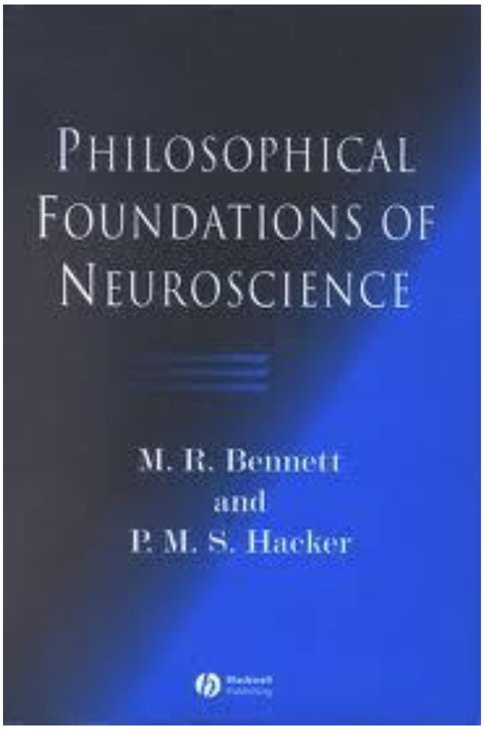
Pragmatic Confusion

A Critical Appraisal of Bennett & Hacker's

Philosophical Foundations of Neuroscience



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1. Introduction

During my masters in Neuroscience, I was working in a laboratory that studied the molecular aspect of cognitive abilities such as knowledge and memory. My research focused on the translocation of the memory engram from its initial formation place, the hippocampus, to its definitive storage place, the parietal lobe. The study design was meant to have implications that transgress levels, from molecules to behaviour, and species, from mice to men. However, the validity of the presumptions made and therefore the overall validity of this research seem to be somewhat questionable. At that time, I came across *Philosophical Foundations of Neuroscience*.

Philosophical Foundations of Neuroscience addresses a lot of conceptual questions that burden neuroscience. The view of M.R. Bennett en P.M.S. Hacker is just as controversial as refreshing. Even though to some the approach feels as a step backward, the authors wish is to free the neuroscientist from hidden assumptions that lead to an indefensible philosophical position in order to make the next big leap forward in neuroscience. Therefore, I decided to dedicate this thesis to an analysis of *Philosophical Foundations of Neuroscience.* In the first part of this thesis I will give an extended summary of the book . In the second part a few of the criticisms will be discussed, ending in some final recommendations on how to use this book in the everyday practice in a neuroscience lab.

2. Summary

Philosophical Foundations of Neuroscience (1; hereafter PFN) is born out of collaboration between a philosopher and a neuroscientist. P.M.S. Hacker is a one of the most powerful contemporary exponents of the linguistic approach to philosophy pioneered by Wittgenstein and his principal expertise is in philosophy of mind and the philosophy of language. M.R. Bennett is a respected neurophysiologist, whose fundamental research on synapses is often used by cognitive neuroscientists who perform research on memory and learning. Together they took on the mammoth task of analyzing the theoretical foundations of current cognitive neuroscience. After an introduction, PFN is divided into four parts. Part I starts with a historical survey on neuroscientific research and theory. Part II and III contain detailed justification for their criticism, which is subdivided by selected psychological concepts. Part IV focuses more on philosophical matters as it discusses the problem of reductionism and the relation between philosophy and neuroscience.

2.1 Philosophical Problems in Neuroscience: Their Historical and Conceptual Roots

2.1.1 *Early growth of neuroscientific knowledge*

M.R. Bennett and P.M.S. Hacker (hereafter: B&H) start their survey of the historical and conceptual roots of the biological basis for sensory, volitional and intellectual capacities with Aristotle's work on the *psuche*. Aristotle ascribed to each living organism a *psuche*, which he described as a set of capacities of the creature. Thus, in his theory of hylomorphism the *psuche* or soul is neither *a part of* nor an additional *entity* related to a living being. This conception of the soul prevents attributing the exercise of the distinctive powers to the soul of the creature whose soul it is, and continued to be the basis for theoretical discussion until the arrival of Descartes.

Descartes transformed the conception of the mind or soul. He held that the mind is the whole soul. This soul consists of a mental substance, which essence is thought (res cogitans). Matter, i.e. the body, was conceived as a distinct substance, but one that is in intimate union with the mind. Subsequent research led to the development of the cortical doctrine, which held that the basis of psychological functions resides in the cortex. The late nineteenth century work of Broca, Fritsch, Hitzig and Sherrington further extended the knowledge about the specificity of the localization of particular functions within the cortex, such as the involvement of the *precentral gyrus* in the execution of voluntary movement.

2.1.2. *Sherrington and his protégés*

Although Sherrington's research revealed a lot about the functioning of the nervous system, the role of the mind and its relation to the cortex was still problematic. Sherrington had a Cartesian conception of the mind and its interaction with the body and found science to be impotent to solve the problems surrounding the latter. Sherrington's disciple J. Eccles completed Sherrington's research program. Eccles was heavily influenced by Karl Popper three-world doctrine which led to a dualist view on the mind-body problem. An important contemporary of Eccles, W. Penfield, was a neurosurgeon, who also contributed much to neuroscientific theory. Clinical observations led him to conceive a man's mind as the person who reasons and decides. In his view, the mind effects its interaction on the highest brain mechanism, the meeting place of mind and brain, by a second form of energy. This shows that even while neuroscientific knowledge grew, the theoretical foundations continued to be dualistic and the brain-body nexus remained problematic.

2.1.3 *The mereological fallacy in neuroscience*

In the final chapter of Part I, B&H sketch their main criticism. The third and current generation of neuroscientists repudiates substance dualism which was endorsed by the previous generations. They attributed the psychological functions of a human being to the brain. However, this is just a degenerated form of Cartesianism as the immaterial mind has been unreflectively replaced by the brain. This, B&H argue, leads to conceptual confusion.

The concept of the brain thinking, believing, seeing, etc. should first be tested by philosophical enquiry, as it is a *conceptual* question whether the brain thinks, believes, etc., and not a *scientific* one. So, before one is able to investigate experimentally whether brains do or do not think, believe, etc. one has to first determine what it would mean for a brain to do so. B&H argue that *ascribing psychological attributes to the brain makes no sense*[1] because the brain cannot possibly meet the

[1] B&H's use of sense en non-sense can be seen as a reference to Wittgenstein. In the *Tractatus* Wittgenstein explores the conditions for a proposition having sense. He concludes that having sense rests on the possibility of representation or picturing. This leads to the distinction three kinds of propositions: meaningful (*sinnig*), nonsensical (*unsinnig*) and senseless (*sinnlos*). Senseless propositions, such as tautologies and contradictions, do not picture anything and do not, therefore, have sense, whereas nonsensical propositions violate logical grammar and are, therefore, devoid of meaning.

conditions of application of psychological predicates. By positioning the brain as the subject for psychological predicates, the third generation of neuroscientists commits a *mereological fallacy*, which is the mistake of ascribing to the constituent parts of an animal attributes that apply only to the whole animal.

