

REFRAMING TACIT HUMAN– NATURE RELATIONS

AN INQUIRY INTO PROCESS PHILOSOPHY AND
THE PHILOSOPHY OF MICHAEL POLANYI

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<p>This thesis consists of two parts. Part 2, the main part of this thesis, consists of a research article titled 'Reframing Tacit Human–Nature Relations: An Inquiry into Process Philosophy and the Philosophy of Michael Polanyi'. Part 1, respectively, serves the role of a 'Preface' for the article in Part 2, consisting of introductory and commentary sections as well as proposals for further research.</p> <p>The research question of Part 2 follows: how can the theoretical frameworks set by process philosophy and the works of Michael Polanyi be implemented in the fields of environmental policy and philosophy, particularly in drawing a philosophical bridge between the two often bifurcated entities of 'society' and 'environment'? The question relates to ongoing discussion regarding the relation of mental models (or belief systems) to environmental behaviour. Process philosophy, a metaphysical school of thought emphasizing the ontological and epistemological primacy of process (change, dynamics or flux) over substance (things), is shown to have the potential of being a more sustainable metaphysical basis for the interpretation of reality than predominant substance-biased mental models. Potential sustainability benefits of process philosophy can be found in its emphasis of fundamental interconnection between humans and nature, its emphasis of processes over products, its reification of change (such as climate change) and its accentuation of the reciprocal relation between individuals and socio-ecological systems. Moreover, process philosophy is shown to provide a coherent alternative for the divisive constructionist–realist debate, which has resulted in the so-called science wars and subsequent discrepancies between the social and natural sciences. The central arguments are reinforced with a variety of examples, most notably by allegorical use of the coastline paradox.</p> <p>The discussion on process philosophy is then supplemented with the epistemological framework of polymath Michael Polanyi. Polanyi's theory of tacit knowledge suggests as its central notion that we know more than we can tell, and that all knowledge, intellectual knowledge included, is rooted in embodied functions. Polanyi's theoretical framework is then presented to suggest the following question: if all intellectual knowledge is rooted in embodied knowledge, can these tacit frameworks be deliberately changed (nudged) in order to promote more sustainable behaviour? Particularly it is suggested that if both the public and experts tacitly carry embodied substance-biased belief systems, the reframing of these embodied metaphysical frameworks with process-philosophical alternatives could induce more sustainable dwelling. Finally, the theoretical frameworks of process philosophy and Michael Polanyi's epistemology are shown to provide together an interesting prospect in the design of sustainable mental models and thus contribute to the design of both educational and political instruments.</p> <p>Part 1 serves the role of an introduction to the topics of Part 2, presenting also a commentary section to ease the interpretation of some of the more challenging themes covered in the research article. Moreover, a plan for subsequent research is proposed, extending the research framework to touch upon the fields of ecological psychology and theories of embodied cognition, as well as providing an outlook on potential empirical studies on the relations between mental models and environmental behaviour.</p>			
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<p>Tämä pro gradu -tutkielma on kaksiosainen. Jälkimmäinen osa (Part 2) on tutkielman pääosa, itsenäinen tutkimusartikkeli nimeltään ”Reframing Tacit Human–Nature Relations: An Inquiry into Process Philosophy and the Philosophy of Michael Polanyi”. Ensimmäinen osa (Part 1) puolestaan on johdantoluku toiselle osalle, ja sisältää johdannon lisäksi myös kommentaariosion sekä tutkimussuunnitelman jatkotutkimusta varten.</p> <p>Tutkielman tutkimuskysymys seuraa: miten prosessifilosofiaa ja Michael Polanyin filosofiaa voidaan hyödyntää ympäristöpolitiikassa ja -filosofiassa? Tarkemmin muotoillen miten kyseiset filosofiset kehikot luovat teoreettisen sillan toisistaan erheellisesti haarautuneiden käsitteiden, ympäristön ja yhteiskunnan, välille? Kysymykset liittyvät suoraan ajankohtaiseen keskusteluun ympäristöajatusmallien ja ympäristökäyttämisen yhteyksistä. Prosessifilosofia on filosofinen suuntaus, joka painottaa prosessin (eli muutoksen ja dynamiikan) ontologista ja episteemistä asemaa. Tässä tutkielmassa esitetään, että prosessifilosofia on mahdollisesti kestävämpi ja ympäristöystävällisempi perusta ympäristöajatusmalleille kuin useimmiten vallitsevat substanssifilosofiset vaihtoehdot. Prosessifilosofian ympäristöystävällisyys juontuu esimerkiksi sen asettamasta perusteellisesta yhteydestä ihmisen ja luonnon välille, sen painotuksesta prosesseihin tuotteiden (eli substanssien) sijaan ja sen korostamasta vastavuoroisuudesta yksilön ja sosioekologisen systeemin välillä. Lisäksi prosessifilosofian esitetään tarjoavan koherentin vaihtoehdon konstruktionimi–realismi-debatille, joka on muun muassa luonut eripuraa pehmeiden ja kovien tieteiden välille ja täten hankaloittanut poikkitieteellistä vuorovaikutusta. Prosessifilosofisia argumentteja tuetaan tutkielmassa lukuisin esimerkein eritoten rantaviivaparadoksia allegorisesti hyödyntäen.</p> <p>Keskustelua prosessifilosofiasta täydennetään yleisnero Michael Polanyin filosofialla. Polanyi esittää teoriallaan hiljaisesta tiedosta, että tiedämme enemmän kuin osaamme eksplisiittisesti ilmaista ja että kaikki tieto (myös intellektuelli ja rationaalinen tieto) on kehollisten funktioiden tuotosta. Polanyin teoreettista kehikkoa seuraa keskeinen ympäristöpoliittinen kysymys: jos kaikki tieto on kehollista ja peräisin eksplisiittisesti tiedostamattomista lähteistä, voisiko tiedon hiljaisten kehysten muokkaaminen (eli tuuppaaminen) johtaa ympäristöystävällisempään käyttäytymiseen? Tarkemmin ottaen jos sekä maallikot että asiantuntijat omaavat hiljaisia substanssipainotteisia ajatusmalleja ja uskomuksia, voidaanko näitä ajatusmalleja kehystää uudelleen prosessifilosofisilla malleilla ja täten edistää kestävää olemassaoloa? Lopuksi prosessifilosofian ja Polanyin epistemologian esitetään olevan yhdessä mielenkiintoinen ja instrumentaalinen teoriakehikko kestävien ajatusmallien kehittämisessä niin opetuksellisessa kuin poliittisessakin kontekstissa.</p> <p>Tutkielman ensimmäinen osa (Part 1) toimii johdantolukuna toisen osan (Part 2) teemoille, kommentoiden tutkielman toisen osan haastavampia teoreettisia kokonaisuuksia ja täten helpottaen näiden tulkintaa. Lisäksi ensimmäisessä osassa esitetään teemoja jatkotutkimukselle, johon etsitään vaikutteita muun muassa ekologisesta psykologiasta sekä kognitiotieteistä. Jatkotutkimussuunnitelmassa esitetään myös yleiskatsaus tutkielman teoreettisen kehikon laajentamismahdollisuuksista empiiriseen tutkimukseen ja erityisesti ajatusmallien ja ympäristökäyttämisen yhteyden todentamiseen.</p>		
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Part 1: Preface

1 Introduction

1.1 Structure

This Master's thesis (pro gradu) consists of two parts. This first part (Part 1: Preface) provides a brief introduction, a commentary overview and a plan for further research on the topics of the second and main part (Part 2: Reframing Tacit Human–Nature Relations: An Inquiry into Process Philosophy and the Philosophy of Michael Polanyi), which respectably consists of a standalone journal article submitted for peer-reviewing (as of 3/2016) to the international journal *Environmental Values*¹. Therefore, as a disclaimer here at the very beginning of this thesis, it is worth noting that this thesis shall quite drastically differ from the traditional Master's thesis model (i.e. IMRD; Introduction, Methods, Research and Discussion) of the Faculty of Social Sciences at the University of Helsinki.

This introductory Preface consists of three main sections. Firstly (in Section 1 of Part 1), I shall explicate the research question of the article in Part 2 and provide an overview of its contextual framework and schema. Second (Section 2 of Part 1), I shall provide an introductory chapter to the two main sections of the research article and one by one follow through its central arguments. Third (Section 3 of Part 1), and perhaps most importantly, I shall set a framework for further research development in relation to the topic of this thesis. These three sections serve the double-purpose of one the one hand providing both the theoretical and contextual basis for interpreting the journal article, particularly for a reader unacquainted with the addressed topics, as well as on the other hand presenting some basic arguments and discussion which unfortunately had to be omitted from the journal article, mainly due to the word limit set by *Environmental Values*.

¹ White Horse Press, limited access online: <http://www.whp-journals.co.uk/EV.html> (Accessed 7.3.2016). *Environmental Values* is fully accessible via the electronic Nelli portal of the University of Helsinki.

1.2 Research Questions

The journal article presented in Part 2 is to be read as a discussion opener in presenting the prospects of interpreting process philosophy and the theoretical works of Michael Polanyi in the light of environmental policy and philosophy. Thus the primary research question of the journal article follows: how can the theoretical frameworks set by process philosophy and the works of Michael Polanyi be implemented in the fields of environmental policy and philosophy, particularly in drawing a philosophical bridge between the two often bifurcated entities of ‘society’ and ‘environment’? The topic is particularly interesting due the fact that the two theoretical frameworks involved, process philosophy (e.g. Rescher, 1996; 2000, Whitehead, 1948; 1967; 1978, Dewey, 1958; Stengers, 2011; Mesle, 2008) and Polanyi’s (1969; 1974; 2009) epistemology, seem to have had very scarce applications in the environmental sciences².

However, it is notable that the primary research question provides a fundamental framework for a variety of secondary research questions. Firstly, a core issue I address with particular detail (in Section 2 of Part 2) is the question of how a substance-biased metaphysical worldview might carry with it some drastically environmentally pathological by-products, and how a process-philosophical alternative might have the potential for a more sustainable cognitive framework. Second (in Section 3 of Part 2), I raise the question of how these metaphysical convictions are not necessarily rational products of the human mind, but deeply embedded and embodied tacit presumptions which we are habituated to through socio-ecological processes. These two secondary research questions give rise to a third question, which is significantly more politically-laden: if we carry with us environmentally pathological tacit mental models, to what extent is it a political responsibility to deliberately change, or ‘nudge’, these mental models? Moreover, I briefly address the issue of what could be the political or educational means of achieving this nudge. This third question is addressed in the final section of the

² Although I acknowledge that philosopher Arran Gare (e.g. 1996) has written on the relations between process philosophy and environmental studies. Moreover, Aligica and Tarko (2012) suggest that Nobel laureate Elinor Ostrom, a particularly influential figure in the fields of environmental policy and economics, has been influenced by the economically oriented works of Michael Polanyi. Polanyi’s work on economics, however, differ significantly from his later epistemological and philosophical phase which I make most use of. It also seems that this influence has not survived to affect the post-Ostrom generation, and Polanyi’s works today generally serve the role of an interesting footnote on (an often misrepresented form of) tacit knowledge (Nye, 2011). Regardless, neither of the two theoretical frameworks (process philosophy and Polanyi’s epistemology) present mainstream approaches in environmental studies.

journal article, and sets the framework for further development in related research (also addressed below in Section 3 of Part 1).

1.3 Contextual Framework

As has already been mentioned above, the journal article presented below (Part 2) is designed in accordance with the format, requirements and guidelines of the international peer-reviewed journal *Environmental Values*. The journal describes their objective as follows:

‘Environmental Values is an international peer-reviewed journal that brings together contributions from philosophy, economics, politics, sociology, geography, anthropology, ecology and other disciplines, which relate to the present and future environment of human beings and other species. In doing so we aim to clarify the relationship between practical policy issues and more fundamental underlying principles or assumptions.’ (Source, White Horse Press: <http://www.whp-journals.co.uk/EV.html>. Accessed 1/2016.)

In compliance, the article below both clarifies some of the ‘fundamental underlying principles or assumptions’ of environmentally oriented action as well as addresses the ‘practical policy issues’ of how these fundamental principles could be utilised in political context. Hence the article should be read as a theoretical approach on practical policy implementations. The target audience of the article is therefore designed to consist primarily of environment-oriented policy makers and designers as well as environmental philosophers and scientists, although I expect the text to be wholly comprehensible – and moreover, interesting – to the more casual reader (this is also in accordance with the journal’s guidelines). Also, since *Environmental Values* emphasizes cognizance and familiarity with current ongoing debate in the journal, I have made numerous references (Honig et al., 2015; Hukkinen, forthcoming; Richardson et al., 2015; Shahar, 2015) to recent (as of 3/2016) articles published in the journal and set the article in the context of current discussion within the journals publications.

