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Ecological neuroscience: From reduction to proliferation of our resources

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Abstract

On a still very common view human activity is explained by neural processes because these implement psychological functions that underlie overt behavior. In the ecological approach such accounts are taken to be non-explanatory because they reify the phenomena they wish to explain. We shall argue that ecological psychology offers an antidote to such reification with concepts like resonance, attunement and anticipation, if they are considered as relational, world-involving activities. Our main claim is that we can understand our scientific explanations of neural phenomena as itself an attunement to sociomaterial practices. This allows us to understand neuroscientific processes as conditions that enable a resonating organism-environment system. In this view, neuroscientific and psychological phenomena are usually found in widely different sociomaterial practices. But we can occasionally achieve coordination between those practices. Establishing that a dependence of a psychological phenomenon on neural events holds, is an achievement of a novel practice that we developed and to which we resonate. Thus the more we want to understand what happens inside the nervous system the more we also need to scrutinize the sociomaterial environment in which we do so.

Keywords: Action; Ecological niche; James Gibson; John Dewey; Perception; Practice; Neuroscience; Sociomateriality

> The world is One just so far as its parts hang together by any definite connexion. It is many just so far as any definite connexion fails to obtain. And finally it is growing more and more unified by those systems of connexion at least which human energy keeps framing as time goes on. (James, 1907/2000, p. 70)

1. Introduction

The workings of the nervous system are among the most important conditions for the phenomena of mental life. At the dawn of modern psychology William James already noted that studying these conditions is one of the main jobs of psychology (James 1890/1950, p. 3). Although realizing the importance of the brain to phenomena of mental life requires "but the slightest reflection" (ibid., p 4), seeing the converse, that is, the importance of mental life to understanding the workings of the nervous system, is substantially harder. Yet, if we want to have an ecological neuroscience, we not only need to understand the function of the nervous system in appropriate terms, but, so we shall argue, we moreover need to understand our scientific understanding of the nervous system as itself a situated phenomenon of mental life – as an experiential aspect of actively adapting to a particular ecological niche.

Traditionally, there is a strong tendency in neuroscience to ignore the role of our understanding of neuroscience. Indeed, the reverse direction is usually taken, in which our understanding is accounted for in neuroscientific terms, chiefly by ascribing psychological functions to neural structure. In this vein, the brain is conceived as essentially a representational system where perceptual content arises, where selections are made (Cisek 2007; cf. Reed 1996) and the effects of action are predicted or anticipated (Friston & Stephan 2007; Frith 2007). Gibsonian psychology by contrast stresses that perceiving, selecting or anticipating are activities of situated organisms, activities that unfold in ecological, often social, contexts. The nervous system vicariously functions as an intricate part of many perceptual or action systems that take shape in such situated activities (e.g. Gibson 1966a, p. 264; Reed 1996; Van Orden et al. 2001). The role of nervous tissue gets renegotiated each time anew, in light of the contextualized (re-)organization of these perceptual and action systems. Taking this Gibsonian perspective has consequences for our thinking of the brain as having a representational function. At first sight, the ecological alternative might be taken to imply that what neural activity could represent is not independent of its behavioral or functional manifestation (e.g. Millikan 1995). Crucially however, taking the Gibsonian stance implies more than such revision: it directly undermines the idea that the notion of representation plays any role in explaining an organism's action. For if the activity determines the representation, the representation can't be cited as the causal antecedent of the activity. Making such an explanatory move amounts to reification: construing the result of activity as its cause (e.g. Dewey 1896; Heft 2003; Holt 1914; James 1890/1950; Shotter 1983).