This mereological principle is a logical principle and convention, which determines what does and does not make sense. Its application to psychological concepts involves certain conceptual commitments.

(i) We start with the notion that we typically apply psychological attributes to others non-inferentially. The evidential ground for the ascription of psychological attributes to others, such as pain-behaviour for the ascription of pain, are not inductive, but rather *criterial*; i.e. the evidence is logically good evidence. The criterial grounds for the ascription of a psychological predicate (pain-behaviour for pain) are partly constitutive of the meaning of that predicate. So, neurophysiological events are inductively correlated with pain-feelings by correlating it with pain-behaviour. This leads to the conclusion that the brain does not satisfy the criteria for being a possible subject of psychological predicates as it does not exhibit pain-behaviour. The observed neural phenomena are just inductively correlated with pain and its nexus with the criterial, non-inductive evidence for it.

(ii) The second explanation for the mistaken ascription of psychological attributes to the brain is the array of Cartesian and empiricist misconceptions concerning 'the inner' and 'the outer'. Psychological attributes are conceived as 'inner' and as 'mental'. According to this picture each person has privileged access to his own mind and private ownership of his experiences. Others have only indirect access by inducing it from one's outward behaviour. This is, however, a misconception as to feel emotions is not to perceive or to observe anything. We observe manifestations of emotions of others; there is nothing 'inner' or unobservable about that. Furthermore, introspection is not a form of perception but a form of reflexive thought. In another sense, it is a matter of attention to one's moods and emotions, sensations and feelings.

2.2. Human Faculties and Contemporary Neuroscience: An analysis

In the second part of PFN the research on sensation and perception, the cognitive powers, the cogitative powers, emotions, volition and voluntary movement is discussed. The accusation made in the first part of PFN, namely that neuroscientific theory is based on crypto-Cartesianism and often commits a mereological fallacy, is meticulously justified in this part. B&H provide this justification by 'connective analysis', a model of analysis introduced by P.F. Strawson (2). In this model, proper understanding of concepts and their connections comes by analyses of the ordinary usage of these terms. This results in a systematical review of the terms used in this part of neuroscience, which is further subdivided in five faculties.

2.2.1 *Sensation and perception*

B&H start with a connective analysis of sensation and perception. First, the passive power to have bodily feelings should be distinguished from the perceptual power of the five senses. Secondly, bodily feelings should be subdivided in sensations (my elbow itches) and feelings of overall bodily condition (I am feeling so tired). To have a sensation, which is the same as feeling a sensation, therefore is not to perceive anything. Sensations have qualities, such a degrees of intensity, phenomenal qualities and a bodily location. The subject of a sensation (such as pain) is the *person* (or animal) that manifests it, not his mind or brain. Similarly, the criterion of the qualities of sensation, e.g. location, is the behaviour of the subject of exhibiting the sensation. The same holds true for perceptions, as the criteria to ascribe it to a subject lie in the manifest behaviour. In contrast to sensations, perceptual powers are *cognitive*, in the sense that by their exercise we can acquire knowledge of our environment and they can be trained (to observe, to hear, to smell, to taste are conscious activities). The brain cannot be the subject of sensation or perception, as it neither a perceptual organ nor can *it* manifest the appropriate behaviour.

B&H address three other issues concerning perceptions. First, they note that the claim that colours, sounds, etc, are essentially subjective is not a physical hypothesis but a metaphysical one, which is misconceived. Second, the classical doctrine on perception that claims what is seen or heard is *an image* is also mistaken. The brain neither takes a picture apart nor assembles one. Therefore, the question how it comes that the input of the different sense organs combines to a coherent picture wherein sound, image, smell etc. are perfectly attuned (*the binding problem* is) confused. Third, the conception of the brain as an operating system of *symbols* that *represents* features of *an image* in order to construct *descriptions* is misconceived. The brain cannot use symbols because *it* cannot *mean* anything by a symbol. As a symbol has a rule-governed use in order to have meaning, there is a correct and incorrect way of using it. However, in the brain there are only neural events that are causally correlated with certain other events; neurons simply *cannot* engage in correctly (and sometimes incorrectly) rule-governed behaviour. In addition, the output of the visual system is not a description but the output is for a creature to see whatever it sees.

2.2.2 *The cognitive powers*

Knowledge is assumed to be akin to an *ability* instead of a *mental state*. When one has acquired knowledge, one has become able to do a wide range of things (find, locate, explain things, etc.) Knowledge acquisition occurs by different methods such as endeavour, words of others, by noticing, recognizing, becoming aware, etc. It is the human being, not his brain, that knows things and possesses the abilities constitutive of knowing something. Furthermore, it is equally confused to speak of the brain containing knowledge, as there are no *symbols* in the brain that express a single proposition. Information can only be 'derived' from neuronal activity which is implied by PET or fMRI scans.

Like knowledge, memory is a *cognitive* power of human beings. It is the faculty for the retention of knowledge. What is remembered does not need to be in the past, but must be something one previously knew or was aware of. In neuroscience memory is divided into declarative (propositional) memory and non-declarative (habit or skill) memory. According to B&H non-declarative memory, including classical conditioning, is not memory at all but just acquisition of certain dispositions. This leads to the conclusion that most studies on memory are not at all studies on memory, as these are mostly based on training and classical conditioning of lower mammals such as mice.

2.2.3. *The cogitative powers*

The cogitative powers signify a group of general concepts such as *belief, thought* and *imagination*. These concepts are linked to but still are very different from *cognitive powers* such as knowing and remembering. The cogitative power of belief is related to the cognitive concept of knowledge. Like knowing, one does not cease to believe when one falls asleep. However, unlike knowing, believing is neither an ability nor akin to an ability. A belief may be true or false, correct or incorrect. Therefore, the concept of belief is also linked in various ways with doubt, certainty, conviction, being sure, etc.

Thinking is a miscellaneous term as there are a lot of varieties of thinking. This has important implications for the neuro-scientific study of thinking. (i) Neuro-scientific research is prone to take one or two examples of thinking to represent the whole variegated field. (ii) The manifold varieties of thinking make it evident that thinking is not an attribute of the brain, but of the human being. (iii) The brain is neither the locus of thought, as Edelman and Tononi claim, nor is the brain the organ of thought. It is true that without very specific neural activities one could not think, but one does not think with one's brain in the sense in which one walks with one's legs.