Furthermore, the article in Part 2 also makes numerous references to the work of Hukkinen (2012; 2014; forthcoming; Antal and Hukkinen, 2010), and the article can in many respects be regarded a commentary on these works. Hukkinen's recent work has primarily been involved with merging insights from the cognitive sciences (primarily theories of 'embodied cognition') to the field of environmental policy. Essentially, the aim here is to develop sustainable mental models with the premise that all thought is physically grounded (hence 'embodied'), thus implying that the deliberate nudging of human thought models or belief networks might result in altered environmental behaviour. Nudging, in the context of this thesis, shall refer to the political act of constructing a sustainable 'architecture' (Thaler and Sunstein, 2009) of thought via the design of 'cognitively attractive and empirically sound mental models that have the capacity to alter people's behaviour toward socio-ecologically sustainable transitions' (Hukkinen, 2012: 2). Accordingly, what I propose in the article below is that many of the most environmentally pathological mental models arise from tacitly (i.e. implicitly) habituated metaphysical frameworks, and that nudging these tacit mental frameworks with ecologically sustainable process-philosophical alternatives might result in more sustainable and environmentally sound behaviour. Thus, despite a differing theoretical starting point from Hukkinen's, I also locate the article below as taking part in the 'cognitive war to save the planet' (Antal and Hukkinen, 2010).

1.4 Methodology and Literature

Since the thesis at hand is by nature theoretical, no methodological school or procedure is strictly adhered to. However, the methodical basis of this thesis consists of a comprehensive review of a large variety of multi- and interdisciplinary philosophical and political literature. The literary style of the article is essayistic, using a range of ontological and epistemological arguments as well as philosophical paradoxes in order to thoroughly reinterpret and reframe some of the most fundamental philosophical themes found in multidisciplinary environmental studies. The majority of the philosophical arguments presented in Section 2 of Part 2 draw particular influence from philosopher of science Nicholas Rescher (1996; 2000), whose work compiles concisely some of the most comprehensive arguments in support of the philosophical school known as 'process

philosophy'³. Other major works drawn particularly noteworthy influence from are by pragmatist philosopher-psychologist John Dewey (1958), philosopher-anthropologist Bruno Latour (1991) and the father figure of process philosophy, mathematician-philosopher Alfred North Whitehead (1948; 1967; 1978). I also borrow economist and philosopher Amartya Sen's (1995) terminology to address some practical issues related to the theoretical and practical limits of exact definition.

The work of Hungarian-British polymath⁴ Michael Polanyi (1969; 1974; 2009) provides the theoretical frame for the analysis of the 'tacit' or 'personal' nature of knowledge in Section 3 of Part 2. Here most prominent is Polanyi's *magnum opus*, the seminal work *Personal Knowledge: Towards a Post-Critical Philosophy* (1974). Much use is also made of Polanyi's comprehensive posthumous essay collection *Knowing and Being* (1969), as well as of his perhaps most accessible work, *The Tacit Dimension* (2009).

Together the set of literature found in the bibliography of this thesis shall be shown to provide a philosophical and theoretical basis for reinterpreting philosophical bifurcations⁵ such as human–nature, subject–object, realism–constructionism and mind–body⁶. Each theoretician mentioned above, among a large variety of others, can be interpreted to

³ This is not, however, to say that German-American philosopher Nicholas Rescher's work is limited to process philosophy. Rescher's lifetime work spans a total of over 100 published books and over 400 articles, touching upon a variety of themes such as pragmatism, (Arabic) logic, metaphysics, philosophy of science, the theoretical limits of scientific inquiry (e.g. Rescher, 1984) and the plausibility of a 'theory of everything'. Given that, regardless, Rescher is not an oft-cited figure outside of the philosophy of science, I also justify my extensive use of his work in this thesis as a means of bringing his work forth towards the environmental and social sciences.

⁴ Michael Polanyi's fascinating work influenced the fields of physical chemistry, economics, philosophy, the social sciences, even touching upon psychology and the then only emerging fields of cognitive science and artificial intelligence. Polanyi could thus be a significant interdisciplinary role model for environmentalists seeking to combine the 'hard' and 'soft' sciences. Also worth mentioning is that Michael Polanyi has perhaps unknowingly had significant second-hand influence on a diverse account of scientists: social scientists, historians and economists might be particularly quaint with brother Karl Polanyi (particularly *The Great Transformation*; 1971) and niece Emerita-professor Kari Polanyi-Levitt; chemists might be particularly familiar with Michael Polanyi's son, chemist and Nobel laureate John Polanyi. Michael Polanyi's students Eugene Wigner (who also was a dear friend of Polanyi's) and John Calvin also went on to win Nobel prizes in physics and chemistry, respectively. See Nye (2011) for a captivating biography (and socio-political history) of Michael Polanyi.

⁵ Although the term 'bifurcation' (stemming from the Latin noun *furca*, or fork) might seem somewhat cumbersome and odd to the tongue, I use this term instead of the more common 'dualism' for two main reasons. Firstly, the noun 'bifurcation' is adapted to a verb, 'bifurcate', and thus tacitly implies action and intent. It does not therefore imply that an ontological order of 'dualism' exists irrespective of action, and instead suggests that any bifurcated entities are, on a fundamental level, ontologically connected (as are the tines or prongs of a fork). Second, the concept of 'bifurcation' is in many respects a part of the standard process-philosophical lingo, and is adopted from major figures such as Whitehead and Rescher.

⁶ This list could go on to include realism–idealism, primary and secondary qualities, subjectivity and objectivity as well as transcendence–immanence (the last one being the bifurcation that once spurred the famous Popper–Kuhn debate, significantly influencing the philosophy of science and consequently fuelling the 'science wars'; see Fuller, 2003).

contribute towards a unificatory philosophical framework dubbed ‘process philosophy’, which I present in the article in Part 2. Moreover, what I believe is particularly interesting about the mixture of thinkers and philosophers involved is the fact that many of the figures mentioned or cited in this thesis are either directly or indirectly influenced by each other. Out of interest, and since these intellectual relations are yet unstudied, I have provided in the Appendix (at the very end of this thesis) a comprehensive chart (Chart 1: Mapping Intellectual Relations) with notes to illustrate and describe some of these philosophical and theoretical connections and overlappings.

2 Commentary

The article in Part 2 consists of an introductory section (Section 1), two main sections forming the body of the article (Sections 2 and 3) as well as a conclusory section (Section 4). I shall now set to provide a brief introduction to both of the main sections in Part 2 in order facilitate the interpretation of the central arguments presented in the article, and later carry on to argue how these insights might relate to future inquiries in environmental studies.

2.1 Process Philosophy

In Section 2 of Part 2 I challenge some prevalent environment-oriented metaphysical conceptions in order to reframe them with more environmentally sound alternatives. Particularly, I propose in this section that the relatively simple assertion that all ‘things’ are more fundamentally described, on the ontological level, as ‘process’ (i.e. change, dynamism, flux or temporality) rather than ‘substance’ has the potential to promote more sustainable thinking and thus also sustainable behaviour. Rather than bifurcate things from their doings, surroundings or features, a process-philosophical standpoint supports a one-tier ontology where things *are what they do*⁷ (Whitehead, 1967: 157) and are co-constructed (i.e. both construct and are constructed by) their environmental and systemic counterparts. For example, as I suggest in Section 2.3 of Part 2 (see Table 2: Processual Reframing of Environmentally Pathological Substance-Bias, p. 28), running the

⁷ This is, of course, analogous to C.S. Peirce’s (1878: 293) classic ‘pragmatic maxim’: ‘Consider what effects, that might conceivably have practical bearings, we conceive the object of our conception to have. Then, our conception of these effects is the whole of our conception of the object.’

‘conceptual blend’ (Fauconnier and Turner, 2002) of ‘things as process’ could be helpful in the cognitive task of environmentally sustainable product consumption (i.e. by reifying the notion of the dynamic life-circle of an only seemingly static product) and help us understand seemingly non-substantial, slow and nonlocal processes such as climate change. A process-philosophical approach can also aid us in developing a reciprocal understanding of individual–system relations, thus facilitating the process of locating the human within the socio-ecological system.

Moreover, this ontological overhaul can also provide a steady alternative for the constructionist-realist debate (the ‘science wars’; Gould, 2000) within the philosophy of science and thus aid interdisciplinary discussion related to multidisciplinary ‘hybrid’ phenomena such as, I reiterate, climate change (Latour, 1991). This is, of course, quite a radical departure from what is often taken to be ‘Western’ (in deliberate scare quotes, this shall be addressed with more detail below) or Cartesian substance-biased metaphysics, although I present briefly in Section 2.1 of Part 2 that process-relational ideas have had a steady foothold within a minority circle of thinkers, mainly within the fields of pragmatism and philosophy of science. I have also gathered the central ontological and epistemological tenets of process philosophy (adopted from Rescher, 1996; 2000) in comparison with substance philosophy in a helpful and concise table (Table 1: Ontological or Epistemological Primacy, p. 23).

I go on to problematize in Section 2.4 of Part 2 in particular the bifurcation between humans and the environment by using the coastline paradox as an allegorical thought-experiment. The main arguments of this section follow: I suggest that the border between human and environment is always suspect to incomplete definition and thus is necessarily an incomplete and pragmatic measure (and is thus always suspect to degrees of arbitration and value-ladenness). In other words, there is no reasonable way to completely define where ‘human’ ends and ‘environment’ begins, and thus humans should rather locate themselves within the process of nature as a whole. Consequently, I criticize individualist notions of a human-versus-nature dichotomy, and rather support a more ecological notion of the individual as fundamentally embedded and situated in nature. Moreover, I suggest that the claim that all things are processual by nature can help us, *inter alia*, to further understand a variety of plastic and gradient ‘things’ (or rather, processes) such as equality, gender, identity, species and ethnicity.

2.2 Tacit Knowledge

Section 3 of Part 2 deals more specifically with the work of Michael Polanyi (1969; 1974; 2009). Complementary to the ontological emphasis of Section 2 of Part 2, this section is largely epistemological by nature, and particularly deals with the relationship between the ‘knower’ and the ‘known’, or in other words, the ‘process of knowing’ (Polanyi, 1969). The main argument here is, in all its (perhaps deceitful) simplicity, that ‘we know more than we can tell’ explicitly, and that the ‘tacit’ (implicit or unspoken) dimension of knowledge is a feat of all knowing, both physical skills and intellectual endeavours included (Polanyi, 1969; 1974; 2009). Whilst I devote a significant amount of this section to elucidate these points through philosophical arguments and practical examples (this is particularly necessary since, again, Polanyi does not represent a major or dominant strain of thought in Western epistemology⁸), the major assertions can be summed up here in a rather brief space.

Since we know more than we can tell, we also carry with us significant feats of tacit knowledge – I refer to these as tacit ‘metaphysical frameworks’ or ‘belief systems’ – which we (mostly) unknowingly embody through a mixture of, for example, socio-cultural, biological (or evolutionary) and habitual factors, and which shape how we explicitly attend to, and thus dwell in, the world. Since we all carry with us tacit metaphysical convictions, in some respect every person is an active philosopher in their everyday life, with the caveat that for most these metaphysical judgments are ‘tacit’, ‘unconscious’ and ‘habitual’ (Polanyi, 2009; Dewey, 1958). However, given the prominent role of these convictions and judgments in shaping morally-laden environmental behaviour, I suggest that the fields of environmental policy and philosophy look more dedicatedly into these tacit belief systems and particularly address the issue of changing environmentally oriented behaviour through the deliberate nudging of tacit mental models. Since I have already established that substance-biased metaphysical frameworks are potentially more environmentally pathological than process-biased ones, I particularly suggest that nudging mental models towards process-biased models could result in more sustainable behaviour. This, essentially, sets the scene for the discussion in the final section of Part 2 (Section 4, ‘Conclusion and Discussion’), where I particularly

⁸ Although as I argue below, Polanyi’s theories of knowledge can be in many respects interpreted to resemble theories of ‘embodied cognition’ (e.g. Lakoff and Johnson, 1999; Fauconnier and Turner, 2002), which can be regarded to be widely influential in the cognitive sciences, AI research, psychology and philosophy.

address the political and educational dimensions related to the issue of nudging mental models.

3 Further Research

Whilst, as has been noted, the article below is by nature largely theoretical, there seems to be no fundamental reason to dismiss the possibility of expanding its fundamental insights into empirical inquiry. In Section 4 of Part 2 I sketch out a concise overview on how the nudging of mental models by repetitive use process-biased metaphor in educational and political context might be helpful in developing more environmentally sound belief systems. However, at this point such claims remain largely debatable, and concrete empirical evidence is required for the further design of process-biased policy tools. In principle, the relationship between tacitly held metaphysical belief systems (or mental models) and environmental behaviour is testable, although a full-blown empirical (quantitative or qualitative) research framework is undeniably suspect to some major challenges. Regardless, moving towards empirical methods would provide a means for overcoming the all too often present disengagement between theory and evidence that plagues the social sciences in particular (Slingerland, 2008).