Gibson argued against such reification time and again. For example, he construed an organism's ecological activities in terms of the currently popular concept of 'resonance' (Gibson 1966a, 1966b; Kelso 1995; Raja 2017). Starting from a reciprocity of an organism in its environment, in which organism and environment co-constitute each other in activity, 'resonance' can be thought of as a relational, world-involving activity – it is the "act of resonating" (Reed, 1989, p. 115). Such activity requires processes on multiple, and often extensive, time scales. Rather than located inside the organism or its brain, resonating or attuning then happens out in the open in a continuous transaction with the environment. With the proper skills and sensitivities, the organism can achieve resonance across the organism-environment system. For example, this might include elaborate acts that change the environment across several time scales. The term 'resonating' then is meant to capture the idea that by coordinating adaptively to its environment, the organism maintains a pragmatic fit with it (e.g. Costall 1997; Dewey 1958, p. 256 ff.; Heft 2007; Rietveld & Kiverstein 2014; Van Dijk & Myin 2018).

The point of concepts like 'resonance,' but also of related concepts such as attunement, anticipation or selection in the ecological approach, is to de-reify explanation by stepping away from explanatory neurocentrism – from the idea that the relational explanations that ecological psychology offers cannot be complete unless we've provided the psychological contribution that the nervous system makes to behavior. Yet, one might say, surely the brain is doing *something* and without an account of that something the ecological explanation remains unsatisfying. However, we claim that ecological theory cannot consistently reject an understanding of psychology in terms of neural function while also accepting that the organism's situated act of resonating (attuning, anticipating) gets reified as a nervous system resonating to ambient structure (e.g. Gibson 1966b; Raja 2017 p. 5; cf. Bruineberg et al., 2016).

As a condition for the phenomena of mental life (James 1890/1950, p. 1), the nervous system plays a crucial role in enabling an organism to adaptively coordinate with its environment. To make sense of this, however, we need to stick to Gibson's original insight that it is the active organism that is achieving resonance with its environment. In fact, for a truly ecological neuroscience we need to take this de-reification of our explanation one step further. For we need to understand neural structures, neurodynamics and whatever we say about those phenomena, as themselves situated in our ecological niche to which we need to adapt our activities.

The practice of neuroscience is itself an adaptation of humans to their environment (Dewey 1958, p. 248 ff.). We shall argue that the Gibsonian mode of explanation, the one that explains in terms like resonance, selection or attunement, explains not just because of what it says, but also because of, and in as much as, what it refrains from saying. In as much, that is, as our own Gibsonian explananda do not get reified and inserted back into their own explanation. Getting this point across will be the main goal of this paper. Our main claim then is that we can understand our scientific understanding of neural phenomena as itself an attunement to our ecological niche. By holding on to that insight we can understand some neuroscientific processes as enabling conditions for a resonating organism-environment system.

1.1. Overview of this paper

To make our case in section 2 we shall first focus on a particular instance of how humans adapt, or resonate, to their ecological niche across multiple time scales concurrently (Heft 2007; Rietveld & Kiverstein 2014). As an example of an ecological niche, we will consider a basic neuroscientific practice, namely that of learning to dissect a human brain. This will serve two goals. First, neuroscientific observations are introduced as examples of refined experiences of skilled individuals, enabled by learning to adapt to highly specialized sociomaterial practices. Getting a view of what such practices involve will show the environmental ecology of the very phenomena that are traditionally attributed to internal neural states, such as reflection, thought and the use of concepts.

Second, scrutiny to neuroscientific practice, in which observations and reflection intertwine, suggests a view of situated activity where attunement to such practices is necessary for the possibility of neuroscientific explanation. We unpack that point further in section 3 by suggesting that we can think of scientific understanding as itself an attunement to practices. In section 4 we argue that this view comes with an important constraint on theorizing: as soon as the phenomena that neuroscience sets out to explain are reified as what explains those phenomena, the resulting explanation loses all its explanatory force. This constraint not only straightforwardly disqualifies any cognitivist interpretation of neuroscience, but also poses limits on an ecological approach to neuroscience. Using several examples we end by showing how an ecological neuroscience can account for the significance of neural events, including its significance for psychology, by not letting sociomaterial practice out of sight.