Imagination is the capacity to think of possibilities and is linked to the concepts of thought and conception, memory, perception, illusion and creativity and invention. It is evident that it is misconceived to suggest, as Blakemore does, that since there are topographically arranged sensory areas in the brain, the brain contains images of the outside world. It is not possible for the brain to have images and there are no images *in* the brain: there are images in mirrors, on screens, on film, on the retina, etc. Moreover, mental images are neither necessary nor sufficient for imaging as much of what is imaginable is not picturable. So, the capacity to conjure up images (*fantasia*) is only loosely connected with the cogitative faculty of imagination.

The faculty of imagining images (fantasia) has attracted much attention from neuroscientists. Posner and Raichle claim, on the basis of PET and fMRI studies, that visualizing something involves the excitation of much the same neural systems as perceiving. However, Posner and Raichle err in supposing that in perception and fantasia alike *an image is formed in the mind*. Furthermore, it is important to keep in mind that there are logical differences between perception and fantasia as a mental image has no objective and determinate properties.

2.2.4 *Emotions*

When analyzing emotions it is necessary to distinguish them from emotional *character traits* and an emotional *attitude*. It is also important to note that one cannot measure emotions simply by the frequency and intensity of perturbations a person feels. Rather, its strength is evaluated by reference to the extent to which the emotion determines behaviour over time. As a result, the idea of the duration of an emotion is ambiguous. This ambiguity and variation make it impossible to have one single conceptual prototype. For neuroscientific investigations, it is important to highlight the following points:

i. Emotions of humans differ significantly from those of non-language using animals. Animals lack the cognitive and appraisive capacities which colour human emotions, as these are linked in complex ways to knowledge and belief.

ii. It is important to distinguish the *object* and the *cause* of an emotion – what *makes* one jealous is not the same as what one is jealous *of*.

iii. Some emotions have characteristic somatic accompaniment, sensation and physiological reactions. The somatic accompaniments of an emotion, e.g. brain states and somatic reactions, do not suffice to identify the emotion or to warrant its ascription.

2.2.5 *Volition and voluntary movement*

Matters of volition are primarily concerned with *action* and each of the concepts within this domain is linked in more or less direct ways with explanations of human behaviour. Among human actions we can distinguish between: (i) voluntary, (ii) involuntary, and (iii) non-voluntary acts. (i) A fully voluntary movement is the exercise of a two-way power to do or to refrain from doing something. Contrary to what is generally believed, voluntary movement is not a movement *caused* by a volition or act of will. If willing would be an act or event which is antecedent to a voluntary movement, willing should also be a voluntary act. Otherwise, the voluntary movement would not be *voluntary* anymore. However, this leads to a vicious regress. Therefore, wanting, intending and deciding are the *reasons* and not the *causes* of action or movements. (ii) Involuntary behaviour, such as an automatic reflex, is distinguished from non-voluntary behaviour. (iii) An act is non-voluntary if someone or something *forces* you to do it.

2.3 Consciousness and Contemporary Neuroscience: An Analysis

In the third part of the book, B&H use the insights from the preceding section to elucidate the conceptual confusions that seem to bedazzle scientists that investigate consciousness. This puzzlement is generated by a crypto-Cartesian thought; how a physical (neural) event can produce consciousness, which is categorically distinct from matter. However, to find the nature of consciousness by scientific inquiry, *empirical problems* should be distinguished from *conceptual ones*.

2.3.1 *Intransitive and transitive consciousness.*

A first step to clarity is to distinguish *intransitiv*e from *transitive* consciousness. Intransitive consciousness is something that a person or animal may lose (on fainting or being anaesthetized) and subsequently recover (when regaining consciousness). Only of a living being, in particular a sentient creature, can one say that it is conscious or unconscious. Consequently, intransitive consciousness is not a feature of the brain but of the *whole sentient creature*. The brain is an essential requirement for consciousness but not a cause, just like oxygen to fire. Thus, ascribing consciousness to the brain, or even to one of the hemispheres of the brain, is a *mereological fallacy.* Furthermore, it is important to note that there is nothing intrinsically private about intransitive consciousness. We can ordinarily *see* whether a person is conscious or not. However, in the first-person case, it is not evident on the grounds of any *behavioural criteria*, as me being conscious (intransitively) is a precondition for me having any experience at all, visual sense experience included.

On the other hand, there is *transitive* consciousness, which lies at the confluence of the concepts of knowledge, realization, receptivity and attention. Transitive consciousness has a *polymorphous* character and can therefore take diverse forms, such as perceptual, somatic, kinesthetic, affective and reflective consciousness. One can be conscious of one's *motives*, of one's actions or of one's self. Due to this diversity, there is no special faculty or organ of transitive consciousness and no one thing that neuroscience needs to investigate to explain transitive consciousness. Transitive consciousness is also factive and existence-implying because when one is *conscious of* something, one also *knows* it to be there. The different forms of transitive consciousness have different relations with concepts such as attention, reflection, deliberation.

2.3.2. *Conscious experience, mental states and qualia.*

When reflecting on the nature of consciousness, neuroscientists are often focused on *conscious mental states* or *conscious experiences*. They extend the domain of consciousness to encompass the whole range of experience or all forms of sentience in general. The question is whether this extension of the concept of consciousness is unproblematic. First, the use of the phrases 'conscious experiences' and 'conscious states' is ambiguous. A *conscious experience* is not an experience that has the property of being conscious. It is an experience of which one is conscious or which is had while being conscious. The latter is normally pleonastic as, dreams apart, all experiences are had while conscious. Extending consciousness to the range of perceptual experience is awry as it masks the discriminations in the concept of *transitive* perceptual consciousness, such as that not everything we see holds one's attention. On the other hand, extension of consciousness can also result in encompassing all conscious mental states, which are states one is *in* for a while. Mental states therefore have a *genuine duration*.

The temptation to extend consciousness to the whole domain of ‘experience’ was strengthened by the philosopher’s conception of *qualia* as the qualitative character of experience. However, neuroscientists should be wary not to get entangled in the problems of the so-called *qualia.* To bypass confusion, it is important to keep in mind that a quality such as red is not an affection of the mind but a property of an object. Furthermore, the appearance of the indescribability of qualities is due to non-conformity with the paradigm for the description of substances, which is the description of a material object by specification of its properties or qualities.