I shall address now some central ideas on how to expand the research framework set by the article in Part 2, starting from theoretical issues and gradually moving into analysis of the prospects of empirical research. These ideas shall also set a framework for a set of future research articles, and serve the double-purpose of a preliminary research plan for my personal doctoral studies. Since there was much that had to be left out of the article in Part 2 due to length restrictions, the theoretical arguments presented in this section also serve a reflective role of how the article could have been extended if it weren't for the word limit, whilst also providing precautionary countermeasures for potential points of critique.

3.1 Theoretical Extension

3.1.1 Towards an Ecological Psychology: On Anthropocentrism and Value

Firstly, the theoretical and philosophical basis of the article in Part 2 must be extended to touch upon some central concerns left yet unarticulated, namely those related to ‘anthropocentrism’ and ‘value’. The issue of anthropocentrism is more or less unavoidable from a process-philosophical perspective (or rather, from any philosophical perspective aiming to overcome the subject–object bifurcation), and thus requires serious analysis. The main problem is as follows: if humans are to be located within the process of nature, to what extent does this blurring of human–nature borders imply anthropocentrism, and moreover, to what measure can humans extend their respective value-frameworks to the natural world?⁹ I believe, however, that a pragmatic resolution can be found in an ‘ecological’ approach influenced by a blend of ecological psychology (e.g. Heft, 2001; Gibson, 1979; Rolston, 1983) and process philosophy¹⁰. The major flaw with the argument ‘process philosophy is anthropocentric’, I believe, is related to what I call the ‘double-edged blade’ of anthropocentrism. Briefly stated, the paradoxical double-edge follows:

- I. Attaching human, socially constructed, value to nature is anthropocentric, in that the ‘*ánthrōpos*’ (human) is at the ‘*kéntron*’ (centre) of the valuing process (see e.g. Cudworth, 2003 for a concise overview on these constructionist perspectives).
- II. However, the human being itself is embedded in the wider ecological evolutionary process. If humans experience and judge value, and are by necessity part of the same ecological process as the rest of the natural world, is it not also anthropocentric to wholly deny the outside natural world of value?

⁹ This is, for example, a central issue in Andy Clark’s and David Chalmers’ (1998) theory of ‘extended cognition’, particularly relating to the question of where ‘mind’ or ‘consciousness’ ends and the ‘environment’ begins. The only way out of anthropocentric ‘panpsychism’ (cf. Nagel, 2011), it seems, is a theory adhering to the gradual ‘emergence’ of consciousness from complex environment–animal relations (Heft, 2001). In other words, cognitive processes exist in an innumerable variety of hierarchical *degrees*, most of which cannot be considered ‘conscious’ on human standards.

¹⁰ This blend of theoretical frameworks comes naturally as James Jerome Gibson, the pioneer of ecological psychology, was strongly influenced by pragmatist and ‘processist’ (Rescher, 1996) William James (as well as James’ student Edwin B. Holt) (Heft, 2001). However, for reasons unknown, Gibson has not to my knowledge been explicitly regarded a ‘process philosopher’.

It seems then that even if valuing nature is anthropocentric, it is at the least equally anthropocentric to deny the natural world of value. However, this seemingly paradoxical ‘Catch-22’ (Heller, 2011) or ‘double bind’ (Bateson, 1977) – a situation in which one is labelled, often pejoratively, as anthropocentric regardless of what they adhere or object to – can be scrutinized through an ecological reframing. If we were to take value not to be a substance in itself, but rather an ecological process emerging from nature, it is possible to locate varying degrees of value in both the human and the external natural world. Value then, is neither a pure social construct nor a natural object, but rather emerges from the interplay and reciprocal interconnection between the observer and the observed within a natural field (i.e. the environment) (see e.g. the concept of ‘Ecological Valuation’ in Rolston, 1983: 147). If perceiving is a ‘process by which animals remain functionally adapted to the environment’ (Heft, 2001: 78), the process of valuation is wholly ‘natural’ and inherent to an adaptive ecosystem.

In psychologist James J. Gibson’s (1979) terminology, in animal–environment relations the structure of nature provides meaningful ‘affordances’ (perceived functional opportunities) for valuation to which animate actors react accordingly to their cognitive capabilities and apparatuses (Heft, 2001). The environment can thus be considered to have an ‘active role’ in ‘driving cognitive processes’ (i.e. ‘active externalism’), valuation processes included (Clark and Chalmers, 1998). Of course, the degree of perceived or experienced value is inherently dependent on the ‘emergent’ (see e.g. Polanyi, 1974; Kauffman, 1995) and ‘autopoietic’ (Maturana and Varela, 1980) status of the observer, that is, the unique and novel cognitive apparatuses that emerge from the natural process of evolution. In this frame of interactivity between humans and nature, there is little room for clear-cut dogma of what counts as the domain ‘in the organism’ as opposed to ‘outside the organism’ (Heft, 2001). Hence any accusations of anthropocentrism should always come with a fundamental caveat that all anthropocentrism is, in fact, embedded in a wider ecological process. Although humans do value nature in a variety of degrees, it is important to acknowledge that nature itself affords these valuations – from an ecological-processual perspective, no pure dichotomy of anthropocentric and non-anthropocentric exists, and defining what counts as human valuation will always remain suspect to pragmatic consideration. As I allude to in Section 2.4 of Part 2 (in relation to the coastline paradox), once reframed with processual metaphor, these categorical problems of defining where ‘human’ ends and ‘nature’ begins do not necessarily disappear as such,

but importantly they *do* appear within a different framework (or Gestalt) where they are not considered to be fundamentally problematic, and are rather related to questions of pragmatic limitation.

Whilst further discussing these questions related to anthropocentrism and value is certainly a daunting task, the problematic question of anthropocentrism seems to be unavoidable and is best taken head-to-head in future inquiry. This is especially the case since the issue of anthropocentrism relates more widely to central questions in environmental management, namely to the extent of responsibilities that humans' respective emergent status endows them with (Lee, 1993). In other words, to extend the discussion on anthropocentrism and value to questions such as 'do natural reservoirs have intrinsic value' and 'to what extent can humans value or manage the natural environment' could prove to be a rewarding field for process-philosophical and ecological-psychological implementation.

Moreover, given that the problems of anthropocentrism and valuing of nature seem to plague laypeople (and even experts) with uncomfortable and often unsustainable double binds, reframing these issues with more sustainable alternatives seems a reasonable political task. In other words, if we are simultaneously brought up in an environment ridden with double binds where A. nature is not to be valued by human-scale arbitrariness (due to principles of impersonal objectivity), B. nature however is valued by human-scale arbitrariness (due to evolutionary adaptation, ecological interrelatedness and the social construction of knowledge) and C. nature should be taken to be valuable (to ensure future existence), how is the layperson to deal with the resulting cognitive dissonance¹¹ without reverting to a potentially unsustainable 'moral inversion'¹² (Polanyi, 1978; 2009), where natural value is simultaneously explicitly denied and tacitly experienced?¹³ If a thorough metaphysical reframing could prevent any of this mental dissonance and internal

¹¹ 'Cognitive dissonance' refers to the inharmonious relationship between two (or more) contradictory attitudes held simultaneously (Festinger, 1957).

¹² Polanyi's (1978; 2009) concept of the 'moral inversion' implies a phenomena in which the existence 'morality' is denied with hidden 'moral passions' (i.e. simultaneous nihilism and value-laden rhetoric; this is, according to Polanyi, a central feature of totalitarian rhetoric).

¹³ This is particularly evident in discussion related to the ethics and ecology of livestock production: despite (B.) our 'tacit' intuitions telling us we are dealing with sentient and conscious beings and (C.) rational knowledge supporting ethical and ecological reasoning for alternative action, the (A.) Cartesian notion that humans are not comparable to other sentient beings and should act with according dominance seems to have won the battle of cognitive dissonance and maintains its prominent foothold in public discourse. For such reasons, finding a reframed cognitively pleasing and intuitive alternative to these myriads of double binds seems more than urgent.

inconsistency – or in Albert Camus’ (1967: 15) terminology, ‘part time nihilism’ – it would certainly be worth the effort.

3.1.2 Embodied Cognition Approaches

Moreover, subsequent research on the relation between mental models and environmental behaviour should look with more detail into the cognitive sciences and particularly the school of ‘embodied cognition’ (e.g. Lakoff and Johnson, 1999; Fauconnier and Turner, 2002). Common to theories of embodied cognition is the central notion that human cognition ‘is inextractibly grounded in and structured by the body and its sensory-motor systems’ and ‘bound up with embodied *action* in the world’ (Slingerland, 2008: 11–12). Of course, to relate Polanyi’s (1969: 214) theory of embodied ‘tacit’ (or ‘personal’) knowledge (i.e. that ‘all our conscious transactions with the world involve our subsidiary use of our body’) to the aforementioned definition of embodied cognition comes naturally, and a comparative approach between the two theoretical frameworks could prove to be a fruitful ground for analysis. Moreover, the priority of ‘action’ and interrelatedness found in process philosophy seems to relate very naturally to the emphasis on ‘embodied *action* in the world’ found in embodied cognition theories. However, although I have drawn references to embodied cognition theories in the article in Part 2, they mainly serve the role of supplementary discussion. A more thorough inquiry could, for example, study further the role of ‘primary metaphors’ (embodied ‘analogue image schemas’ that ‘serve as primary tools for reasoning about ourselves and the world’) in forming substance-biased tacit metaphysical frameworks (Slingerland, 2008: 21; Lakoff and Johnson, 1999).

Particularly, an embodied cognition perspective on process philosophy should consider the evolutionary history of the ‘Cartesian’ substance-bias, which seemingly has evolved as a useful and fast heuristic for interpreting the environment, and has thus facilitated surviving in a hazardous and contingent environment (Dennett, 1991). Indeed, what I do not perhaps address with sufficient detail (much due to the aforementioned word-limit restrictions) in the article in Part 2 is that whilst this substance-bias is often framed a ‘Western’ (e.g. Rescher, 1996; 2000; Whitehead, 1978) or ‘modern’ (Latour, 1991) issue, there is sufficient reason to believe that the tendency for bifurcation or dualism is, at least

to some extent, common to all human beings¹⁴ regardless of culture, time or *Zeitgeist* and has its roots in evolutionary adaptation (see e.g. Slingerland, 2008 and Dennett, 1991 for related discussion)¹⁵. Since the evolutionary usefulness of this trait, it seems, has somewhat backfired (particularly due to the existential risk posed by unsustainable human–nature relations), it seems increasingly important to provide a detailed overview of how these evolutionary features might, or rather should (as a means of survival), be nudged through political or educational means (see Hukkinen, 2012 for discussion on ‘nudging evolution’).

This should not, however, be taken to imply that due to biological prescriptions, changing prevalent metaphysical models is somehow impossible (although it must be humbly acknowledged that this might make the political task significantly more complicated). As I suggest in Section 2 of Part 2, evolution itself is best described an ever changing dynamic and adaptive *process*, and thus nudging evolution is not an impossible task at all (indeed, the notion that cultural memes, tools and artifacts play a Lamarckian role in shaping evolution is well documented; Heft, 2001: 347). Or rephrased in the Humean tradition, that evolutionary features *are* does not imply that they necessarily *ought to be* so¹⁶. This is also akin to the pragmatist notion of ‘meliorism’: since change and novelty are inherent to the universe, nature itself is malleable and can be changed for the better. Conclusively, whilst I do note in the article below that the tendency for cognitive bifurcation is both a social and biological feature of human beings, a deeper dive into the cognitive sciences seems a natural direction in which to further continue these arguments and lines of thought. Even more so, a textual interplay between social and cognitive sciences would be complementary towards the current urge for more interdisciplinary discussion between the so-called ‘soft’ and ‘hard’ sciences, and thus take part in providing

¹⁴ In this respect, contra Latour (1991), we (humans) *have* always been ‘modern’ (although to various degrees, and some cultures less than others), even if Latour’s ontological statement that *nature* as a whole has ‘never been modern’ still holds.

¹⁵ For these reasons, I prefer to adopt Rescher’s (1996; 2000) term ‘substantialist’ (or ‘substance-biased’) to describe ‘Cartesian’ metaphysics, instead of referring to these tendencies as ‘Western’.

¹⁶ Indeed, one could take this argument to evolutionary food consumption patterns: that high energy nutritional sources (e.g. fats and sugars) cause addiction is undeniably a consequence of evolutionary adaptation. However, this does not imply that educational or political means to nudge such behavioural habits would be either impossible or unwarranted. In fact, the case is quite the opposite, and the nudging of food consumption patterns is a regular tool in social epidemiology policies (take, for example, the internationally significant North Karelia Project in Eastern Finland; Laaksonen and Silventoinen, 2011). In other words, that a phenomena is ‘evolutionary’ does not imply biological determinism or political incapacity.

a more peaceful and reciprocal resolution in overcoming the ‘science wars’ (Gould, 2000; Slingerland, 2008).

3.2 Empirical Extension

A theoretical expansion should not only elucidate the arguments already presented in Part 2, but also facilitate a variety of empirical research, dealing more explicitly with the relation between mental models and environmental behaviour. I shall now present a cursory outlook on what such empirical endeavours might look like and address some potential problems that might be faced in the process.