2. Resonating in action

Before we get started one point of clarification is in order. When we talk about neuroscience, unless stated otherwise by the adjective "cognitive" or "ecological," we shall refer to the methods practices and observations of the study of the nervous system as a relatively autonomous physical science. A field concerned with the anatomical, physiological, biochemical or morphological details of the nervous system and its structural and dynamic phenomena at different time scales – not with any additional psychological function thereof. The significance of such neuroscientific findings, we will suggest, starts in the practical context in which they are found. Neuroscientific observation is an observation achieved in a specific practice. Such findings are therefore perfectly ecological and worthy to be studied on their own terms. For instance, the modifications in synaptic structures or the changes to neural circuitry by glial cells are only observable under very specific (in vitro) situations. Bringing such glial cell functioning out as part of a neural assembly will require great skill and care in isolating that functioning from the activities that made them visible. All the while, the physical functioning of glial cells is shown because of an even larger sociomaterial practice that affords us to observe and study it (Latour 1999).

A neuroscientific study free from the import of psychological concepts and theories, like physics and many other disciplines, can show us more of our environment. Such a study can increase our understanding of our environment by allowing us to further intertwine with that environment. In other words, once committed to a ‘neural neutrality’ with respect to psychology, the engagement in the specialized practices of neuroscience by appropriately sensitive individuals can lead to understanding the intricate working of nervous tissues. As we shall see in this section, scrutinizing those neuroscientific practices can already teach us something of what it takes to be an experiencing and reflecting animal resonating to a sociomaterial environment.

2.1. Experiencing brains

When one of the present authors was an undergraduate student in human movement sciences he was allotted one half of a human brain for dissection. Every week he would go with a small group of fellow students to a dedicated room in the basement of the faculty building. There, over the course of several months, that brain was systematically dissected. Guided by experts and through books, manuals and pictures the brain was carefully cut open with a scalpel. Slowly it unfurled and afforded the students to see hidden structures, and to look increasingly further and deeper inside the nervous tissue. All the activities in the dissection room were interlaced with lectures in which anatomical facts were taught by drawing out macroscopic structures of the brain on a blackboard. Students tried to copy these drawings into their notebooks quickly before they were erased again from sight. The students would ask questions, get instructions and ceaselessly talk to each other about their experiences. Returning to the brains in the dissection room they could thus lay bare numerous new macroscopic structures and pathways, such as the lenticular nucleus and the mammillothalamic tract. While the brain came apart, affordances proliferated.

Indeed, the bits and pieces of tissue cut off allowed skilled people to do other things too: sometimes throwing them out, sometimes drawing them, storing them or preparing slices for further scrutiny under a microscope.

What this example of learning to attune to a specific ecological niche, a niche of neuroscientific (in this case neuroanatomical) research, shows, is that the activities that are required to adapt to this niche are intertwining across various time scales and situated in shared practices (Heft 2007; Ingold, 2011; Van Dijk & Rietveld 2018). Let's consider three time scales for now (ignoring the history of each). First, there is the scale of a single action, such as that of copying off the blackboard or cutting a piece off the brain. Second, there is a larger scale activity that this other action contributed to, say making notes or finding the lenticular nucleus. Third, there is the overall situation that the activities help constitute: the unfolding lecture and dissection class respectively.

Importantly, there need not be any strict hierarchy in these three scales. On the contrary, it is the very same action that is concurrently contributing to the activities that unfold on the three scales, albeit to different degrees. The lecturing situation is a "behavior setting" (Heft 2007), which is, among other things, enacted by attentively listening (together) and making notes. These notes are made in part by copying drawings. In acting to copy a drawing then, one contributes to the act of making notes and the lecturing situation all at once (see Heft 2001; 2007). Similarly, the setting in which dissection is taught is enacted by students finding the lenticular nucleus, which is enacted in cutting into the nervous tissue. Cutting into the brain is thus concurrently the activity of finding the lenticular nucleus and part of learning dissection. In acting one is concurrently keeping multiple time scales coordinated and bringing each of their activities closer to fruition.