2.3.3 *Puzzles about consciousness*

The many misconceptions about consciousness lead to a number of ‘puzzles’ about consciousness, such as its *evolutionary emergence*. This puzzlement is rooted in the picture of consciousness as a realm of subjectivity, populated by qualia, which emerges mysteriously from a complex arrangement of material particles. However, we attribute consciousness on the grounds of a creature’s behaviour. There is no *sharp* divide in nature between a creature to which it makes sense and to which it makes no sense to ascribe consciousness. Furthermore, it is an illusion to think that it is mysterious that physical events, such as nerve excitation, affect consciousness. This misconception is based on the impression that after nerve excitation, in the brain, occurs a categorically distinct phenomenon: namely, an experience, a quale or an image. The confusion lies in the misconceived picture of what *an experience* is. The discoveries in neuroscience just point out *which neural events in the brain are necessary for a human being to have such and such an experience*.

There is further puzzlement over what consciousness is *for,* how one is able to be aware of the *contents* of perception, but cannot be aware of the *process* of perception and the problem of *other minds*. According to B&H, the question of the evolutionary advantage of consciousness is either naïve or confused. Transitive consciousness enables the creature to react to its environment and the advantages of this are patent. Intransitive consciousness is a presupposition for transitive consciousness. The problem of awareness is bogus as it is a logical truth that one cannot be aware of something that is not perceptible to one (we do not have an organ for perceiving neural excitation). Finally, B&H disentangle the problem of other minds as the ascription of consciousness is done by reference to the behavioural criteria, not by analogy to our own case.

2.4 On Method

2.4.1 *Reductionism*

In the final part of the book, B&H discuss the methodological ramifications of their analysis. They start with a critique of reductionism. Reductionism encompasses an *ontological* (one kind of entity is no more than a structure of other kinds of entity) and an *explanatory* (a complex system can be explained by the behaviour of its interacting parts) type. However, reductionism in neuroscience is implausible as human beings are not ontologically reducible to their nervous system. Firstly, there are no psychological laws of human action to reduce to neural laws nor are there bridge principles which would allow such ontological reduction. Secondly, the neuroscientific reduction which is used to explain behaviour is just a *redescription*. When one asks *why* somebody is *V*-ing, one is asking for the reason or motivation that is referenced to social norms and convention, not for the neural events that underlie *V*-ing. What neuroscience *can* do is explain the neural conditions of *the possibility* of the possession and exercise of human powers (*V*-ing), and also can contribute to explanations of irrational and pathological behaviour.

B&H continue to discuss a more radical form of reductionism: *eliminative reductionism*. This advocates eliminating all psychological explanations of human behaviour and replacing it with a future neuroscientific theory that will explain all human conduct. B&H's answers to supporters of this position is that there are forms of explanation and understanding that are neither scientific nor theoretical. It is not a scientific discovery that one knows that there is a tree in the garden. Although this observation is *concept-laden* (expressed in language using concepts), it is false to suppose it is *theory-laden* (no *theory* has been employed: a 3-year old toddler can know it). In addition, eliminative reductionism is not a serious option for the explanation of human nature and human behaviour as it is not a possibility to jettison the folk-psychological concepts that define *its* subject-matter, and the use of which in discourse is partly constitutive of its subjects.

2.4.2 *Methodological reflections*

In the final chapter, B&H turn to methodological questions and objections. Two objections against the accusations made in PFN are be discussed, namely that apparent errors in neuroscientific writings are in fact linguistic innovations warranted by a new theory or are just figurative uses of language due to inadequacies of the English language, or both.

The first objection is defended by P.S. Churchland, who objects to the examinations of use as a key to the determination of sense. She claims that 'whether a hypothesis makes sense to someone will not be independent of his background beliefs and assumptions'. However, questions of sense antecede questions of truth as conceivability and imaginability are not criteria for making sense. What makes sense is up to the rules of language and to adopt a new framework is to change the rules and therewith the meanings of the words. Neuroscientists do not redefine the meanings of the psychological vocabulary and as a result they often commit a mereological fallacy. They transgress the bounds of sense as they attribute existing psychological vocabulary to the brain, without determining the rules for a new 'neuroscientific' use.

Secondly, neuroscientists' application of psychological predicates to the brain cannot be justified by reference to the poverty of English, as C. Blakemore claims. When new technical terminology is needed, it is introduced by means of appropriate explanations, as in the case of the 'cAMP-PKA-MAPK-CREB pathway' or 'vesicle exocytosis'. There is no 'problem of language' in brain research, only conceptual confusions.

In conclusion, the relationship between cognitive neuroscience and philosophy is scrutinized. This relationship seems to be unclear to many neuroscientists. Neuroscientists often conceive philosophers as junior partners or obsolete as neuroscience will solve all philosophical problems. With this study, B&H tried to demonstrate the importance of conceptual clarification, which is needed for the clear formulation of problems and the correct description of discoveries made. In order to disentangle the conceptual confusions that afflict neuroscience B&H have used *connective analysis.* In their view, conceptual clarification should be philosophy's main contribution to neuroscience: it is not the task of philosophy to propose theories for neuroscientists.

Neuroscience cannot, in contrast to what S. Zeki claims, contribute to the solution of philosophical problems. Neuroscientific discoveries (e.g. blind-sight) may pose new conceptual problems, however they cannot be the solutions for conceptual entanglement as the description of any discovery in cognitive neuroscience *presupposes* the relevant psychological concepts. Therefore, neuroscience cannot resolve the status of secondary qualities or the conceptual nature of knowledge.

B&H stress that their connective analysis is intended to be used to understand experiments. Correct description of neuroscientific discoveries is important for the assessment of their significance and the further progress of cognitive neuroscience. Only after eradication of various forms of Cartesian dualism and other forms of conceptual confusion, these achievements can be seen aright.

3. Criticism

B&H display a very tendentious outlook on current neuroscientific research. Their views have been discussed, defended and critiqued by both neuroscientists and philosophers. In this chapter, some of the major criticisms on PFN will be discussed. First, their philosophical critique will be discussed. Second, the relevance and feasibility of the conceptual framework that B&H have presented will be addressed as the book is mainly written for neuroscientists for the purpose of seeing their achievements aright.

3.1 Cartesianism in current Neuroscience

PFN starts with a historical survey of (neuro)science, starting at Aristoles and ending at the first real generation of neuroscientists: Sherrington, Eccles and Penfield. B&H use these chapters to emphasize the contrast between the Aristotelian view of the soul and the Cartesian. The latter is according to B&H incorrect as it sees the mind as a distinct matter from the body. In the consequent chapter, neuroscientists are accused of 'crypto-Cartesianism'. Although the current generation of neuroscientists overtly reject Cartesian dualism, B&H claim that their whole theoretical framework remains based on it.