3.2.1 Meta-Empirical Inquiries

Firstly, a meta-empirical inquiry is required to provide a comprehensive review of precedent socio-political, (social) psychological and cognitive research on the relationship between mental models and environmental behaviour. This might be a trickier task than it seems, since whilst, for example, research on the relationship between socio-psychological belief systems and social status is plentiful (see e.g. work related to environmental ‘risk perception’: Slovic, 1999; Finucane et al., 2000; Lo, 2014; van der Linden, 2015), research on the relation between belief systems and actualized behaviour seems scarce. Moreover, since I present in the article below that nudging tacit metaphysical mental models might result in more sustainable environmental behaviour, it is particularly important to address some potential challenges that might be faced in the actual process of nudging. The most evident problem might be what is known as the ‘value-action gap’, that is, the apparent gap between held values (or knowledge) and actual realized behaviour (see e.g. Kollmuss and Agyeman, 2002). A particularly important question therefore is whether or not the nudging of metaphysical belief systems could actually result in notably altered behaviour, or in other words, whether or not the value-action gap can be efficiently bridged.

There is, however, reason to believe that this gap between values and actions can be sufficiently overcome. If, as I claim, ‘tacit metaphysical frameworks’ are precedent to explicitly held belief systems (since they are ‘embodied tacit knowledge’), they might be even more fundamental to habitual behaviour patterns than explicitly stated values. Therefore, subjects explicitly reporting a set of held values might be wholly unconscious

of a more fundamental set of tacit values. If, for example, person A claims concern for environmental issues, her conception of the ‘environment’ might (even on an ontological level) tacitly differ from person B, even if the explicit use of the term ‘environment’ were similar. Thus to distinguish between ‘explicit’ and ‘implicit’ (or tacit) values and belief systems (and to acknowledge that tacit values, generally speaking, precede explicit values) when addressing the gaps between values and actions is of fundamental importance.

Furthermore, a topic I unfortunately only vaguely touch upon in the article below is that reframed ‘awareness’ is not in itself sufficient in changing environmental behaviour if sufficient institutional ‘pathways’ to facilitate this do not exist (Honig et al., 2015). Whilst my focus in the article is almost purely on a bottom-up approach, this perspective should not be interpreted in any way to deny macro-level top-down approaches of instrumental utility. That being said, I do believe I make this point sufficiently clear in the analysis of the reciprocal interrelation between macro and micro processes in Section 2.3 of Part 2. Yet still, further research particularly related to how change in micro-level (or intrinsic) mental models is facilitated by change in macro-scale factors (or extrinsic factors, e.g. institutional change, economic empowerment and poverty reduction) would be contributory towards more comprehensive process philosophical endeavours in environmental policy and philosophy (see Gare, 1996 for macro-scale analysis of process philosophy and systemic change).

Perhaps a good starting point for reconsidering this micro–macro bifurcation would be Amartya Sen’s (1995; 2009) near-pragmatic ‘Capability Approach’, which combines both systemic and personal¹⁷ analysis in its focus on actual realized ‘social processes’ (i.e. ‘capabilities’ and their derivative ‘functionings’). An empirical inquiry on the relationship between mental models and environmental behaviour should thus also take notice of social and economic processes that facilitate or impede belief systems from realizing as actual behaviour.

In fact, drawing on the discussion on ecological psychology above, the capability for sustainability could thus be reframed as processual and reciprocal subject–object

¹⁷ Intriguingly, Sen’s focus on the ‘personal’ aspects of equality, justice and liberty as well as their pluralistic interpersonal variation might be influenced by the works of Michael Polanyi. Sen has, for example, republished and written a foreword on Polanyi’s work ‘The Tacit Dimension’, praising Polanyi’s ideas ‘far-reaching’ and ‘foundational’ (Sen in Polanyi, 2009: xvi).

interaction. In other words, if the socio-ecological environment does not ‘afford’ (i.e. offer the functional opportunity and capability) for sustainable action, it is unlikely for sustainable behaviour to occur, no matter how sustainable the mental models were. For example, ecological psychologist Harry Heft (2001: 248), drawing on the work of psychologist Kurt Lewin, notes how ‘nonpsychological’ objects play a significant role in shaping individual food consumption patterns: the ‘food preferences of an individual’ are largely determined by ‘nonpsychological factors, such as availability of certain foods ... and economic factors.’ Again, however, it is worth noting that these insights are in no way incompatible with the theoretical framework set in the research article below, and that indeed the case is in fact quite the contrary. It is merely the case that the development of sustainable mental models must go hand-in-hand with political development where the socio-ecological environment – or the ‘behaviour setting’, inanimate objects and environments included (Heft, 2001) – affords pathways and capabilities for sustainable action and enables the functional realization of sustainable tacit knowledge frameworks.

Finally, prior to any empirical testing, some ethical and practical issues related to nudging should be cleared up with self-reflective and critical caution. Indeed, it is worth noting that nudging has been criticized, among other concerns, on ‘ethical grounds for being manipulative and patronizing’, on ‘societal grounds for being undemocratic and elitist’ and on ‘cultural grounds for being culturally biased’ (Hukkinen, forthcoming). However, it is crucial to understand that from the theoretical bases of process philosophy, embodied cognition and ecological psychology, nudges appear to be in a fundamental sense unavoidable – we are constantly embedded and situated within an ecology of action full of nudges and nudgees. In other words, ‘the fate of human beings as socially and materially circumscribed organisms is to constantly nudge and be nudged’ (Hukkinen, forthcoming).

This processual or ecological perspective does not, of course, justify an ‘anything goes’ attitude towards the design of mental models. However, it does imply that the subtle and non-coercive design of sustainable mental models (for educational and political use) is not *by necessity* ‘undemocratic’, since it must be acknowledged that democracy itself inevitably involves various degrees of ‘manipulative’ nudging¹⁸. On the contrary, in fact,

¹⁸ In fact, these arguments could be continued, particularly following Polanyi’s work, to suggest that any form of (scientific or political) expertise involves ‘authoritative’ and ‘elitist’ social relations, and that these terms need not take a pejorative meaning in *every* possible context (since science, for one, is a particularly conservative social system). See e.g. Polanyi, 1974, Nye, 2011 and Kuhn, 2012 for related discussion.

rightly designed ‘boundary conditions’ (Polanyi, 1969; Heft, 2001) for human thought (e.g. the ‘process-biased’ mental model as an ‘architecture of thought’ suggested in this thesis) might actively increase democracy and freedom: as is in the game of chess, from a small number of rightly limited initial behaviour-rules emerges a vast complexity of inexhaustible freedom and creativity. Whilst any change of the lower level of this nested hierarchical rule-set (or ‘behaviour setting’; Heft, 2001) would imply drastic changes to how the game is played, the players would still enjoy significant (higher emergent level) freedom and creativity that simply would not exist if it were not for any constraining rules.

Nudging, as portrayed here, is thus not coercively telling ‘what’ to think but inspiring a way of thinking that emerges from a relatively simple ‘protocategorical’ reframing of the most ‘basic and rudimentary questions that initially get the process of factual inquiry under way’¹⁹ (Rescher, 2001: 49). Thus the initial restriction of lower-level boundary conditions (that is, in this case the protocategorical emphasis of process-bias over substance-bias) does not necessarily entail loss of absolute freedom in the higher hierarchical order of human thought and action, and conversely might in fact be the emergent basis of significant freedom, (intergenerational) capabilities²⁰ (Sen, 1995; 2009; Rauschmayer et al., 2011) and novelty. This is even more so due to the tendency of sustainable societies being simultaneously more democratic, participatory and empowering than their unsustainable counterparts (Thiele, 2013; Winner, 1989). On similar lines, nudging via the design of sustainable mental models could even be defended on the (admittedly unfashionable) utilitarian grounds of being, ultimately, ‘more’ democratic than the hypothetical society resulting from decades of continued ecocide. However it must be duly acknowledged that nudging does not come without very real ethical concerns and any applications should come with appropriate caution and public deliberation. Consequently, and humbly, providing a clear, self-reflective and self-critical overview on the ethics of nudging (perhaps continued on the lines of which I have asserted

¹⁹ It is also worth noting that some of these rudimentary ‘protocategorical’ questions, somewhat similar to what Lakoff and Johnson (1999) call ‘primary metaphors’, seem to be common to all human beings and transcend cultural and national borders. This might be an asset in any potential intercultural applications of ‘process-biased nudging’ and perhaps take some weight off the ‘cultural-bias’ critique.

²⁰ Given the processual continuity of human society, it should be emphasized that sustainable thought and action today amounts to more capabilities tomorrow. This is accounted for, for example, by the continued intergenerational existence of ecosystem services (Thiele, 2013). Political restriction today, it follows, might conversely result in capabilities and freedoms tomorrow (Rauschmayer et al., 2011).

here), particularly due to the politically inflammable nature of nudging, seems an essential prerequisite for any empirical experimentation.

3.2.2 Towards Empirical Methods

As for concrete empirical testing, I believe there are two directions to head onwards. The first of these is what could be called a ‘nudge experiment’, consisting essentially of a blind (or double-blind) test where subjects are presented either textual or visual stimulations with (one of) either substance-biased or process-biased claims or metaphorical statements. The subjects would subsequently be presented with a variety of environment-oriented scenarios (again, either in visual or textual context or a blend of the two) related to, for example, sustainable behaviour. The results would then be scrutinized through either quantitative (e.g. factor, variance or cluster analysis) or qualitative methods, with the null-hypothesis (H_0) that there is no substantial difference between the two differing nudges and the resulting simulated environmental behaviour patterns. The rejection, or disprovement, of the null-hypothesis could therefore imply there being a causal relationship between how we tacitly perceive the world and how we act towards it, and suggest that this relationship can be nudged through political means. A major challenge with this approach is the question of how process-biased and substance-biased claims or metaphors are successfully operationalized into pragmatic research instruments, and these efforts are, of course, questionably suspect to degrees of dubious arbitration.

A second, more simple (yet uninformative), approach would be a survey-study (again, possibly a mixture of both qualitative and quantitative methods) which would present a variety of metaphysical claims (including both process-biased and substance-biased statements) measured, for example, on a Likert scale along with a variety of freeform questions. The ‘metaphysical’ question set could then be compared in relation to answers to more practical questions related to environmentally sustainable behaviour and action (e.g. recycling or consumption patterns) or perceived environmental risk (e.g. related to climate change and ecocide). However, whilst this approach could provide interesting insight into the relationship between metaphysical mental models and environmentally oriented perception (e.g. risk perception), it would perhaps be less informative on how these two relate to actual realized environmental action (and not only reported behaviour), and would thus particularly face the problem defined above as the ‘value-action gap’.

In sum, the article presented below is merely a starting point for a wide-ranging variety of potential research, and forms a philosophical basis for considerable theoretical and empirical extension. Whilst there undoubtedly remain many questions to be answered and further addressed, this might not be as much a flaw as it is an advantage. I thus hope that readers from various academic fields are intrigued to catch upon some of the loose-ends for the moment left in the yet unspoken ‘tacit dimension’, and I particularly wish readers are inspired to seek applications for process-philosophical inquiry in their respective fields of expertise. As Rescher (1996: 166, 170) has wittingly remarked, process philosophy has not, ‘as yet, received the attention – and the opposition – that it deserves’²¹ and is still, without doubt, very much a ‘philosophy in process’ (and, of course, shall by necessity of its own maxims always remain so).

²¹ Appropriately, Latour (foreword in Stengers, 2011) has likened following process philosophy to ‘whale watching’: every now and then some magnificent work appears, only to be followed by an era of complete silence.

Part 2: Reframing Tacit Human–Nature Relations: An Inquiry into Process Philosophy and the Philosophy of Michael Polanyi

Abstract

To combat the ecological crisis, fundamental change is required in how humans perceive nature. This paper proposes that the human–nature bifurcation, a deeply entrenched and environmentally pathological metaphysical mental model, stems from embodied and tacitly held substance-biased belief systems. Process philosophy can aid us, *inter alia*, in providing an alternative framework for reinterpreting this bifurcation by drawing an ontological bridge between humans and nature, thus providing a coherent philosophical basis for sustainable dwelling. Michael Polanyi’s epistemology can further help us understand these environmentally oriented tacit processes of knowing, and also provide a basis for political and educational implementations of process-philosophical insights, particularly via the nudging of mental models.

Keywords

Process metaphysics, tacit knowledge, sustainability, framing, nudging.

