiotemporal scales provides the ontological foundation of the PV as basis of subjectivity. The PV can be understood as one particular Russian doll nesting and being embedded within a much larger one, the natural world. This is realized empirically be the brain's scale-free neuro-ecological LRTC to the world which, ontologically, provides the basis for subjectivity and its 'being in the world'. Accordingly, the iterative procedure, i.e., concept-fact iterativity of NRNP makes possible to take into view a deeper layer or dimension of what the philosopher Heidegger described as 'fundamental ontology'. The latter can be complemented by "spatiotemporal ontology" on a deeper neuro-ecological layer of the temporal, i.e., scale-free world-brain relation.

Is Spatiotemporal ontology phenomenologically and empirically plausible? Temporo-spatial theory of consciousness (TTC)

We moved from the empirical domain of scale-freeness and investigated its ontological presuppositions; this led us to enrich, broaden and extend Heidegger's "Fundamental ontology" by Spatiotemporal Ontology. One may now be inclined to enter the neurophilosophical iterative loop yet again and move back from the ontological to the phenomenological and ultimately empirical domain.

Is Spatiotemporal ontology phenomenologically and empirically plausible? Is it in accordance with for instance the phenomenon of consciousness and its empirical basis in the brain? This additional methodological step serves two-fold purpose; (i) it will allow to empirically support (not reduce) the ontological assumption of Spatiotemporal ontology associating it with the logical space of nature, i.e., the natural world, rather than exclusively with the logical space of reason, i.e., the logical world (as distinct from the natural world); (ii) it will allow to provide an ontologically valid and consistent empirical and phenomenological view of consciousness and its relation to the brain.

We are now searching for the phenomenological and empirical implications of Spatiotemporal ontology for consciousness and brain. If Spatiotemporal ontology holds, one would expect both consciousness and brain to be ultimately based on spatial, i.e., topographic and temporal, i.e., dynamic features. That is indeed both phenomenologically and empirically plausible. Consciousness is featured by an intrinsic dynamic of subjective time like the "stream of consciousness" as "inner time consciousness" with pretention, retention, and primal presentation. At the same time, there is experience of space in a subjective way, a mental topography accompanying the mental dynamic. Accordingly, characterizing the phenomenology of consciousness including different phenomenal features like transparency, ipseity, qualia, intentionality, etc, in subjective-experiential spatiotemporal terms is realistic and plausible (Northoff, 2014; 2018). One may thus want to speak of a "Spatiotemporal Phenomenology" of consciousness.

How about the brain itself and the neural mechanisms yielding consciousness? The brain itself can be characterized by its inner time and space as distinguished from outer time and space, to borrow the old Kant'ian distinction. Moreover, the brain's inner time and space shapes its perception and cognition including their contents – this led to the concept of "Spatiotemporal Neuroscience" (Northoff *et al.,* 2020; 2020b). Most important. Are the brain's inner time and space, the topography and dynamic of its neural or better neuro-ecological activity also relevant for consciousness and its various phenomenal features? This is exactly is postulated by the Temporo-spatial Theory of consciousness (TTC) (Northoff, 2018; Northoff and Zilio, 2022a).

In a nutshell, the TTC argues that the way the brain constitutes or better constructs its own inner time and space relative to the outer time and space of body and world is key for consciousness. This construction is described by four most basic temporo-spatial mechanisms, temporo-spatial nestedness, alignment, expansion, and globalization; all four mechanisms have received substantial empirical support in recent years (Northoff, 2018; Northoff and Zilio, 2022a; 2022b). The TTC therefore proposes that time and space, i.e., topography and dynamic, are shared by both brain and consciousness as their "common currency" (Northoff *et al.,* 2020; 2020b) which therefore makes possible for neural/neuro-ecological activity to transform into phenomenal features (Northoff and Huang, 2017; Northoff and Zilio, 2022a; 2022b).

Finally, the TTC must be distinguished from other theories of consciousness in neuroscience (Northoff and Zilio, 2022a and 2022b for an overview). Without going into detail, one key feature is that the TTC focuses on the most basic and fundamental non-special features of the brain, e.g., its inner time and space. In contrast, the other theories assume a special feature within the otherwise non-special neural activity to relate to consciousness.

Why are inner time and space non-special? They are just specifications of time and space in general which characterizes the natural world. This points to the deep ontological implications of the TTC which, considering its focus on dynamic and topography, presupposes a relational ontology, that is relation of distinct points in time and space. Such relational ontology, obviously, is proposed by Spatiotemporal ontology. The TTC and its various lines of empirical support may thus provide empirical plausibility and credibility to the ontological domain, i.e., Spatiotemporal ontology.

Conclusion

We introduced neurophilosophy in a particular variant, non-reductive neurophilosophy (NRNP) as distinguished from others like reductive neurophilosophy, parallelism of neuroscience and philosophy, and neurophenomenology. In a first step, we characterized NRNP in its methodological strategy with key features like domain vs method and concept-fact iterativity. These

were then exemplified by the question of subjectivity. NRNP allows us to take into view both empirical and ontological investigation of subjectivity by connecting them into a unified truly neurophilosophical theory.

Converging both empirical data and ontological assumptions, we propose that the deeper neuro-ecological layer of the brain with the world, the world-brain relation, may be key in providing a point of view as basis of subjectivity in the natural world. Since such point of view may be empirically be based on time as in scale-free activity with its Long-range temporal correlation (LRTC), we assume that a corresponding ontology of subjectivity must be based on time and space, i.e., spatiotemporal ontology. Spatiotemporal ontology may provide a deeper layer for Heidegger's "Being in the world" as it complements his subjectivity-based 'Fundamental ontology' by the more world-based Spatiotemporal Ontology.

Spatiotemporal ontology in such world-based way may provide not only a novel approach to subjectivity but also to other philosophical problems like consciousness where it resurfaces empirically in the Temporo-spatial theory of consciousness (TTC) (Northoff and Huang, 2017; Northoff and Zilio, 2022a; 2022b). NRNP can also lead to a broader more comprehensive re-framing of traditional philosophical questions like subjectivity and others like the mind-body problem which then can be reformulated as world-brain problem (Northoff, 2014).

Rather than providing new answer to the set of predefined questions, as it is aimed for in especially current analytical philosophy, NRNP may put into doubt those very same questions and thereby shift or, even more radical, dissolve the problem itself. For instance, NRNP shifts the question for mind-brain relation to the one of world-brain relation as the latter is, following the here postulated neuro-ecological and spatiotemporal approach, the necessary condition of the former – the mind-brain problem can then be dissolved and replaced by the empirically (and ontologically and conceptually) more plausible world-brain problem (Northoff, 2018).

Accordingly, NRNP offers a novel approach to both philosophical and neuroscientific problems by providing a much wider and more comprehensive framework. This is possible by including different domains, i.e., domain pluralism, and methodological strategy, i.e., method pluralism, as well as their intimate connection and linkage, i.e., concept-fact iterativity. That renders possible for NRNP to make substantial contributions to both neuroscience and philosophy by providing a wider and more comprehensive framework beyond their specific domains and particular methodological strategies.

In conclusion, NRNP provides a novel broader perspective on traditional and current philosophical problems like subjectivity, mind-body problem, and consciousness (and various others). Moreover, it allows for re-interpretation and re-framing of historical philosophers like Heidegger, Sartre, Zhangzi, Leibniz, Whitehead, Kant, and Hume. This will allow us not only to take into view these traditional philosophers in a broader framework that extends beyond their original often single domains like ontological, epistemological, or ethical. It may also allow us to shed a new light on current and more systematic problems like mind-brain relationship and the question for consciousness including its neural basis.

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