> A cardinal conceptual error of so much current cognitive neuroscience is that it ascribes to the brain attributes that it makes sense to ascribe only to the animal as a whole. In so doing, contemporary neuroscience commits what we called 'a mereological fallacy'. Strikingly, neuroscience ascribes to the brain much of the same range of properties that Cartesians ascribed to the mind. It thus operates with a conceptual scheme that is roughly isomorphic with Cartesian dualism. (p.111)

Instead of speaking of mind and matter, current neuroscience speaks of brain and body. For B&H this conservative foundation of the theoretical framework is very important. As they show by connective analysis that the Cartesian view of a person is logically awry and disposed to committing a mereological fallacy, they continue to use analogical arguments to critique current neuroscientific writings.

> Like Cartesianism, it [*cognitive neuroscience*] ascribes psychological attributes to a part of a human being. Furthermore, it *explains* the possession of psychological attributes by a human being by

> reference to the psychological attributes allegedly ascribable to a part of the human being, namely, to the brain. This (…) is not an error of fact, but a logical or conceptual error. (p.111)

However, it remains the question if one can claim that Cartesian dualism is at the base of neuroscientific theory if it so overtly rejected by the scientists. If this fundamental assertion does not hold true then analogical arguments cannot be used to point out the logical faults in current neuroscientific theory. It would have to be scrutinized on its own terms.

Furthermore, even if the analogy holds and current neuroscientific theory is in fact crypto-Cartesianism, it is unclear whether the conceptual entanglement, i.e. the mereological fallacy, in current neuroscience can occur in Cartesian dualism. B&H claim that because the brain or mind is seen as a distinct entity from the body, psychological predicates could be attributed to the brain or mind, which logically can only be attributed to a person. This is referred to as the mereological fallacy. Mereology is concerned with part-whole relationship of things. Therefore, a necessary condition for committing a mereological fallacy is that the substance to which attributes are wrongly ascribed is part of a whole to which these particular attributes can be ascribed. However, as Burgos and Donahoe (4) argue, it is not clear whether a soul is part of a human in Cartesian dualism, which is the necessary condition to commit the fallacy. Primary candidates for parthood are spatial and temporal parts. As the soul is an immaterial substance, it cannot be a spatial part of anything. Equally, the soul cannot be a proper temporal part of a human (e.g. an inning of a baseball game or an act of an opera). Therefore B&H's main criticism against Cartesian dualism, i.e. it disposes to committing a mereological fallacy, does not hold good . However, in contemporary neuroscience, the brain is a spatial part of the human being, even of the body. So, the conditions for a mereological relation are clearly met here. Thus, although the mereological fallacy can be committed in neuroscientific writing, analogical arguments based on Cartesian dualism do not hold.

3.2 The Homunculus in Neuroscience

The *homunculus* model is seen by B&H as another remnant of Cartesian dualism. In a homunculus model, a phenomenon is explained in terms of the very phenomenon that it is supposed to explain. Vision is 'explained' by a set of 'inner' eyes. However, it is clear that this would result in an infinitive regress of further sets of 'inner' eyes. Again, it is not clear if Descartes actually commits the homunculus fallacy. While Descartes is cryptic about precisely how sensory awareness comes about, he is quite clear that it is not a matter of images being transmitted to the soul. Descartes is aware of the dangers of the homunculus model and tries to head off the threat of an infinite regress, by noting:

> while this picture [*peinture*], in passing thus into the inside of our head, always retains some resemblance to the objects from which it proceeds, we must nonetheless not be persuaded that it is by means of this resemblance that it enables us to sense them, as if there were yet other eyes within our brain with which we could perceive it. (*La Dioptrique*, AT vi., p. 130.)

Thus, even though he states that images are formed on the retina and pineal gland, he rejects the homunculus model. The allegedly defining picture of Descartes' *Dioptrique*, namely the Cartesian theater, seems therefore, not a picture that Descartes has offered us.

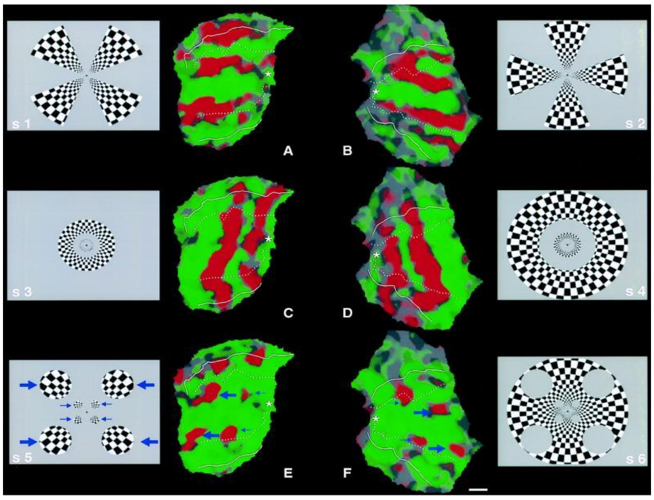

Figure 1: Retinotopy of the primary visual cortex.

Stimuli are shown in S1–2, S3–4, and S5–6, and the corresponding activity is shown in A *plus* B, C *plus* D, *and* E *plus* F, *respectively. The activities produced by the first and second retinotopic stimuli (in each scan) are shown in red and green (respectively) in the activity maps. The activity maps are on fully flattened portions of the cortical surface.*

B&H continue their critique on Descartes by stating: "Descartes was, of course, wrong to identify the pineal gland as the locus of the *sensus communis,* and wrong to think that an image corresponding to the retinal image (and hence what is seen) is reconstituted in the brain" (p. 29). Nowadays everybody would concur with their first claim. However regarding the latter, the facts are on the side of Descartes. For more than sixty years it is known that a projection of the retina on the cortex exists. However, much of this research is done on non-human mammals such as cats and monkeys. With the introduction of fMRI, retinotopic images can be shown on the primary visual cortex (V1) of humans. Tootell, R.B., *et al*. (5) have shown the retinotopy in V1 by exposing subjects to six visual stimuli. Figure 1 shows activities produced by these external stimuli. Athough the activation pattern of neurons on the cortical surface of V1 shows a mathematical projection, it retains resemblance to the external objects, just as Descartes claimed. This activation pattern is not used by an inner homunculus that sees the cortical image. The retinotopy of V1 is important for correct processing of the visual input in further downstream populations of neurons (such as V3, V4, MT, etc.) (6). The cortical image can only be seen by the researcher which visualizes the neuronal activation pattern using modern technique such as fMRI or deoxyglucose labeling. As B&H do not dispose of the hypothesis that there is an retinotopic activation pattern in some cortical areas but claim that it is incorrect to think an image is reconstituted in the brain, they are quite correct. Thus, retinotopy of the visual cortex is a fact, although this kind of activation pattern is not an *image* which is formed: with modern techniques such as fMRI it can be *visualised as an image* and therefore seen. In the brain however it remains an activation pattern of neurons, *not* an image.