1 Introduction

In midst of the ecological crisis, inquiries into novel forms of understanding the interconnection between societal and natural systems have emerged, noting that an ‘altered sensibility’ or cognitive ‘reframing’ is required for individuals to ‘shift their relationship with earth systems’ to one where humans and ecosystems are ‘fundamentally interconnected’ (Honig et al., 2015: 677; Hukkinen, 2012; Richardson et al., 2015). Whilst this ‘art of the cognitive war to save the planet’ is undoubtedly a political task, it can also be interpreted to represent a philosophical – even metaphysical – endeavour of reframing the ontological and epistemological relationship between the human and its environment (Antal and Hukkinen, 2010; Hukkinen, 2012). Accordingly, novel comprehensions of the relationship between individual actors and socio-ecological systems (SES’s) have been called for to transcend dichotomous frameworks such as human–nature, human–environment, realism–constructionism and individual–SES (Antal and Hukkinen, 2010; Hukkinen, 2012). I suggest in this article that environmental philosophers and policy-makers might find two particularly interesting philosophical

allies in (1) process philosophy and (2) Michael Polanyi for reinforcing their tasks in drawing the bridges between the aforementioned dualistic frameworks, thus strengthening the philosophical ties between society and environment.

The philosophical proposition I shall develop is a twofold argument built on the insights of process philosophy and Michael Polanyi's epistemology. Firstly, in Section 2, I wish to show that the dichotomies mentioned above, among others, arise from a predominantly substance-biased metaphysical framework, and that the best alternative to reframe these 'bifurcations of nature' is through a philosophy which emphasizes the ontological primacy of process (change) over substance (things) (Whitehead, 1978). I shall suggest, providing illustrative examples such as the coastline paradox, that a process-biased worldview might have the potential for inducing a sustainable '*Gestalt* switch' (Kuhn, 2012) in how both the public and experts relate to and think about nature and the environment.

Following the insights of process philosophy, in Section 3 I shall introduce some central ideas of polymath Michael Polanyi. What shall be proposed is that mental and bodily modes of knowing are fundamentally interconnected, and thus reframing some of our most fundamental, often tacit or implicit, substance-biased philosophical presumptions with process-philosophical alternatives might open doors for novel modes of sustainable behaviour and a revived appreciation of nature. Finally, in Section 4 the insights of process philosophy and Michael Polanyi shall be discussed in relation to their potential for setting a philosophical framework for environmental policy development. I shall particularly suggest that the nudging of our unsustainable mental models might result in an effective political and educational instrument.

However, there remains an important secondary motive for writing this article. The theoretical frameworks of both process philosophy and Michael Polanyi have been largely side-lined in mainstream philosophy and policy despite their obvious relevance to acute socio-environmental concerns. Hence to revive process philosophy and Michael Polanyi's work – two strains of thought which have received generous praise from prominent thinkers Bruno Latour (foreword in Stengers, 2011) and Amartya Sen (foreword in Polanyi, 2009), respectively – under the *aegis* of environmental policy and philosophy holds, I argue, great potential for novel development towards a sustainable future.

2 Perspectives on Process Philosophy

2.1 Process and Processists

Process philosophy, generally considered an endeavour in speculative metaphysics, represents a long strain of thought which can be dated (in Western Europe) at least to pre-Socratic philosopher Heraclitus and his famous teaching that ‘everything changes’²². Since Heraclitus, processists²³ alike have had the commonality of stressing the ontological (or at the very least, epistemological) primacy of process (i.e. change, movement, dynamism, flux, temporality, activity or other ‘items better indicated by verbs than by nouns’, see Table 1) over substance (i.e. ‘things’) (Rescher, 2000: 4).

Table 1: Ontological or Epistemological Primacy (based on Rescher 1996; 2000)

Substance Philosophy		Process Philosophy
staticity		dynamicity
discrete individuality		interactive and reciprocal relatedness
separateness		wholeness (totality)
humans, society	nature, environment	socio-environmental process
classificatory stability, completeness		classificatory fluidity, incompleteness
passivity (things acted upon)		activity (agency)
product (thing)		process
persistence		change, novelty
being		becoming
digital discreteness		analogical continuity

Due to its broad underpinnings, it comes perhaps as no surprise that process philosophy has historically found a large variety of interdisciplinary – or ‘hybrid’ (Hård and Jamison, 2005) – applications, with notable advocates ranging from American pragmatists John Dewey, C.S. Peirce, G.H. Mead and William James, chemist-philosophers Ilya Prigogine and Isabelle Stengers to, most famously, mathematician-turned-philosopher Alfred North Whitehead (see Rescher, 1996). More recently, prominent process philosophy scholars

²² Often referred to as *panta rhei* (‘everything flows’).

²³ A neologism developed by Nicholas Rescher (1996; 2000) along with related concepts ‘substantialist’, ‘processual’, ‘processism’ etc. in order to cope with the insufficient lexical resources in English for dealing with process-related issues.

include Nicholas Rescher (whose work²⁴ much of this Section is based on) and Arran Gare, whilst process philosophy is also known to have influenced Bruno Latour. Interdisciplinary biologists such as Francisco Varela, Humberto Maturana and Stuart Kauffman might also be read to support process-philosophical endeavours in their theories of autopoietic or emergent systems. I also suggest in this article that Michael Polanyi (1969: 132) – a polymath whose intellectual career spanned physical chemistry, economics, social sciences and philosophy – might be considered amongst the processists, particularly due to his advocacy of the view that ‘knowledge is an activity which would be better described as a process of knowing’ and that science is a dynamic inquiry ‘ever on the move’. However, before getting into further detail, a disclaimer should be placed that process philosophy cannot not be considered a unified doctrine or ideology, and it naturally follows that not every claim I make of process philosophy will apply to all those labelled ‘processists’.

2.2 Process and Substance

Western²⁵ (European) philosophy, broadly speaking, has predominantly biased things, or substances, as the basic ontological units of reality (Rescher, 1996: 29, 51; 2000: 3–4). Rescher notes that, as is often the case with philosophy, process philosophy is perhaps best understood against what it opposes: the ontological supremacy of substance over process. By reversing the ontological order of priority (that is, by emphasizing process over substance) process philosophy can be interpreted to provide a philosophical framework for reinterpreting the paradigmatic bifurcations – most prominently the human–nature dichotomy – which have left a significant mark on human dwelling and its environmentally pathological manifestations. Instead of viewing substances (things) as discrete entities, process philosophy reconceptualises substances as manifolds of process: substances are reduced from their status as ontologically separate entities to relatively static modes of dynamic process subject to pragmatic definition. As Rescher (1996: 28) articulates, ‘substantial things emerge in and from the world’s course of changes’ and

²⁴ Which I regard the most coherent compilations of the general theses of process philosophy.

²⁵ I duly acknowledge the problematic nature of the term ‘Western’ here, for two reasons. Firstly, ‘Eastern’ and ‘Western’ philosophies are often exaggeratedly contrasted and falsely stereotyped as ‘holistic’ and ‘dualistic’, respectively. Second, to reduce the question of cognitive bifurcation to merely being a ‘Western’ issue would not make for a coherent account of our biological and evolutionary tendency for dualism and bifurcation. See Slingerland, 2008 for related discussion.

thus ‘processes have priority over things’. For process philosophy, there is no fundamental ontological distinction between subject and object nor subject and predicate; an actor is not ontologically isolated from its environment nor is it ontologically separate from its dispositions (i.e. what it does). Rather, the world is best described a ‘unified macroprocess’ consisting of ‘a myriad of duly coordinated subordinate microprocesses’ (Rescher, 1996: 84).

One primary argument against substance-biased philosophy is its neglect (or downplay) of action. Indeed, if a substance does nothing, it lacks property and is thus meaningless – we can only know about ‘things’ as they relate to and interact with other ‘things’ (including the knower) (Rescher, 1996: 47). An entirely static world would have no qualities (Dewey, 1958: 90). Hence substance simply cannot do without process – yet the same does not apply when the parts are reversed (Rescher, 1996: 57, 62–3). Processes, such as climate change, can exist and be very real without having a static identifiable substantial form or spatiotemporal borders. It follows then naturally for processists to ask: why insist on the separateness of static entities if they only appear as real when interacting? Is the world not more coherently portrayed as the interaction and interrelation of things, and if so, is the process involved not ontologically precedent to the substance it temporarily manifests as? Accordingly, processists emphasize the pragmatic maxim that ‘things’ are better described as what they ‘do’ rather than what they ‘are’ (Rescher, 1996: 47; Whitehead, 1967: 157).

Process philosophy is thus best described as a one-tier ontology, where the bifurcations of thing–activity (i.e. the primary/secondary quality distinction) and subject–object are replaced with a ‘monism of activities of different and differently organized sorts’ (Rescher, 1996: 49). The subject and object, generally separated in a substance metaphysics, are united as not different ‘kinds’ of substance but rather as pragmatically distinguishable ‘degrees’ of process. The difference between subject and object is hence not in kind but in degree. If process is taken as the basic ontological unit (that is, all things are fundamentally processual), the matter of distinguishing one thing from another is always pragmatic by nature.

An explicated definition of a thing, therefore, is analogous to taking a set of filmstrip-like photographs of a flying arrow: the photographs give us interesting detail, but fail to exhibit the ‘structure of spatiotemporal continuity’ and thus the totality of the process

(Rescher, 1996: 39). No fixed categories can completely capture the contingency of reality, although they are undeniably of extraordinary instrumental use. Yet still, for processists, ‘once reality falls apart into disjointed discreteness, not all the king’s horses and all the king’s men can get it together again’ – discreteness always induces loss of reality at the price of pragmatic value (Rescher, 1996: 40). Hence it follows that a process philosophy always adheres to a degree of incompleteness in explicated definition. I shall make use of Sen’s (1995) concepts here to enlighten the question at hand: for process philosophy, explicated knowledge of reality always remains ‘fundamentally incomplete’ (in that reality is always in process and static descriptions cannot fully capture this dynamic) yet there remains all reason to be ‘pragmatically incomplete’ (i.e. make tangible sense of the process) via pragmatic limitation.

Here, it could be argued, is also the key for merging the bifurcation of constructionism–realism through a framework of process philosophy: process philosophy is, heuristically speaking, simultaneously realistic about process and idealistic about substance (although the ontological emphasis is on the former). Process is basic ‘and things derivative, since it takes a mental process (of separation) to extract “things” from the [Jamesian] blooming buzzing confusion of the world’s physical processes’ (Rescher, 2000: 7). Thus substance is always a category imposed on process, yet process remains real (and has structure) even without substance. As Rescher (1996: 71) articulates, ‘abstraction [social construction] does not *create* structure but presupposes it [realism]’ (brackets added for emphasis, see also Heft, 2001). Constructionism and realism are thus reframed as long lost relatives. Thus Dewey’s (1958: 47) idea that philosophical feuds tend to be ‘family quarrels’ seems appropriate: these conflicts ‘go on within the limits of a too domestic circle’ and are best settled ‘by venturing out of doors’. The realist–constructionist and idealist–realist debates mostly occur within a substance-metaphysical framework – perhaps they too are best settled through the ‘outdoor’ prospect of process philosophy.

But what about the individual–system relation? This is certainly an imperative question for the ecological sciences. Process philosophy approaches this issue by adhering to the notion that reality is processual ‘all the way down’: processual particles themselves consist of clusters of processes (Rescher, 1996: 54–55). Processes are parts of wider structures and themselves contain inner structures, constituting what is essentially a nested *holon* (Koestler, 1967; Ostrom, 2005) or ‘Chinese box’ of processes within processes. A central tenet in this organismic analogy is also its inherent notion of

hierarchical emergence: lower processes form structures from which higher novel forms of processes emerge. Nature, it follows, is an integrated whole of emergent²⁶ processes – it is humans who ‘for our own convenience, separate them into physical chemical, biological and psychological aspects’ (Rescher, 1996: 55). Since a process is always Janus-faced (it looks both inwards and outwards), causality and feedback is interpreted as two-directional: socio-ecological systems emerge from the interaction of its particular constituents (e.g. the dynamic relations between actors and natural resources), but the SES also has influence on how its dispositional particulars act within the system. As is generally the case with process philosophy, the difference between human actors and their SES is not in ‘kind’ but rather in ‘degree’. A system is thus not some ‘magical’ entity hovering above the individual, but both emerges from individuals and has effect on how individuals operate (Hukkinen, 2012; Slingerland, 2008).

The strength of process philosophy also lies in its intrinsic dynamism: it can be advocated in either its ontological (strong) form or its epistemic (weak) form. Whilst ontological forms of process philosophy are by no means toothless against even the harshest critique²⁷, process philosophy represents at the very least a pragmatic epistemic instrument for reconceptualising the basic premises that lie under an unsustainable culture. Thus, at the very least, process philosophy represents a pragmatic ‘thought instrument’ for organizing both everyday and scientific knowledge (Rescher, 1996: 25, 34, 165; 2000: 3–4). It is also worth emphasizing that process philosophy does not deny the existence of substance nor does it stand against materialism, but rather reconceptualises physically stable things as static ‘stability waves’ in a dynamic ‘sea of process’ (Rescher, 1996: 53). Process philosophy, in other words, does not do away with substance, but imposes an alternative way of looking at things by reducing the ontologically fundamental status of substance to what is best described as ‘pragmatic’²⁸. It is also worth noting that process philosophy does not necessitate change in explicit language: it does not imply we explicitly call ‘this pen’ by the convoluted phrase ‘this instance of a pen process’ (Rescher, 1996: 33). Indeed, Rescher (ibid.) goes on to wittingly note how ‘Copernicans have not desisted from speaking of sunrises’. However,

²⁶ Thinkers such as Gare (1996), Polanyi (1958) and Kauffman (1995) have stressed the necessity for humans to locate themselves in this process of natural emergence.

