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Does the Brain Cause Conscious Experience?

Abstract: *It is generally assumed that the brain causes conscious experience. A broad view of this kind can be termed neuronal reductionism. It is universally regarded that neuronal reductionism is founded on a solid empirical basis. However, it is possible to show that none of the arguments usually advanced to support its contentions are conclusive. Moreover, there are a number of serious empirical as well conceptual difficulties that this view has to face, and to which it has not responded in a satisfactory way so far. Taking these challenges in their entirety it seems justified to claim that neuronal reductionism is a failed theory and that the search for an answer to the question about the origin of consciousness has to take a novel turn.*

It has become almost a tautology to state that the brain produces (causes) conscious experience, conscious states, or more broadly consciousness.[1] We read daily about the brain learning, making decisions, remembering, directing our behaviour, etc. but does it really do all

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[1] It is not easy to define consciousness. Indeed, in a recent article Vimal discussed no less than forty possible understandings of this term (Vimal, 2009). In the following the concept will be used to denote that aspect of experience which can be broadly termed 'subjective representation of the world'. Of the forty meanings of the term 'consciousness' discussed by Vimal this seems closest to the understanding of the term formulated by Chalmers in 2003 (*cf.* Vimal, 2009, p. 17). However, it seems to me important to stress that to my mind even simple animals are conscious — when they are not sleeping — thus I would not regard the ability to report (verbally) information as essential for consciousness; moreover dreams should — to my mind — be regarded as a form of conscious experience. Thus consciousness should not be regarded as an on/off phenomenon, but rather as a continuum ranging from some rather dull forms such as that of the, say, earthworm, to its highest manifestations such as in abstract conceptual thought or in some meditation states. Furthermore, it should be understood as an aspect of the experience of a creature, without prejudicing the question of the origin of this experience.

Journal of Consciousness Studies, **19**, No. 3–4, 2012, pp. 121–44

these things? Or to put the question in a different way — can we really be sure that it does? We seem to have overwhelming evidence to confirm this central tenet: 1) destroy a part of the brain and you destroy some mental function(s) — *ergo* the brain is necessary for this mental function (this line of argument goes back at least to the studies of Broca, 1861, and Wernicke, 1874; *cf.* a recent review by Rorden and Karnath, 2004); 2) stimulate the brain in an appropriate way — electrically (*cf.* e.g. Penfield and Jasper, 1954; Libet, 1973), magnetically (*cf.* e.g. Persinger, 2001), or chemically (*cf.* e.g. Linton and Langs, 1962; Snyder, 1986) — and you produce a change of a conscious state (*ergo* a change of the brain state is sufficient for a change of the conscious state); 3) we can accurately predict which part of the brain will be active whilst a specific mental activity is taking place — we can almost tell what thoughts a person is currently thinking on the basis of the analysis of her brain activity (Roth, 2004; Reddy *et al.*, 2010); 4) we can translate brain activity into muscular action (*cf.* e.g. Abbot, 2006; Hochberg *et al.*, 2006; Miller, 2008); 5) it is easy to imagine how the brain produces consciousness because we know how to translate digital signals (and the firings/not-firings of neurons can be assumed to correspond to the ones and zeros of the digital code) into pictures and sounds — mp3 players, DVD players, digital TV-sets, and finally computers do it all the time (the brain as computer metaphor is a very old one, *cf.* e.g. von Neumann, 1958; or, more recently, Hameroff, 2007); 6) moreover, it has been repeatedly demonstrated that neuronal processes have to take place *before* consciousness can arise, which conclusively demonstrates (or so it seems) that it is the neuronal processes which cause consciousness and not the other way around, since a cause cannot follow its effect(s) (*cf.* e.g. Libet *et al.*, 1982; Libet, 1993; or, more recently, Haggard, 2008).[2]

Before I proceed to attempt to demonstrate that these arguments are not sufficient to establish the thesis that the brain does indeed produce consciousness, I should like to pose a seemingly absurd question: does the Earth go around the Sun or the Sun around the Earth? The answer is clear: of course the Earth around the Sun! But if you reflect on the reasons for our certainty, you will quickly realize that this statement goes against the grain of almost all experiential evidence we have on the issue. We certainly see the Sun rising and setting, and we certainly do *not* have any direct experience of the motion of the Earth — neither its rotary motion around its own axis, nor its linear

[2] It is not possible to discuss the last two lines of argument fully within the spatial limitations of this paper. I shall attempt to tackle them in follow-up papers.