3.3 Conceptual confusion throughout Neuroscience

According to B&H, the conceptual confusion extends beyond perception and “retinal images on the visual cortex” . Neuroscientist have a tendency to ascribe a variety of *representations* to the brain. They speak of “maps”, “symbols” and “descriptions” of some kind. These terms are meant to be used as metaphors, but B&H argue that they dispose neuroscience to conceptual confusion. “Whether there is any danger in a metaphorical use of words depends on how clear it is that it is merely metaphorical, and on whether the author remembers that that *is* all it is” (p. 79). The crux is that B&H believe that “representation”, “maps”, etc. start out having metaphorical meaning but always end up being taken literally which results in nonsensical talk.

3.3.1 Maps

One of “banana skins” in the pathway of the neuroscientist is the term “map”. B&H comment the following on “maps”:

> … a map is a pictorial representation, made in accordance with conventions of mapping and rules of projection. Someone who can read an atlas must know and understand these conventions, and read off, from the maps, the features of what is represented. But the ‘‘maps’’ in the brain are not maps, in this sense, at all. The brain is not akin to the reader of a map, since it cannot be said to know any conventions of representations or methods of projection or to read anything off the topographical arrangement of firing cells in accordance with a set of conventions. For the cells are not arranged in accordance with a set of conventions at all, and the correlation between their firing and the features of the perceptual field is not a conventional one but a *causal* one. (p. 80)

In this cited paragraph, the backing for the view that talking about "maps in the brain" makes no sense, is two-layered. First, the brain is not *a reader of a map*. Second, cells are not arranged in accordance to *conventions*.

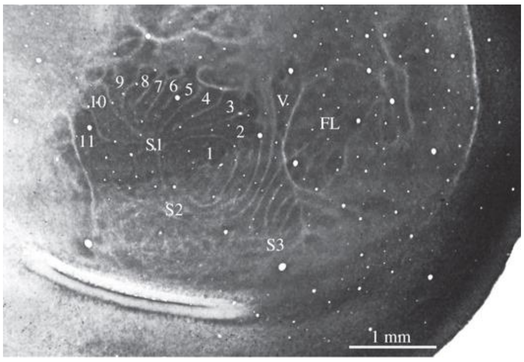

Figure 2: Sensory maps on the cortex of the star-nosed mole.
A series of modules and stripes correspond to different body parts in flattened sections processed for NADPH-diaphorase histochemistry. The most obvious part of the pattern corresponds to the S1 star representation.

In response to the first objection against the use of "maps", it has to be said that it is not clear at all if neuroscientists think off the brain as the reader of the "maps". The better guess is that the neuroscientists seem themselves as the readers. By colouring, probing and imaging techniques they are trying to find distinct areas in the brain and find the conventions of mapping in these areas. Investigators have studied mammals of different order, with the objective to determine the shared and derived features of cortical organization, and hence understanding the rules of projection (7). A nice example of this kind of research are studies about the star-nosed mole. Star-nosed moles are functionally blind and depend on twenty-two appendages that ring their nostrils to explore their environment. They are found to be somatosensory specialists. Figure 2 from K.C. Catania (8) shows by NADPH-diaphorase histochemistry different anatomical modules in an anatomical section of the star-nosed mole cortex. Due to cortical magnification eleven appendages are clearly visible in the primary somatosensory cortex (S1). Another complete map can be seen in the secondary somatosensory area (S2) and caudally from S2 a third, smaller map (S3) can be observed. That these three maps are functionally related to the eleven hemilateral appendages is confirmed by injections of neuroanatomical tracers and electrophysiological recordings. Thus, even though the brain cannot read these maps, investigators can sum up the rules of projection of the somatosensory input on the cortex.

The second claim B&H make is that cells are not arranged in accordance with a set of conventions at all. In the previous paragraph it is shown that within species and for one sensory modality, cells can be arranged by mechanisms understandable for men. However, comparative studies show there are principles for organization of unimodal and multimodal neurons which hold true between species. The superior colliculus, hereafter SC, is often used for comparative studies on organization (9; 10; 11). The SC is a midbrain structure that can be said to contain three topographic maps (visual, auditory and somatosensory) of the being's immediate space and a deep layer that contains motor neurons which can execute saccadic eye movements. As each map is metrically deformed, they end up having a mutual register. This enables the same relative increase in stimulus size in all three modalities will result in the same absolute increase in firing rate of SC's cells. Although overall functional significance of maps in the brain is unclear (12), in the SC an subthreshold stimulus in two or more sensory modalities can elicit an response due to the mutual register of the different maps. This organization can be observed by mapping electrophysiological responses to different stimuli. These studies suggest that the SC differs little intra-species in organization and functionality, despite different ontogeny and behavioral repertoire.

These organization principles especially hold for 'core' fields, the primary sensory areas. Further downstream, organization depends less on molecular specification and more on the behavioral repertoire of an animal (7; 13). In fact, when neuroscientists talk about conventions of mapping, it is often that they describe the organization pattern determined by molecular specification. Although the relation between mapping of the cortical 'core' areas and genomic expression pattern is a causal one, it does not mean that mechanisms for mapping cannot be extracted in which also the behavioural determinant is included. These mechanisms give more insight into the evolution of brain and cognitive capacities. Furthermore, identification of maps in the brain gives insight into the basic neuronal requirements for our cognitive capacities.

3.3.2 *Symbols*

Another final salient example of what B&H mark as conceptual confusion is "symbolic description", on which the authors comment the following:

> For something to be a (semantic) symbol, it must have a *rule-governed use*. There must be a correct and an incorrect way of using it. It must have a grammar determining its intelligible combinatorial possibilities with other symbols, which is elucidated by explanations that are used and accepted among a community of speakers. There can be no symbols in the brain, the brain cannot use symbols and cannot *mean* anything *by* a symbol … (p. 146)

A strong counterargument against this definition of the term symbol and therefore the claim that neuroscientists are conceptually confused when they talk about symbols in the brain, is made by P.M. Churchland (3).