²⁷ See e.g. Rescher’s (1996) responses to P.F. Strawson’s critique.

²⁸ Yet, importantly, the pejorative phrase ‘merely pragmatic’ would be ill-placed here.

what process philosophy does imply is a tacit Gestalt shift in how we relate to the world – these themes shall be returned to in more detail in Section 3.

2.3 Reframing Environmental Bifurcations

Applied to environmental concerns, at least five particularly unsound features of substance-biased philosophy stand out which could be efficiently reframed through the ‘cognitive blend’ (Fauconnier and Turner, 2002) of ‘substance’ reframed as ‘process’ (see Table 2).

Table 2: Processual Reframing of Environmentally Pathological Substance-Bias
1. Human and environment are unified under a comprehensive processual framework.
2. Things are what they do and how they become: process has priority over product.
3. The ontological status of change (e.g. climate change) is strengthened.
4. Potential alternative for the realist-constructionist debate and the science wars.
5. Individual actors are merged with their systemic counterparts and vice versa.

(1) First is the ontological separation of things from their surroundings. This is best portrayed in the prominent dichotomous framework between humans and their environment: nature is substantialized and commodified, viewed as an ontologically separate object on which human subjects impose their will and control. Technological and economic progress is portrayed as a victory against nature, whilst in all reality seemingly independent individual actors are merely strengthening the processual feedback-relations between them and their socio-ecological environment through excessive and unsustainable material consumption (Latour, 1991; Antal and Hukkinen, 2010).

(2) Second is the ontological separation between products and processes. Products are displayed and branded as hard-edged substance whilst production processes are (often deliberately) hidden and untraceable. Carefully branded products are not portrayed as process (e.g. how they became, how they were manufactured and how they will manifest as waste) but rather as discrete modes of substance separate from the environment. The action of inanimate things is downplayed, and feedback is often left unnoticed.

(3) Third is the subjugated ontological status of change. Within a substance metaphysics framework, as has been noted above, change is inevitably less real than stability. This is a direct concern for an era in which change is of primary concern for the survival of civilization. Environmental concerns, often dealing with slow, ambiguous and fuzzy modes of change (e.g. climate and environmental change), are commonly subjugated to more hard-edged and tangible ideas (e.g. material consumption and natural resource extraction). By reifying the ontological status of change, perhaps a process-philosophical approach could provide a framework for reinterpreting complex and slow events such as climate change.

(4) Fourth is the academic and intellectual division between constructionists and realists, which has effectively separated the ‘hard’ and ‘soft’ sciences and resulted in what are commonly referred to as the ‘science wars’ (Gould, 2000). If humans do not construct nature, nature appears as remote, foreign and hostile; if humans do construct nature, nature appears as artificial (Latour, 1991: 30–31). The effort to overcome this dilemma is apparent in much, if not most, of the social sciences in particular. As has been noted, a processual framework does not allow such a sharp discrepancy between constructionism and realism, and effectively unifies the two in claiming that whilst processes are real in themselves any strict categorical imposition on them is fundamentally incomplete and thus potentially value-laden. Moreover, process philosophy emphasizes the interconnection between natural sciences, humanities and social sciences – an increasingly topical issue due to the ‘hybrid’ nature of most global problems (e.g. climate change) (Latour, 1991).

(5) Fifth and last is the disjunction between systems and actors: ‘micro’ and ‘macro’ are reframed as not bifurcated ontological entities but rather as mutually and reciprocally constituent (Latour, 1991; Heft, 2001). Individuals and systems are merged seamlessly within one philosophical framework without downplaying the influence of the actor nor that of the system. In a process framework, therefore, individuals cannot merely ‘blame the system’ (since they themselves are, as cognitive actors, a part of the emergence of a system), although a marked change in the SES’s institutional basis does have an effect on the processes and events that occur within it.

Conclusively, the primal question for process philosophy is not how the human acts environmentally, but rather how the human-embedded-in-nature manifests itself within a

reciprocal socio-ecological process²⁹. The human, for process philosophy, is not a separate entity with fixed borders, but rather part and parcel a manifestation of the ‘megaprocess’ we call nature (Rescher, 1996; 2000). These simple tenets emphasizes the notion that no human action happens without environmental consequences, and that feedback is always expected. Yet even more at that, process philosophy raises a fundamental question of our ontological identity with the natural process that we both constitute and are constituted by. To locate the human in the process of nature should, of course, come naturally for anyone remotely quaint with evolutionary theory (indeed many of the early processists and pragmatists drew great influence from Charles Darwin), yet the fundamental bifurcation of human–nature still seems to remain strong in our cultural *mythos*, pathologically reinforcing phenomena such as ecocide, climate change, mass extinction and even evolution denialism (see e.g. Dawkins, 1993).

2.4 The Coastline Paradox: An Illustrative Example

A paradigmatic example of the central arguments related to process philosophy can be made with reference to the coastline paradox. Whilst the paradox is by nature mathematical (and, indeed, inspired Benoit Mandelbrot to develop fractal geometry), my reference to it shall be at best allegorical. Essentially, the paradox states that a coastline cannot have a completely defined length since the result of the measurement is inherently dependent on the method used to measure it. In other words, when measuring the coastline of, for example, an island, the length of the measured coastline is dependent on the length of the ruler used. If one were to measure the coastline with a standard 30 centimetre ruler, the coastline would appear to be considerably longer than when measuring it with a yardstick, since the use of a shorter tool of measurement would entail more bumps and curves to measure around. The paradox gets particularly interesting when the hypothetical ruler gets shorter and shorter: as the length of the ruler nears zero, the coastlines theoretical length approaches ‘infinity’ (or at the very least, ‘undefinability’) (Mandelbrot, 1967). It follows then that there is no completely definable length for a coastline, since the process of measurement necessarily bears effect on its result.

²⁹ This fundamental emphasis on non-bifurcated perceiver–environment interaction is also, interestingly, a central idea in ‘ecological psychology’ (see e.g. Heft, 2001).

Here we can note similarities to several process-philosophical themes addressed above: firstly, the coastline is fundamentally incomplete since it escapes precise definition and can (theoretically) diverge to huge lengths and even infinity. Second, the coastline is pragmatically incomplete in that, regardless, it is possible to agree on a certain length by pragmatic methods or political³⁰ reasoning. Indeed, evoking the words of polymath Henri Poincaré (1958: 129), the island might be measured ‘very nearly’ (and enough so for pragmatic application), even if the exact description remains ‘necessarily incomplete’. Moreover, the island is processual ‘all the way down’, since the information we acquire at any scale is dependent on the process of measurement. As Rescher (2000: 81–82) notes, physical nature ‘can exhibit a very different aspect when viewed from the vantage point of different levels of sophistication in the technology of the nature-investigator interaction’, and is thus cognitively inexhaustible. Thus an analogy to overcome the constructionist–realist debate follows: the coastline’s structure undoubtedly is there insofar as it affords measurement and experience (realism), but any acquired information is inherently dependent on the selective act of measurement (constructionism)³¹.

Yet even all this is assuming the island and the coastline were an ideal-type static entity, which simply does not apply to real life. Indeed, stepping back on the hypothetical island, we shall notice that the island itself is in dynamic process. Thus not only is the island’s coastline not precisely measurable in a static ideal-type situation (due to the processual nature of measurement), it is also embedded in the dynamic process of constant contingencies affecting the measurement. Tides (caused by gravitational effects of the Moon and the Sun as well as the Earth’s rotation), erosion (due to water flow and wind), human and other organic impact (including the very act of measurement), climate change (sea level rise) and plate tectonics are all among the indefinite factors constantly shaping and reshaping the island. That is not, of course, even considering the human-scale arbitrariness of how to measure around, for example, deltas, estuaries and tidal flats. It follows then that even the island itself is, ontologically speaking, better defined in

³⁰ It is not far-fetched to draw an analogy here to the political nature of science. Intriguingly, the coastline paradox has in fact resulted in several actual political feuds related to border lengths and territorial ownership.

³¹ This should not be, however, read as an offensive towards the scientific enterprise: it is simply the reverse side of science’s ‘strength as an endlessly versatile intellectual instrument capable of accommodating itself to ever-changing cognitive circumstances’ (Rescher, 1984: 4). The perceptive limitation of processual structure when forming conceptual entities is at the heart of all cognitive efforts (see Heft, 2001).

processual than substantial terms. Islands come and go, emerge and perish³², and during any attempt to measure a precise account of a coastline the coastline would have changed. To ontologically describe the island as a substance with fixed properties and borders would be in Whitehead's (1978) terminology a 'fallacy of misplaced concreteness'. The static substance-island can only ever be a pragmatic categorization of the island-in-process. Thus, paraphrasing Heraclitus, 'we do not step twice on the same island', although it is undeniably pragmatic to assert so.

The real insight here is that there is no fundamental reason why the analogy of the coastline paradox shouldn't apply to every form of substance. This 'fuzzying of borders', of course, has often been applied to discussion related to plastic or gradient 'things' such as race, gender and sex (Haraway, 1991), equality (Sen, 1995), ethnicity and identity (Barth, 1969) and even species (Dawkins, 1993). However, analytical process-philosophical applications in these domains remain scarce, and I sincerely believe process philosophy would provide a pragmatic framework for interpreting these (and so many other) phenomena as well.

In the context of this article, however, applying these insights to the human–nature bifurcation is of the highest importance: there are no fundamentally fixed borders between humans and their environment. Thus, the coastline paradox also provides a metaphorical basis for an ecological reinterpretation of individualism. Although we can pragmatically speak of an individual as a separate entity, it is, like the island, fundamentally embedded in a worldwide web of interrelated processes from which it emerges. Thus even describing an individual in the metaphorical language of 'an island' (e.g. an independent and rational decision maker) should lead to the interpretation that, fundamentally speaking, the individual has no fixed borders and inevitably exists in and under the influence of a world of dynamic socio-environmental process. As Whitehead (1967: 225) remarks, 'we cannot tell with what molecules the body ends and the external world begins', and hence 'human experience is an act of self-origination including the whole of nature'. This insight, I believe, is fundamental for developing sustainable modes of thought where individual actors simply cannot ontologically bifurcate themselves from nature. Hence, 'no person

³² A substance metaphysics would also run into trouble in defining when precisely a substance-island would begin or cease to exist (see Rescher 1996).

is an island’, or alternatively, people are islands, but ‘islands aren’t what they appear to be’ (Mesle, 2008: 9).

3 The Process of Tacit Knowing

I hope to have established by now a comprehensive (albeit brief) reasoning for reframing some of the basic tenets of what might be called ‘substantialist’ metaphysics in order to draw a process-philosophical bridge between some of its paradigmatic environmentally pathological bifurcations. Yet the question of how humans, both the public and experts included, carry these metaphysical convictions requires further illustration. The move is now from ontology-oriented analysis to specific epistemology. I shall approach this issue through Michael Polanyi’s philosophy of ‘personal’ (1974) or ‘tacit’ (2009) knowledge. An afterthought to his accomplished career in physical chemistry, Polanyi sought to develop a philosophical system bridging the knower and the known, the subject and the object as well as facts and values. I argue here that Polanyi presents us with a through and through embodied account of knowledge, carrying with it further implications on how even the most intellectual endeavours are embedded in tacit knowledge arising from socio-ecological process. Polanyi’s epistemology can thus be particularly insightful regarding the feedback relations between mental models and human–environment relations. If much of our environmentally oriented decision-making and behaviour arises from embodied, or ‘indwelled’, tacit knowledge, might we seek to alter environmental behaviour by consciously reframing tacit knowledge-frameworks?

I begin with Polanyi’s (2009: 4) simple and heuristic notion that ‘we can know more than we can tell’. As Polanyi (1974) himself has acknowledged, for some this statement might seem too obvious to merit high emphasis, whilst for others it might seem to bear almost mystical features. I argue that neither of these claims hold truth, since Polanyi’s account of epistemology has profound implications whilst being in no sense logically untenable. The conception that we can know more than we can tell is in its most intuitive (yet impoverished, as shall be explained later) form in acts of physical motion. Polanyi (1974: 49) notes that ‘the aim of a skilful performance is achieved by the observance of a set of rules which are not known as such to the person following them’. Indeed, few people familiar with the skilful performance of swimming are consciously aware of the delicate manner in which they keep themselves afloat via regulation of respiration (i.e.

maintaining an increased level of buoyancy by refraining from emptying lungs when breathing out and by inflating them more than usual when breathing in). Similarly, the casual cyclist is likely to be completely unaware of how balance is maintained through intricate manoeuvres making use of centrifugal forces. These examples are, of course, commonsensical – this is wholly intentional, since much of Polanyi's (1974: 94) work is focussed on drawing a bridge between 'sound common sense' and sophistication. Consequently, the notion of tacit knowing becomes increasingly more intriguing when taking the step from the practical domain to the intellectual.