2.1.1. Sociomaterial practices in action

Within and across time scales brains and pictures, scalpels and words, students and teachers, lecture halls and dissection rooms intertwine in activity. In such a view all these aspects do not merely form as a pre-existing background in which activity takes place, but instead the materials as well as the people using them and talking about them take shape together in the unfolding activity. Consequently, the practices that form through multiple individuals' situated activities are constitutively 'sociomaterial,' in which "there is no social that is not also material, and no material that is not also social" (Orlikowski 2007, p. 1437). In our practices both social and material aspects take shape together, and as they do, so does the possibility to continue those practices as a participating individual (see Costall, 1997). We can think of practices as determining the (social and material) constraints up to the current situation. This process continues by drawing in, or "inviting," the participation of a sensitive individual to determine the situation further by acting appropriately (Shotter 1983; see Van Dijk & Rietveld 2018 detailing this process in terms of affordances).

One can, in other words, attune to practices by becoming sensitive to what is required to continue them, by learning to act along with them. This is however not limited to the scale of a single lecture or dissection class, where the situation can invite to participate and act in accordance with it (and in so doing sustain it). Rather the interlacing of lecturing and dissecting unfold across a (fourth) time scale in which dissection of a human brain is taught. By participating in that process, with each act of cutting, drawing, and talking together, a student also learns to resonate to the practice of dissection. By doing and exploring, attuning to the (large scale) practice of dissecting over time would allow one to see along with that practice. It would yield a sensitivity to the fact that a fresh human brain allows uncovering the lenticular nucleus (see Gibson 1979, p. 198). Once attuned to the practice available in its niche, one could even sense the possibility of doing so without a brain to work at hand (e.g. Gibson 1979, p. 139; p. 256).

2.2. Experiencing attunement

Having gained sight of the relational, multi-scaled environment, we now want to suggest that it is in this pragmatic, world-involving process that we find the phenomena of mental life that are usually ascribed or located in the brain. We shall show how this works by taking a page from Dewey. This will allow us to introduce a place in our approach for theoretical terms and concepts, which are typically evoked in giving an explanation. By showing the practical continuity from action to reflection and explanation we will argue in section 3 for understanding our understanding of neuroscience in terms of resonance.

Dewey (1958) distinguishes between primary, lived, experience and secondary, reflective, experience. Lived experience pertains to experiencing phenomena of the world – the experience of brain tissue by touching, of a nerve cell by looking through a microscope, of a sentence by listening. Lived experience is thus in action and includes both ("crude") everyday perceiving and ("refined") scientific observations arrived at through using instruments or texts, books or lectures. For Dewey it was moreover important to consider the activity of reflecting on, or thinking about, lived experience as equally a phenomenon of the world. Reflection is part of our ongoing practical involvement and therefore equally open to experience.

The distinction between lived and reflective experience then is not one of kind. In both cases, the focus is on the experiential aspect of world-involving activity, of attunement and adjustment. However to experience reflection, in the view we develop here, requires continued attunement to ongoing practices of using language. In general, humans have been adapting to linguistic life, through years of sociomaterial participation (Hodges 2009; Rączaszek-Leonardi 2009; Szokolszky & Read 2018). This seamlessly intertwines with other activity. We saw this in the practice of dissection: in learning to dissect, the students and teachers actively read, drew and talked together, they reminded each other of earlier experiences and their instructions and encouragements guided the scalpel as it cut into brain tissue. When doing this, one is coordinating activities across different time scales, such as those of lectures and dissection classes. By talking then, one forms a path that continues one activity into the other over time.

As said in this continuing process words, drawings and gestures educate attention, allowing for making "refined" distinctions or discriminations (Gibson 1966a). But apart from educating attention to brain tissue, with the activity of talking also comes a new possibility: the possibility to educate attention to the path of lived experience itself. Language, in other words, allows for reflection. One might notice recurrent aspects of different situations along paths of activity and give those aspects a name. By naming a color or learning the name of a neuroanatomical region we are able to experience more of the world together. Equally, we can turn language on itself, such as asking for the meaning of a word, or just ask "what did you say?" (Taylor 2013). That is, we can make language an issue for itself (Varela et al. 1991). By noticing patterns in language, say focusing on when and where words are used or should be used (e.g. articulating their "meaning"), we can articulate methods or develop concepts for using them. In the pragmatic view we take from Dewey, the phenomenon of reflection or thought is an experiential characteristic of attuning to such language involving sociomaterial practices.