> The authors' resistance to such metaphors may also appear plain uncomprehending, because the aptness of such metaphors is already long established with regard to *electronic computers*. … Desktop computers are artifacts, to be sure, but they were *deliberately built* to engage in the ''rule-governed manipulation of complex symbols.'' (p. 470)

To computer scientists and even to simple Mathlab users such talk makes perfect sense. Input can result in symbols (e.g. 01000001) which can further processed or visualized (e.g. as an A on the computer screen). This would be the correct use this particular symbol. However, problems with the input or *bugs* in the program can result in that incorrect usage of the symbol. This will often result in the ever dreaded *crash* of program. Using terms such as "symbols" and "rule-governed manipulation" of symbols is not even metaphorical any longer, given the well-developed theoretical and technological background against which such talk now takes place in computer science. No wonder system neuroscientists and philosophers are intrigued by the hypothesis that the biological brain might function is the same manner as digital computer. According to D.C. Dennett (14),

> the concepts of computer science provide the crutches of imagination we need if we are to stumble across the terra incognita between our phenomenology as we know it by "introspection" and our brains as science reveals them to us. By thinking of our brains as information-processing systems, we can dispel the fog … discovering how it might be that our brains produce all the phenomena' (*Consiousness Explained,* p. 433).

This started a quest for the biological analogs of the structural elements and global organization of electronic computers. And vice versa, by building more complex programs system neuroscientists and computer scientists are trying to make the equivalent of the human brain. However, are these experiments based on a proper empirical hypothesis or is this all conceptual confusion? The suggestion that we should think of ourselves as computer programmes and the brain as a Von Neumannesque machine is according to B&H incoherent. They do not make a lot of work of giving grounds for dismissal and this seems to be downright uncooperative. Their claim that human beings possess a lot of attributes (such as weight, sex, emotions) which are not possessed by computer programs is a truism. It is clear that the concepts from computer science are meant as metaphors. No one would think human beings are same as complex computer programs and that the brain is exactly built up following the rules of Von Neumann architecture. However, these metaphors can be very useful in simplifying the problems that face current neuroscience.

In conclusion, even though B&H are very dismissive about metaphors in neuroscience as the preceding shows, the highlighted examples of representation, namely “images”, “maps” and “symbols”, show that metaphors are very apt in describing results of current neuroscientific research. Furthermore, through analogy with other scientific branches or simplifying matters they can result in proper and inspired hypotheses.

3.4 Reductionism

In the final part of PFN, ‘On method’, reductionism is discussed, which is nowadays the default stance in biology. B&H distinguish *ontological* and *explanatory* reductionism and leave out *methodological* reductionism. Ontological reductionism is explained as the view that “one kind of entity is no more than a structure of other kinds of entity” (p. 355), and epistemic models that focus on whether representations of higher level features can be explained by representations of lower level features, are viewed as explanatory reductionism. The overall dismissive tone of PFN is followed in the discussion on reductionism. B&H reject both forms of reductionism, although their arguments for rejection are somewhat unimpressive. B&H argue that human action cannot be explained in terms of neural laws because there are no *psychological laws* of human action. However, this statement is ambiguous, as it can mean either that psychological laws do not exist or that they remain to be discovered. The first would require much more argument, as it has major ontological implications. The second suggests that it is a temporary condition, which may or may not end.

Furthermore, the psychological laws sought after by B&H are deterministic laws:

> … these explanations do not specify anything that could possibly be deemed a strict *law:* nor do they explain the behaviour by deducing it from a law and a set of initial conditions. Instead, they identify it as an instance of one or another kind of rough regularity of the person’s behaviour, which may admit of many exceptions. (p. 362)

However, philosophers of science largely admit probabilistic or statistical laws (4). In this case, psychological laws would admit exceptions. Acceptation of probabilistic psychological laws leads to an abandonment of explanation of human behaviour by a deductive-nomological model. As bridging principles are mainly necessary in a deductive-nomological model, abandonment of this model leaves the question whether bridging principles are logically possible pointless. Thus, acceptance of probabilistic psychological laws results in a different model in which the alternative explanations of human behaviour given by B&H are good candidates for psychological laws.

Nevertheless, even if explanatory reductionism is logically possible, B&H deem it useless as explanation of human action. According to them, reductionistic explanations are far inferior to those that appeal to a person's reasons:

> We call on Jack only to find him out. We ask where he is, and are told he has gone to town. We want to know why, and are told that it is his wife's birthday, that he booked tickets for *Tosca* weeks ago, and that he has taken her to her favourite opera. Would a neuroscientific story *deepen* our understanding of the situation and events? In what way does it need deepening? Does anything remain puzzling once the mundane explanation has been given? (p. 364)

B&H's negative answer permits them to stop the explanation of Jack's behaviour at social practices. However, many philosophers, scientists and layman are not satisfied with this explanation. This is shown by the overwhelming interest of the public and the scientific world in psychology and neuroscience. There are questions about how everyday practices and conventions are acquired and maintained, how they are instantiated in specific individuals, what the origins of the similarities and differences observed among them are, and so on. If cognitive neuroscience were to answer these questions, our understanding of the situation would certainly be deepened.

3.5 Mind the Conceptual Hygiene

Neuroscientists are not the only ones who can be criticized for their methods and logico-linguistic practices. Ironically, B&H are also guilty of illegitimately redeploying concepts outside their proper context for non-metaphorical use and even explanatory homuncularism can be found in PFN (p. 3). Throughout PFN it is pressed that a hypothesis only makes sense if its constituent terms are used correctly. The correct use of a concept is examined by connective analysis and "the meanings of words are determined by their rule-governed use" (p. 382). Connective analyses of a variety of cognitive concepts show that for each term there is at least a handful of rules that are required to effectively guide its use. This holds also true for non-cognitive concepts and expressions. An average English speaker has vocabulary of approximately 20.000 words. With a crude calculation, this would result in a presumptive total of 100.000 rules that a normal English speaker has to have ready to be able to engage properly in a conversation. But this must be confused. Even if someone could produce such a massive list of rules, for example a lexicographer, it would take years. It is implausible that ongoing speech is literally governed by real time application of such rules as the human brains are a great deal slower that digital computers.

Futhermore, P.M. Churchland explains a more fundamental problem with this explanation of conceptual and linguistic behaviour (3):

> …in order to comprehend and deploy the rules that supposedly give our concepts meaning, we would already have to possess concepts adequate to recognizing the circumstances appropriate for the application of those rules, and we would have to possess concepts adequate to understand what those rules mean in the first place. Accordingly, B&H's preferred account of how meaning arises for cognitive creatures appears itself to be a presumptively homuncular account, requiring an inner creature with antecedently meaningful concepts in order to explain a creature's supposed command of the rules that give meaning to its concepts. (p. 476)

This analysis leads to the conclusion that the critique of current neuroscience depends largely on a rule-based theory of meaning that itself transgresses the bounds of sense and therefore needs to be dismissed.