Although tacit knowledge is often (mistakenly) referred to merely in the context of practical know-how, Polanyi (2009: 7) – who was the first to coin the concept of tacit knowledge – had no intent on separating the practical realm of knowledge from the intellectual. Hence, it cannot be stressed enough that for Polanyi (1969: 133; 1974: 257, 312; 2009) the unformalized tacit coefficient permeates all knowledge, practical and theoretical, and that there are no reasonable grounds to accept a fundamental distinction between the two. The tacit coefficient of knowledge is no 'mere imperfection' but in fact a necessary component of all knowing. Polanyi's (1974: 87, 257) stance, therefore, represents a radical distaste towards the 'Cartesian doctrine of "clear and distinct ideas"', and extends the embodied knowledge hypothesis to include the most rational and explicit forms of knowing.³³

To support the idea that all knowledge is rooted in tacit knowledge, Polanyi (1974: 88) quotes Whitehead (1948: 73) to demonstrate the incomplete³⁴ nature of any explicit formalized statement: 'There is not a sentence which adequately states its own meaning. There is always a background of presupposition which defies analysis by reason of its infinitude'. Hence, strictly speaking, nothing we say can be said precisely: every act of explicit statement bears with it a reference to some thing or experience, which at the moment of utterance, remains tacit. Whilst we can explicate some of the particulars we

³³ An analogy here lies to discussion related to the dual mode of cognition, or the idea that humans are characterized by distinguishable type 1 (fast, automatic and unconscious) and type 2 (slow, deliberative and conscious) cognitive processes (see e.g. Hukkinen, 2012; forthcoming). Polanyi's philosophy supports claims that type 1 ('tacit') and type 2 ('explicit') cognitive processes are deeply intertwined, and that tacit intuitive cognitive processes are fundamental constituents in even the most rational forms of knowing.

³⁴ It is perhaps noteworthy that much of Polanyi's (1974) philosophy is influenced by Gödel's incompleteness theorems.

are tacitly referring to, this explication only brings forward new tacit presuppositions which would themselves require explanation, *ad infinitum*.³⁵

Ultimately, it follows, to know something is to rely on ‘common sense’ (or a Duhemian *bon sens*) in the face of fundamental incompleteness. Explicit knowing, then, whilst being a ‘superb instrument’, ultimately ‘requires a background of common sense’, or tacit knowledge, for its operational basis (Whitehead, 1948: 74). Whilst tacit knowledge can be possessed or embodied in itself, explicit knowledge must rely on being tacitly understood: all knowledge is ‘*either tacit or rooted in tacit knowledge*’ and a ‘*wholly explicit knowledge is unthinkable*’ (Polanyi, 1969: 144). It follows, contra the caricatured ‘early Wittgenstein’, that we should not be ‘quiet of what we cannot speak of’ as this would very fundamentally contradict the nature of human knowledge. Formalizing all knowledge to the exclusion of any tacit knowledge is evidently self-defeating (Polanyi, 1969: 133; 1974: 87, 91; 2009: 20).

Formalization can and does, however, immensely expand the powers of the mind, but only when explicit rules sink into the tacit matrix (Polanyi, 1969: 156). Rules or maxims do not determine the practice of the art when alienated, and maxims are only successful guides when embodied and integrated to practice (Polanyi, 1974: 49, 162). Furthermore, when explicit maxims are ‘interiorized’ (embodied) into the tacit domain they become faster and more intuitive (Polanyi, 1969: 144). This is akin to what Dreyfus and Dreyfus (in Flyvbjerg, 2001: 9–24) and Collins and Evans (2007) call ‘expertise’: fast, holistic, non-rule based, intuitive and embodied decision-making; it is also what Rochlin (1997) simply calls ‘having the bubble’.

Polanyi (1969; 1974; 2009) argues that the relation between tacit and explicit modes of knowledge is based on the distinction between ‘subsidiary’ (proximal) and ‘focal’ (distal) awareness and what Polanyi calls the ‘from-to’ structure of knowing. In essence, the argument follows: knowledge is formed in the integration of embodied tacit particulars to an explicit whole (Gestalt), to which we attribute meaning. A physiologist who has completely mapped all that takes place in the eyes and brain of a human being does not see what the human being subject to the mapping sees, because the physiologist is merely looking ‘at’ these happenings and not attending ‘from’ them ‘to’ something – this is, of

³⁵ A clear analogy here could be drawn to the Duhem thesis: no scientific hypothesis can be tested in isolation, since any empirical test is dependent on interconnected auxiliary hypotheses.

course, not to deny that the physiologist might learn something useful from the mapping process (Polanyi, 1969: 147).

This is particularly what Polanyi (1974; 2009) refers to when claiming that we cannot learn an art – or science – by simply learning its maxims, but we learn through experience and its bodily internalization. Only when we subsidiarily interiorize, or embody, an art or scientific theory can we focally interpret things in its light. We attend from tacit subsidiary awareness to focal explicit awareness. Therefore, to rely on a theory for understanding nature is to interiorize it, or to ‘dwell’ in it (Polanyi, 2009: 17). This is, for Polanyi, the bodily root of all knowledge, and this is also why I consider Polanyi akin to processists. Polanyi (2009: 15) argues that our bodies are the ultimate instruments of all our external knowledge, whether intellectual or practical. Since our body is involved in the process of perceiving external objects, it participates in the process of knowing external things by ‘dwelling’ in them – it follows that the subject and object are necessarily merged in the act (or process) of knowing (Polanyi 2009: 29). Indwelling applies to all forms of knowledge, both practical and intellectual: similarly to how we dwell in the hammer to drive in a nail we dwell in a scientific theory to make sense of empirical observations (Polanyi 1974: 60). Both are acts of skill and connoisseurship, and both involve a degree of personal commitment, which is hence involved in all acts of intelligence (Polanyi 1974: 61). In both acts, consequently, we also rely on embodied tacit knowledge.

Herein, I believe, lies the fundamental insight of Polanyi’s philosophy for environmental policy and philosophy. Let us first assume, like Polanyi does, that intellectual and practical knowledge are both bodily functions fundamentally embedded in the tacit domain. It follows, therefore, that any feat of environmental behaviour is not fundamentally rooted in rational explicit knowledge of nature, but rather in our tacit belief frameworks and embodied experience in relation to nature. Consequently, our focal awareness of the environment – that is, the way we experience our environment and attach meaning to it – is embedded in a subsidiary framework which we have tacitly interiorized, embodied, and been ‘habituated’ to (Dewey, 1958: 14). Polanyi (2009: 17) calls this the ‘tacit framework for our moral acts and judgments’, the framework ‘from’ which we attend ‘to’ things seen in its light. In other words, we have a tendency of projecting our

conceptual worldview (which at the moment of observation remains tacit) on how we focally experience, or dwell in, the world³⁶.

It follows then that similarly to how the layperson is unaware of the tacit knowledge underlying a simple act as riding a bike, the layperson – or even the expert – is unaware of the primary tacit metaphysical frameworks from which meaning is attached to the socio-ecological environment. This implies that our environmental action and its precedent moral judgments are tacitly grounded in the (relatively static) metaphysical framework³⁷ we have embodied – through culture, tradition, conviviality, authority, and not the least, ecological and evolutionary³⁸ processes – and ultimately results in the focal experience by which we *prima facie* confront the world and attach meaning to it (Polanyi, 1974: 207). We ‘believe many things not because they are so,’ but because we have been habituated through ‘unconscious effects’ to do so (Dewey, 1958: 14). We dwell, subsidiarily, in tacit embodied metaphysical convictions which manifest in our focal awareness of the world – we attend from our tacit belief systems to our explicit manner of attaching meaning to the world.

I have already established above that the dominant metaphysical conviction in which we dwell in is one where substance is asymmetrically biased over process. Since knowledge is an activity better described as an embodied ‘process of knowing’, modifying this ‘tacit framework’ changes how we dwell in the world (Polanyi, 1969: 134). In other words, tacit belief frameworks manifest themselves in how we act towards nature and the environment. As Dewey (1958: 14) emphasized, ‘the *ways* in which we believe and expect have a tremendous affect upon *what* we believe and expect’. That such metaphysical convictions, for most, are tacit does not make them any less real, since all knowledge is fundamentally rooted in its tacit predecessor.

³⁶ Note that this personal coefficient of knowledge is not, in a fundamental sense, subjective (nor a pure ‘social construct’), as it is reciprocally shaped by our dynamic interaction with the socio-ecological environment. It would be a dire misrepresentation to portray Polanyi a subjectivist, despite his obvious distaste for impersonal objectivism.

³⁷ An analogy can be drawn here to Bijker’s (2007: 122) ‘technological frame’. Similarly to how technological frames induce stability in ‘ways of thinking’ and ‘fixed patterns of interaction’, people dwelling in particular metaphysical tacit frameworks ‘will find it difficult to imagine other ways of dealing with the world.’

³⁸ Indeed, to omit biological factors from this list would be folly, although further addressing the question of ‘innate cognitive dualism’ is out of bounds for this article (see e.g. Slingerland, 2008 for an overview on the topic).

Whilst it follows then that this tacit framework will escape any complete explicit formalization, it is reasonable and justifiable to apply pragmatically incomplete measures to attempt to explicate an environmentally unsound tenet of metaphysical thought that much of our civilization dwells in. I have suggested above that we live in a framework of substance metaphysics where the human has separated itself from nature and has justified itself to abuse its environment at the price of both its own and the environment's well-being. As Honig et al. (2015) note, altering environmental behaviour requires a novel understanding of how society and earth systems are connected, yet to achieve this it is simply not enough to attempt to modify human–environment interaction through building on explicit or rational knowledge. A more thorough Gestalt shift in how we attend to the world is required, and I suggest process philosophy can serve as the metaphysical basis for this thorough reinterpretation of human–environment interaction. To dwell in a tacit framework of process, due to the five tenets mentioned in Section 2.3., arguably has the potential for being more sustainable and environmentally sound than a substance-biased framework. It is the implementation of this framework, which Gare (1996) has dubbed a 'metaphysics of sustainability', that is left for environmental policy.

4 Conclusion and Discussion

So far I have suggested that some of the most environmentally pathological 'bifurcations of nature' arise from substance-biased metaphysics, and thus we might have sufficient reason to look at alternative frameworks for interpreting, and thus dwelling in, reality. As has been noted, a process metaphysical approach might be able to play the active role of such an alternative, much due to its emphasis on the reality of 'change' in nature and the fundamental interconnectedness it ascribes between bifurcated entities such as 'human' and 'nature'. With Polanyi's theory of knowledge I was able to draw the fundamental line of interconnection between mental and physical processes of knowing, thus suggesting that the ways in which we tacitly apply meaning to the world have fundamental effects on how we dwell in our environment. Yet whilst these insights are valuable in themselves, they can also be regarded as pragmatic instruments for facilitating the development of a sustainable culture. Therefore the evident question remains of how to go on about changing the most unsustainable mental models in which human and nature are bifurcated.

Education, of course, would be the most obvious means. This comes as no surprise since two major figures quoted in this article, Whitehead and Dewey (and to a lesser extent, Polanyi) deeply emphasized the role of education in social progress. Common to these thinkers was a ‘process’ approach to education; that is, learning should happen through participatory, transdisciplinary and pragmatic means. Environmental education should not be substance-biased (i.e. merely learning ‘about’ things), but rather learning through process (i.e. participation and direct experience, thus building on tacit knowledge and expertise). These ideas are in line with claims that strictly rational or explicit learning methods are not alone sufficient to induce sustainable behavioural patterns (see e.g. Kollmuss and Agyeman, 2002). Indeed, other behaviour-affecting parameters suggested in sustainability research, such as values, attitudes, socio-economic processes, awareness, affect, interconnection and involvement could all be interpreted to be at the heart of the process-philosophical inquiry (Kollmuss and Agyeman, 2002; Honig et al., 2015; Richardson et al., 2015).

Yet due to the urgency of the issue at hand it is the responsibility of environmental policy-makers to consider supplements to educational methods in order to swiftly move civilization towards sustainable dwelling. Recent discussion in environmental policy (Hukkinen, 2012; forthcoming), drawing insights from theories of embodied cognition (e.g. Lakoff and Johnson, 1999), has addressed the ‘nudging’ of mental or cognitive models in order to induce sustainable behaviour patterns. Nudging here is to be interpreted as the political means of designing ‘cognitively attractive and empirically sound mental models that have the capacity to alter people’s behaviour toward socio-ecologically sustainable transitions’ (Hukkinen, 2012: 2)³⁹. Since I have already addressed that tacit substance-biased mental models might be at the very heart of unsustainable thinking, I propose that environmental policy makers could find particular interest in process philosophy when designing sustainable cognitive models. Nudging towards process-biased thought could happen, for example, by perpetual use of process-relational metaphors (see e.g. Table 1) in textual or visual context, since the ‘process’ of process thought itself starts with the simple substitution of the fundamental metaphor ‘things are static’ (substance) with ‘things are dynamic’ (process). Whilst the

³⁹ I agree with Hukkinen (forthcoming) in that whilst nudging is not ethically unproblematic, the ‘fate of human beings as socially and materially circumscribed organisms is to constantly nudge and be nudged.’ Whilst nudging can be criticized on democratic grounds (although I would not regard it being ‘eco-authoritarian’; Shahar, 2015), a truly undemocratic society would prevail in a post-ecocide future – it is the wholehearted responsibility of political actors to prevent this future from occurring.

development of sustainable process-biased cognitive models⁴⁰ is out of bounds for this article, what should be briefly discussed is what exactly could be expected to result from them.