It was important to Dewey that experiencing reflection is part and parcel of adapting to human sociomaterial practices and never leaves this process. Experiencing thought and phenomena like "inner speech" in this conception are experiences of an open system attuning to ongoing language involving practices of the environment-at-large. They are not self-sufficient internal representational content-carrying states. Indeed, it is in the context of further acting by talking, using words, gestures or drawings that reflective experience gets its significance. Crucially, by continuing reflection into activities of talking, gesturing and so on, it returns us to lived experience and makes a difference to our behavior. This behavior can be turning attention to a scalpel for making a cut, but can also be limited to situations of evaluating or refining the use of words (such as we often do in academia). In any case, by "laying down a path in talking" (Van Dijk 2016), reflection helps to "regulate further experience" (Dewey 1958, p. 18; see also Gibson 1979, p. 260; Ingold 2011). By starting from and returning to lived experience, the use of abstractions can attune us to increasingly large scale practices, guiding activity towards a refined experience of the world we try to keep a grip on.

There is much to develop further here, which space prohibits us from doing. The point we need to take from this is however that this processual approach locates lived and reflective experience, observations, thought and our use of concepts in an ongoing, widening and situated process. It is the attunement to this extensive process that allows us, as active participants in this process, to furthermore explain the refined observations we make through the concepts that we develop within it. Bringing these ideas to bear on ecological neuroscience, our claim will now be that we can only explain neuroscientific observations if we take them as continuations of this process and not as underlying the concepts we used for making them.

3. Ecological explanations

With this processual and situated view of human activity, ecological psychology can understand our scientific observations in terms of attunement across time scales, but also understand our scientific understanding in terms of a sociomaterial process. That is to say, scientific explanation, the experience of having explained something by evoking scientific concepts, consists in a similar attunement to a practice. To see this, let us return to Dewey who, armed with the notions of lived- and reflective experience, asked how science as a human activity can help us understand nature. How is it, Dewey (1958, p. 5) asked, that theories and concepts (the objects of reflective experience) can *explain* the observations we make (the phenomena of lived experience) in a practice such as brain dissection? How can we grasp such observations "with *understanding*" (ibid, emphasis original)? His answer was that our reflective experience of scientific concepts, via formalizations and hypotheses define or lay out:

> "a path by which to return to experienced things is of such a sort that the meaning, the significant content, of what is experienced gains an enriched and expanded force because of the path or method by which it was reached" (Dewey, 1958, p. 5)

Our theories then define a path of sociomaterial practices to follow. They afford us to make new, significant observations. To take Dewey's own example: Einstein's "methods of reflection," such as his activities of calculating the deflection of light by mass, afforded a turn to a rare piece of lived experience: to see an eclipse of the sun in a new way. With Einstein's calculations, the proper training and instruments, during the solar eclipse of 1919 a change in the positions of stars near the sun could be experienced—one which otherwise would have gone unnoticed. The expedition led by Dyson and Eddington didn't just observe these deflections of light for the first time, but they were moreover *significant* to the observers. No longer an anomaly or an "isolated detail" they were *understood* because they were "rendered continuous with the rest of nature and take on the import of the things they are now seen to be continuous with" (ibid.).

In other words, through shared and distributed activities over time, the sociomaterial practice of doing science can lead to attunement to previously unavailable phenomena. These phenomena are open to experience for those that participate in the practice. The elaborated methods of reflection such as calculating, using telescopes, copying drawings, reading books and using scalpels are a constitutive part of achieving this particular instance of resonance. As humans develop new ways of manipulating materials, this enables them to notice and *understand* a phenomenon of lived experience. On this view, to explain how scientific practices enable us to understand, it doesn't suffice to point out that they get one to the pre-existing reality (of philosophers), to which our abstractions somehow "correspond" correctly or incorrectly. On the contrary, we can explain how our abstractions explain by seeing that they afford us practices that entangle us further in the world (Costall 2004). Resonating to these practices allows taking new paths and differentiating activities to refine lived experience, making this refinement continuous with "the rest of nature" (Dewey, 1958, p. 5). For the importance of *theory* Dewey thus points back to the history of *practices* that embodies it; scientific theory explains because of what its methods of reflection afford individuals resonating to those practices.