Furthermore, the imposed standards for "conceptual hygiene" in PFN are based on the 'common usage' of words. However, to thusly restrict "the bounds of sense" is awry in two respects (15). *First*, one should realize that 'common usage' is the result of thousands of years of language development. Language inevitably still contains remnants of many old misconceptions. Although once universally held concepts such as a flat Earth have been removed, the cleansing process is certainly not yet complete. The confidence to certify 'common usage' error-free and the basis for the search for the truth seems therefore to be misplaced. *Second*, it is very unclear how this 'common usage' is to be determined. It is doubtful that an Oxford professor and a Manchester United football player would have to same 'common usage' of language. The discussion on "maps" and "images" shows that many transgressions in neuroscience would not occur when the 'common usage' of a concept is explored by other scientists or philosophers, instead of B&H. In conclusion, the presuppositions of B&H are untenable which make their methods and logico-linguistic practices just non-sensical.

3.6 The Abyss after Conceptual Clarification

B&H wished to make a conceptual reference book for cognitive neuroscientists and assist neuroscience forward by resolving conceptual entanglement. However, their unremittingly negative reflection and plain uncooperativeness seem to hinder this aim. Some neuroscientific writings clearly do commit the mereological fallacy and thus transgress the bounds of sense, while other get conceptually entangled by the metaphorical or technical use of terms. However, to many neuroscientists it seems a lesser sin to stretch the usage of concepts than to play down the scientific achievements of the last century. Although B&H claim differently, PFN seems to offer no new way. This can be exemplified with the case of blind-sight. B&H seem to give a new definition of this phenomenon, however this explanation does not differ from an extensive summary of the study result on blind-sight. Aside from the fact that this definition is impractical due to its length, it lacks the generality that is so important for science to enable comparison and better understanding of systems.

The fear of scientists is that when strict standards of "conceptual hygiene" are imposed, it will result in a diminish understanding of the psychological capabilities of human beings and the origins of these capabilities. Conceptual clarification would than lead to explanatory mystification. This can be exemplified by the reaction of P. Hagoort to B&H's article about language and cortical function (16). In that article, B&H analyze the model for fluent speech that was developed by Levelt in the early 1990s. According to B&H the model is full of conceptual confusion. In addition, "the theory of Levelt is more a mythological redescription of the observed phenomena than an explanation of them". However, B&H do not put forward another model or do not suggest modifications that would eradicate conceptual confusion. According to P. Hagoort, this is proof of misunderstanding the supporting evidence for the Levelt-model and its empirical achievement. Patients with a variety of neurological pathology can display aphasia. Before the Levelt-model aphasia was considered as a group of speech disorders which were not further classified. Using the Levelt-model, different kinds of aphasia can be explained as a deficiency in a certain module. The accuracy with which the clinical practice fits on the theoretical model is a supplementary proof of the correctness of these models. Furthermore, by classifying the different kinds of aphasia, patients can receive more accurate information and more efficient therapy. Abolishment of the Levelt-model without an alternative would therefore pragmatically make no sense. Maybe scientists need a certain degree of admittance of conceptual confusion in order to be able to formulate new theories: the ethics towards concepts that B&H advocate might be so cumbersome that it actually stagnates scientific progress.

3.7 Advice to a Neuroscience Laboratory

Philosophical Foundations of Neuroscience is a very extensive conceptual investigation into neuroscientific theory. B&H tried to make it more convenient by making chapters on selected psychological concepts as self-contained as possible. However, the lack of practical advice is a giant obstacle for implementing the results of their connective analysis on the research done. Furthermore, when a neuroscientist takes on the job of making his results logically correct, things become even more complicated. There is a vast literature criticizing B&H's attempt of eliminating conceptual confusion in neuroscience. Much of the critique concerns philosophical disagreements and the underpinnings of B&H's view. As a result the willing neuroscientist is left feeling even more confused and entangled. Therefore, this thesis will conclude with some practical advises based both on PFN as on the criticism.

The majority of the literature, PFN included, focuses on the use of metaphors. Some claim they are vital, some consider them harmless, while others think they are pernicious. B&H give some very nice examples where metaphors go astray and lead to faulty conclusions. Consecutively, these conclusions result in confused hypothesis and study designs. However, when new phenomena are described, the standards for 'conceptual hygiene' should not be excessively rigid. Often neuroscientists do not completely understand the results and the implications of their experiments. They choose the *most* fitting terms, even though these are not entirely correct to describe the found phenomenon. As time progresses, more insight is gained into the phenomenon and new or more appropriate terms can be used. In the meantime, the results can be used by scientists to gain more insight into the physiology of the brain and by physicians to aid patients with certain pathology. However, one should remain mindful that most findings in neuroscience, which is a relatively new branch of science, are only described by approximation and conceptual confusion is close at hand. To prevent this, it is advisable to state in papers which concepts are only approximations and what the difference is with the standard usage of that concept. This will stimulate the evolution of the neuroscientific vocabulary as the mismatch with common language becomes clearly visible. Furthermore, it prevents hypothesizing based on the non-metaphoric use of employed concepts and terms.

Next to understanding and describing your last experiment, PFN can be useful to examine the design of your next experiment. Neuroscientist often research some psychological capabilities by a study design that in fact involves other concepts, e.g. fantasia instead of imagination, or involves subjects that are logically incapable of having the allegedly examined capabilities, e.g. knowledge and belief. As E.R. Kandel's work on *Aplasia,* the giant marine snail, exemplifies, excellent neuroscientific research is no guarantee for logically correct conclusions (18). In his essential experiments, Kandel isolated a ganglion and observed that synapses changed systematically in response to patterns of electrical stimulation. Kandel concluded that the synaptic changes in the *Aplasia* ganglion after electrical stimulation paralleled changes in the overt behavior of intact animals during learning. Therefore, these synaptic changes can be seen as neural analogs for learning and the formation of memory. However, as B&H already pointed out, this is confused. First, it is not the ganglion that learns, only a whole animal is able to learn. Second, the *Aplasia* is not able to learn and retain knowledge, at most it acquires a habit or a skill. Via conceptual clarification of the study design, it becomes clear what the implications of the results logically can be. By performing this check before starting experiments, a lot of effort can be saved, which would otherwise have been spent in senseless research.

In conclusion, conceptual clarification does not have to lead to an explanatory abyss. By being mindful of the metaphors one uses and the logical reach of one's research, non-sensical talk that holds neuroscience down can be avoided. It is important for neuroscientists to remember that neuroscience and philosophy are two different kinds of inquiry that can aid each other. Although PFN is a very tendentious book, it can be a useful aid when one finds oneself bedazzled and entangled in what neuroscientists are telling.

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