The intended result is to evoke what is perhaps best described as ‘double-loop’ thinking. Instead of thinking of things ‘as substance’ (single-loop), the trick to process-relational thought is to think of ‘substance through process’ (double-loop)⁴¹. In Polanyi’s (2009) terminology, the process-loop would represent the ‘tacit dimension’ of thought whereas the substance-loop would represent the business-as-usual ‘explicit’ dimension. What results is, essentially, ‘thinking about thinking’ with the caveat that ‘thinking’ here should largely happen in the tacit dimension for it to be truly habitual and consistent – this is, essentially, ‘tacit metacognition’ (Swartz and Perkins, 1990).

If successfully implemented, it is not a long stretch to see this resulting in more sustainable behaviour: replacing substance-bias (e.g. ‘I need this thing [substance]...’) with process-bias (e.g. ‘...but this thing emerged from [process₁] and will result in [process₂]’) could result in more sustainable consumption patterns as well as heightened environmental consciousness. To imagine this scenario in, for example, a mundane grocery store setting is even less far-fetched. The single-loop mental scenario ‘go to a store [store-substance] and buy familiar food [grocery-substance]’ should be replaced by a double-loop mental model of ‘think of how to get to the store [process of transport] and how products have become [process of production] and shall become [process of disposal]’. Similar process-reframed double-loop mental models, I believe, could be related to all five points made in Table 2. Think of how, for example, the coastline paradox was used above to reframe how we think of an island (from ‘island as substance’ to ‘island as environmentally embedded process’), and how similar mental models could be used to reframe a variety of human–environment relations. Whilst further investigations are, for now, left to the imagination of the reader, I believe applied process-thought could prove to be a fruitful approach in development towards sustainable models of thinking.

⁴⁰ See the ‘roller-coaster blend’ in Hukkinen, 2012 for what I regard a sustainable process-relational cognitive model.

⁴¹ Recall Rescher’s metaphor of substance arising from a ‘sea of process’.

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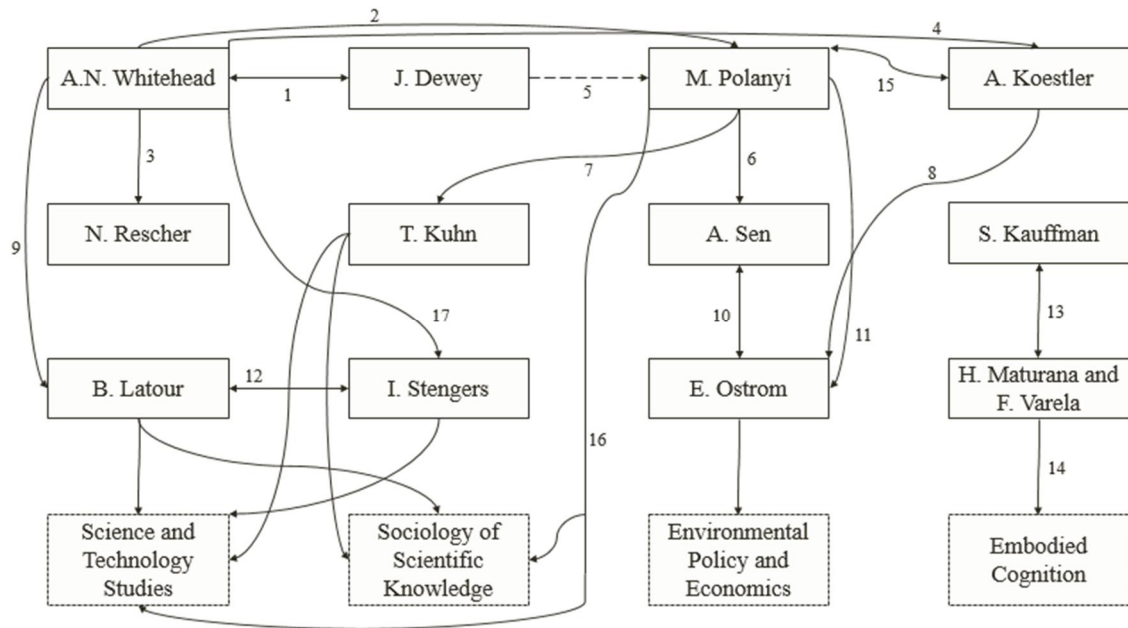
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Appendix

N.B. This Appendix is not included as a part of the article of Part 2, and thus was not submitted to *Environmental Values* for peer-reviewing. It does, however, thematically relate to both Parts 1 and 2 of this thesis.

Chart 1: Mapping Intellectual Relations



This chart is intended to be interpreted with two themes in mind: ‘diffusion of knowledge’ and ‘history of ideas’. The philosophers or scientists depicted (all mentioned or referred to in Part 2 of this thesis) here are shown to have several mutual intellectual nodes, contributing towards a network of thought and perhaps explaining why their respective conceptual and theoretical frameworks seem to fit so nicely into a ‘process-relational’ philosophy – with the important caveat that not all correlation of ideas is due to causation of direct intellectual interaction. Again, I maintain it is worth mentioning, these particular sets of relations, or diffusions of ideas, have not to my knowledge been investigated in the academia in any detailed inquiry. Moreover, the chart could be extended historically to include its current senior members’ (Alfred North Whitehead and John Dewey) inspirers, such as William James, C.S. Peirce, Henri Bergson, and importantly, Charles Darwin, whose theory of evolution helped shape the very fundamentals of process philosophy.

I have briefly explicated the nature of these intellectual relationships below (in notes 1–17), although further and more detailed investigation in this distinctive area of the history of science and philosophy might be warranted. I have also depicted how these thinkers have contributed to four theoretical frameworks (the lowest row of Chart 1) which are particularly influential in current environmental studies. Future inquiries related to the topic of this thesis might look to further unify the above illustrated complex of thinkers and theoretical frameworks in a single ‘process-philosophical’ approach on environmental studies, with the three major recurrent ideas between the intellectuals involved being (A) the processual nature of things (including both social and natural entities), (B) a hierarchical (or nested), emergent and reciprocal approach to systems-studies as well as (C) an emphasis of the self-organization of socio-ecological systems. Furthermore, as can be noted, the ‘Embodied Cognition’ group on the lower right corner of the picture remains somewhat detached from the rest of the network – drawing a connecting node between Rescher, Polanyi and field of Embodied Cognition could be a fruitful ground for analysis (and, in fact, could be interpreted to be a central, albeit somewhat understated, theme in Part 2 of this thesis).

1. The reciprocal intellectual relationship – and not less importantly, friendship – between Whitehead and Dewey is well documented. Common to the two thinkers is a thoroughly process-biased ontology and a general distaste towards ‘dualism’ or ‘bifurcation’ (Dewey, 1958; Whitehead, 1978). See for example Whitehead’s (1948: 91–92) essay *John Dewey and His Influence* and Dewey’s (1951) essay *The Philosophy of Whitehead*.
2. Michael Polanyi, particularly in his seminal work *Personal Knowledge* (1974), draws influence from Whitehead’s ideas (Nye, 2011). This is commented upon more thoroughly in Section 3 of Part 2 of this thesis.
3. Nicholas Rescher (1996: preface) notes that Whitehead’s process philosophy has been a major influence ever since his first reading of *Process and Reality* as a student in 1949.
4. Arthur Koestler (1967) – perhaps an unlikely figure in this chart, and a somewhat controversial public intellectual of his time – draws reference to Whitehead in his work *The Ghost in the Machine*, although more importantly his constant use of ‘Whiteheadian’ lingo (e.g. ‘process of becoming’) seems to imply heavier unmentioned influence.
5. Polanyi (1974) seems quaint with Dewey’s work, although Polanyi is surprisingly (and perhaps unwarrantedly) somewhat dismissive of Dewey’s pragmatism. Regardless, Polanyi (2009: 77) concurs with Dewey that ‘we shape all knowledge in the way we know it’.
6. Amartya Sen (foreword in Polanyi, 2009) has republished and written a foreword to Polanyi’s work *The Tacit Dimension*. Particularly, Sen’s (1995; 2009) treatment of social phenomena as

epistemologically irreducible, incompletely defined as well as inherently plural and personal seem to resonate strongly with Polanyi's (2009) theories of emergence and tacit knowledge (Sen also makes explicit reference to Polanyi's theory of emergence in the 2009 book *The Idea of Justice*). I have previously written an unpublished comparative text (in Finnish, available at request) on similarities between Sen's concepts of 'fundamental' and 'pragmatic' incompleteness of equality and Polanyi's theories of tacit knowledge and emergence.

7. Michael Polanyi is known to have influenced and debated with Thomas Kuhn, influencing Kuhn's (2012) famous work *The Structure of Scientific Revolutions*. Kuhn (ibid.) also discusses the role of 'tacit knowledge' extensively in the Postscript of the aforementioned work. See also Nye, 2011 for a historical overview on this relation.
8. Elinor Ostrom (2005) makes significant use of Koestler's (1967: 45–58) concept of the '*holon*' – that is, simultaneous 'wholeness' and 'partness' (the concept *holon* is derived from Greek *holos*, or whole, and suffix *on* implying partitivity) of systemic entities – when discussing the hierarchical order of systems.
9. Bruno Latour praises Whitehead as the most important philosopher of the 20th century in the foreword of Isabelle Stengers' (2011) *Thinking with Whitehead*. Latour's Actor Network Theory (i.e. the treatment of objects as processual entities, 'actors') and his distaste towards bifurcation (or 'modernity'; Latour, 1991) have many overlappings with process philosophy.
10. Both Nobel laureates in economics, Amartya Sen and Elinor Ostrom are acquainted and Sen (2009: xxvii) has according to himself 'benefited a great deal from conversations' with Ostrom. The two share theoretical similarities in a distaste towards transcendental definitions of social phenomena and systems as well as a focus on actual 'social processes' (Sen, 2009: 22–24) and 'processes of self-organization' (Ostrom, 1990: 26–29) instead of mere outcomes.
11. Michael Polanyi's (1951) work on the 'polycentricity' of economic systems is known to have influenced both Elinor Ostrom and Vincent Ostrom (see Aligica and Tarko, 2012). Other theoretical similarities include the hierarchical nature of nested systems (Polanyi's theory of 'emergence' and Elinor Ostrom's nested '*holon*', see note 15 below) as well as the spontaneous order of self-organizing systems.
12. Bruno Latour is known to have collaborated with Isabelle Stengers, and the reciprocal intellectual relationship they share is perhaps most evident in their shared admiration of Alfred North Whitehead (see Stengers, 2011 and its foreword by Latour).
13. Stuart Kauffman (1995: 274) comments that he has discussed the concepts of 'autopoiesis' (or self-originating systems) and emergent 'autocatalytic sets' with Chilean scientists Humberto Maturana and Francisco Varela, noting that he later became friends with the latter.
14. See e.g. Varela et al., 1991 for discussion related to the 'emergence' of mind from body.
15. Michael Polanyi and Arthur Koestler, both part of the 'Hungarian phenomenon' group of early 1900's refugee intellectuals (among the likes of Eugene Wigner, John von Neumann, Karl Mannheim, Edward Teller and Leo Szilard) were friends and draw reference to each other in Polanyi (1969; 1974) and Koestler (1967) (see also Nye, 2011). Theoretical similarities include

Koestler's *holon* (see note 8 above) and Polanyi's (2009) idea of hierarchical and nested structures in emergent systems.

16. Polanyi, an acclaimed scientist himself, was a pioneer in theorizing on themes related to what would later be called the 'social construction of science and scientific knowledge' (and indeed, with considerable detail addressed the problematicity of the realism–constructionism debate before such an academic bifurcation even explicitly existed; Nye, 2011). Sociologist of science Harry Collins (e.g. Collins, 2010; Collins and Evans, 2007) makes perhaps the most explicit reference to Polanyi when discussing the relation of 'tacit knowledge' to 'expertise'. See the Epilogue in Nye, 2011 for extensive discussion.
17. Belgian philosopher and chemist Isabelle Stengers (who has written extensively on chaos theory with compatriot Nobel laureate Ilya Prigogine) discusses Whitehead's philosophy extensively in the 2011 book *Thinking With Whitehead*.