3.1. An addition to our resources

In a Deweyian vein, neuroscience offers ecological psychology ways of explaining by taking observation, reflection and explanation as pragmatic continuations of each other. It offers the tools to study some of the physical processes that allow organisms to be sensitive to the possibilities for action such practices bring – from talking over coffee to reflecting on scientific phenomena. The ecological concepts of resonance, attunement and so on, seamlessly fit into this just so long as they are understood as an achievement of this ongoing relational process rather than as its precondition. In short, neuroscientific explanations should not be the means to reduce our resources (i.e. reducing affordances or resonance to neural states) but should be tools to proliferate them (Dewey 1958, p. 263). To see how this works this, let us consider an example of the way changes in neural connectivity might be explained by our learning to differentiate colors over time (see Van den Herik 2018 for a discussion of these findings in a related context) and how a blind person's ability to read braille might be explained by neural enabling conditions.

As illustrated by Angus Gellatly (1995), building on Alexander Luria's work, different day-to-day practices based on the visual characteristics of objects, influences how people sort different objects into 'similar' categories. For example, non-literate Uzbek traditional farming people, though capable of using the standard hue names, do not rely on those standard names in spontaneously verbally labeling or sorting of colored samples of wool. Rather they make "great use of figurative labels, often relating to everyday practical activities (spoiled cotton, calf's dung, peach)" (Gellatly 1995, p. 210). Because of their sociocultural surrounding, specific aspects of the colored objects are practically relevant. This relevance shapes the transgenerational education of the attention of those continuing to inhabit this specific ecological niche, leaving traces on materials, language, bodies and brains alike.

Congruent with these findings, it has been reported that people who speak languages which lexicalize the difference between light and dark blues, have different, and neurally distinguishable, perceptual sensitivities: they show dissimilar neural activation profiles when looking at light and dark blues (Thierry et al 2009). To be exact, both the P1 latency and P1 amplitude measured at the parieto-occipital area differed significantly between people that did or did not grow up in a language that have separate single words for light and dark blues (i.e. Greek and English respectively), as did the variance within participants of both those measurements between groups. Moreover these people quite unsurprisingly show verbal responses in tasks involving those two kinds of blues unlike the verbal response of people whose language doesn't lexicalize the relevant difference (Winawer et al. 2007). Clearly, it would be rash to conclude from the existence of these neural differences that they explain the differential verbal behavior in such tasks. Rather, the converse holds: the neural differences have a sociomaterial origin and are understood because of that: the participation in different languages, each uniquely immersed in the sociomaterial context of their respective ecological niche predicted and explains the distinguishable neural profiles in a discrimination task.

In these and similar cases it is our taking note of the practices that subjects have learned to attune to that allow us to observe some neural phenomenon "with understanding" (Dewey 1958, p. 5). P1 latencies become significant in the context of the available linguistic distinction in blues. Equally, the size of the hippocampus is seen with significance given the practice of driving a taxi cab in London (Maguire et al. 2000), and plaques in the brain get their significance in the context of Alzheimer's disease (see Kumar & Singh 2015) not the other way around. Once the practice within which those neural differentiations were made have come into being, one might predict that they will be a crucial factor in sustaining these practices. Although this seems plausible, research taking the trouble of showing this is less common. A proper ecological neuroscience in which neuroscience can help explain ecological activity aims to establish and pay attention to these connections too.

3.1.1. Piece-meal paths

Neuroscientific phenomena and psychological phenomena are different things and found in widely different sociomaterial practices. But we can also aim to achieve coordination between a neuroscientific phenomenon and a psychological one. This then adds to and continues our practices, rather than reduces the one to the other. From an ecological perspective neuroscientific theories allow us to refine our observations of ecological phenomena. On the basis of a particular neural dynamic, such as the P1 latency effect in a particular task, it is conceivable that we can perhaps predict or change how behavior will unfold next by disrupting it. Thus we would be able to show that that particular neural tissue is an enabling condition for that particular situated activity. It is thus essentially an open empirical question whether we can show that neuroscientific theory can make a difference to human behavior in a particular context.

Disruptive techniques such as Transcranial Magnetic Stimulation (TMS) notably offer such a possibility, as can be illustrated by a seminal study of reading braille (Cohen et al. 1997). In persons without visual impairment, the occipital cortex is, rather suggestively, called the “visual” cortex. In blind people however the cortex comes to make a difference in haptic perceiving. This was shown by disrupting the dynamics of the occipital cortex in (early) blind people during braille reading. This intervention hampers braille reading and moreover causes haptic illusions (without it having these effects on normal-sighted subjects) (Cohen et al. 1997). What this study shows is a concrete dependence of an ecological activity upon the proper working of some nervous system. It shows that particular neural dynamics are an enabling condition for the adaptive situated activity of reading braille.

Importantly, such concrete dependence is still tied to the particular situated activity of reading braille for understanding it. One recent experiment details how the surrounding practices override any function allotted to the nervous system. Subjects attuned to languages with or without the light/dark blue lexicalization were asked to decide whether a blue shape was of the same color as a target blue shape (Winawer et al. 2007). When there was a distractor shape which was also blue, but of the alternate light blue/dark blue category than the target, subjects attuned to a language that lexicalized the distinction took less time to perform the task than subjects were not adapted to making that distinction in their lexicon. Interestingly, these differences disappeared when the subjects who showed the effect were asked to simultaneously engage in another verbal activity (rehearsing digits), but not when performing a nonverbal activity. Here we see that the situated activity overrides the “function” a neural structure could bring. While the subjects will have neural structures that have taken shape in light/dark blue distinction making practices, the actual situated activity, in this case the addition of a verbal task, still supplies the terms by which we can assess the difference that such a neural distinction makes to actual performance.

Neuroscientific theory can guide scientists in a piece-meal way to return to lived experience, and make a refined observation of ecological phenomena. When we succeed in doing this we establish a path of activities that achieves continuity between two practices: that of the ecological activity we were out to understand (such as reading braille), and that of the study of neural dynamics (such as of the occipital cortex). Crucially, when we get to explain the former in terms of the latter, we explain because we successfully coordinated these two practices, because the observations we thus were able to make are not isolated details, but "continuous with the rest of nature" (Dewey 1958, p. 5).

4. Explanations without reification

In the preceding examples of explaining neural observations in light of the practices that surround them and, conversely, explaining ecological observations in light of the neural conditions that enable them, we've suggested that scientific explanation gets its "force" from the "path or method by which it was reached" (Dewey, 1958, p. 5). Even though the explanations go in opposite directions, this need not involve any circularity. Indeed, as we shall now argue, this explanation works only as long as the path does not become circular: as long as it does not reify the phenomenon to be explained as its own explanation (Van Orden et al. 2001).

In reification features originally taking shape in an ongoing sociomaterial relation (observing a mammillothalamic tract, discriminating colors) are taken out of the process and concretized as "interact-able" parts that precede the relation in which they were originally found. In cognitive (neuro)science, the process of reification increasingly dissociates and relocates the "social" aspect of the sociomaterial practices that we visited in section 2 inwards (as cognitive, subjective, knowing) and the "material" aspect outwards (as physical, objective, known). In ecological neuroscience, the same tendency would turn the practical relation into a resonator (the organism or its brain) on the one hand and a ready-made world (ambient information or environmental dispositions) on the other. By staying with the continuous formation of the sociomaterial process (section 2.1.1), the more we scrutinize the widening and differentiating web of sociomaterial relations, the less we are required to think of either cognitive behavior or resonance as located internally. In fact such reification would undermine the whole framework.

Reification often takes the form of a circular explanation. Such an explanation is problematic because it pre-supposes what it sets out to explain, when an explanation "[implies] cognition so as to account for cognition" (Gibson 1979 p. 253; see p. 304). For instance, Einstein's skill in calculating the diffraction of light, cannot be explained by saying that Einstein's brain was doing those calculations. By the same token, of course, neither can the phenomenon of calculating be explained by saying that we resonate to the possibility to calculate that was already afforded by the environment. A phenomenon cannot both require an explanation *and* be doing interesting explanatory work *at the same time* (Hutto & Myin 2017; Ramsey 2017).

From the perspective we sketched here, the problem with the circularity of reification is that it turns the path of continuing reflective experiences into refined lived experience idle. That is, in spite of the many activities, no real move is ever made, and the conclusion coincides with the starting point. For instance, in a rigorous analysis of 'double dissociation', Van Orden et al. (2001) convincingly showed that the observation of modular psychological functions in the brain on the basis of brain damaged patients is premised on the theory that already takes for granted the existence of such functions. Any empirical observation of a neural process not functioning as predicted by a previous ascription of function, can simply be redescribed to fit a different function– *de facto* showing that the observation is inconsequential to the theory of psychological function. It is thus no longer the established continuity of our practices that allowed for a refinement of lived experience and our understanding of it. It is rather an *a priori* assumption about the nature of reality (e.g. of the architecture of cognition) that takes care of such continuity beforehand. As we saw from Dewey's example however, if scientific explanation gets its force from our ability to resonate and continue our practices into refined observations, then neglecting those practices at best yields pseudo-explanations, at worst it makes researchers deny the intricacies of the human ecological niche that got them in the position of being able to explain the facts in the first place (Costall 2011; Wilcox & Katz 1984).

The upshot of all this is that if we buy into the logic of reification we would be denying the fabric of ecological reality and are left empty-handed. Starting from the ecological framework we should not just be suspect of representational explanations in psychology but equally of any view of realism that gives rise to such reifying explanations for our scientific understanding (Costall 2004; Van Dijk 2016). Once we consider neuroscience to be a part of the human econiche, it allows us to study its practices in order to gain an understanding of the intricacies of such niches. What's more, on this view neuroscience is required to take its own practices seriously – i.e. not to reify them – if it is to offer us an understanding of phenomena, such as resonance, selection and attunement, it allows us to explore.

5. Concluding remarks

Neuroscientific experiments can be genuinely ecological and explanatory just so long as we do not take their explanatory powers to go beyond showing the enabling conditions for phenomena mental life. We may well determine experimentally that there is a neural pattern necessary for several (similar) activities to unfold. But we should refrain from adding that *therefore* these activities share a common psychological function embodied by these neural dynamics (cf. Anderson 2014, p. 151). We should rather stick to the phenomena and look for piece-meal answers that don't negate the very practice that enabled experiencing the phenomena to begin with. Attuning or resonating is enabled in part by a vicariously functioning nervous system (Gibson 1966a; Reed 1996; de Wit et al. 2017), but crucially the nervous system is not doing the resonating, the acting, selecting or anticipating. Such claims undercut the explanatory gain achieved by neuroscience by presupposing what it sets out to explain, or losing the explanatory force gained by the pragmatic continuity "which human energy keeps framing as time goes on" (James, 1907/2000, p. 70). It would moreover jeopardize the very processual framework that offers us a way of making sense, in a non-representational way, of the phenomena of mental life, such as those of reflection and understanding.

The more we want to understand what happens inside the nervous system then, the more we also need to look at the wider (sociomaterial) environment through which we gain such understanding. Indeed, it is by considering neuroscientific observations in their practical context that they have significance at all. By doing the work of attuning and adapting to their econiche, scientists can perhaps predict some of the behavior of situated organisms. In particular cases, this shows a concrete dependence of “life and mind” (Dewey 1958, p. 262 ff.) upon neural events. But we should not forget that we establish such a relation by proliferating our affording practices. By achieving coordination between practices we establish a new path of activity, which is an “addition to our resources” (ibid., p. 263). Neuroscience can fend for itself, but for a sustainable ecological neuroscience our evolving sociomaterial practices require ever closer attention.

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