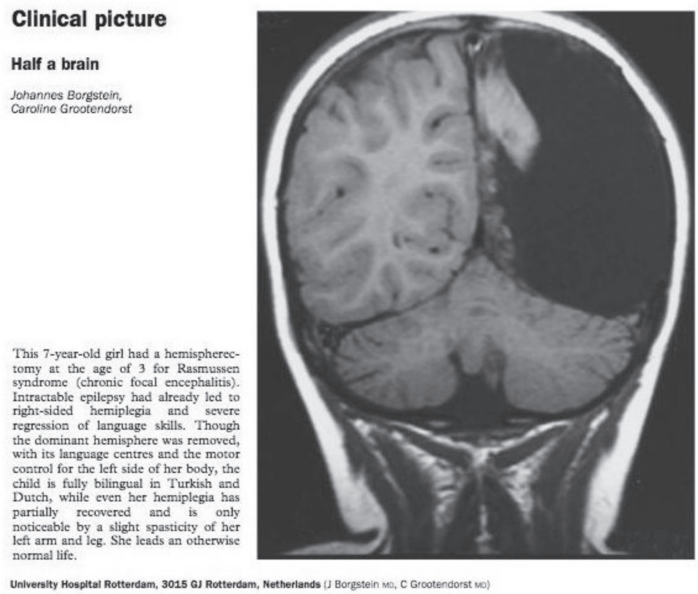
movement along its orbit around the Sun. Now, if you further consider the fact (and it is a fact of course) that the Earth revolves around its axis at the speed of some 1667 kmh^{-1} at the equator[3] and that it moves along its orbit around the Sun at the speed of (on average) some 29.79 kms^{-1} (or over 107,000 kmh^{-1}) (Moore, 2000, p. 98), you will have to admit that it is rather surprising that we have no direct perception of these motions at all. To our senses and our pedestrian life experience devoid of the pictures of the Earth from the orbit around it the Earth stands still: it does not rotate either around its axis or around the Sun. Which proves that appearances and life's certainties might be deeply deceptive. Can it be the case that our certainty about the causal role of the brain in producing consciousness is equally deceptive? Well, let us have a look.

Loss of Mental Function Following Brain Damage not Sufficient to Establish the Causal Role of the Brain in Producing Consciousness

It is possible to show that *none* of the above mentioned six groups of empirical facts usually adduced to support the claim that the brain causes consciousness is sufficient as an argument to establish the reductionist thesis of the mind/brain relationship, the thesis which I want to refer to as *neuronal reductionism* in the remaining part of this article. In the case of the first two avenues such a demonstration is easy: 1) destroy a part of the brain and you destroy some mental function(s). Yet the brain may be less necessary for consciousness than it initially seems: there are known cases of people leading what appear to be normal lives with (more or less) half of the normal brain. Consider the following picture published in *The Lancet* on 9 February 2002 (Borgstein and Grootendorst, 2002; Figure 1). It depicts the brain of a person whose dominant hemisphere has been surgically removed. The reason for this drastic surgical intervention is stated in the caption: the person subjected to it had suffered from the so-called Rasmussen syndrome, that is chronic focal encephalitis or acute inflammation of the brain. This led to intractable epilepsy with the resulting right-sided hemiplegia and severe regression of language skills. The physicians treating the person decided to conduct hemispherectomy, i.e. to remove the affected hemisphere, considering the risk of partial paralysis of the body and total loss of language the

[3] The rotation period of the earth is — as is well known — approximately 24 hours (to be exact: 23 hours 56 minutes and 4 seconds; Moore, 2000, p. 98) and its equatorial circumference 40,075 km (*ibid.*).

lesser evil relative to the danger that the encephalitis might spread further. Yet as the caption makes clear neither paralysis nor loss of language occurred after the operation. The patient in question, a girl, underwent hemispherectomy at the age of three and was, at the age of seven, 'fully bilingual in Turkish and Dutch, while even her hemiplegia has partially recovered and it is only noticeable a slight spasticity of her left arm and leg. She leads an otherwise normal life' (*ibid.*).


Clinical picture

Half a brain

Johannes Borgstein, Caroline Grootendorst

This 7-year-old girl had a hemispherectomy at the age of 3 for Rasmussen syndrome (chronic focal encephalitis). Intractable epilepsy had already led to right-sided hemiplegia and severe regression of language skills. Though the dominant hemisphere was removed, with its language centres and the motor control for the left side of her body, the child is fully bilingual in Turkish and Dutch, while even her hemiplegia has partially recovered and is only noticeable by a slight spasticity of her left arm and leg. She leads an otherwise normal life.

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Figure 1. Picture published in *The Lancet*, 9 February 2002 (Borgstein and Grootendorst, 2002; reprinted with permission).

What is remarkable about this report is, apart from the shocking facts of the matter (shocking to our assumptions about the role of the brain in the production of consciousness), that the caption to the left of the picture is everything in the way of a comment about the case that was provided in the journal at the time and also, as far as I could follow it up, after its publication. Yet it seems that that report should have been supplied with a large red title stating something to the effect 'A major medical miracle: normal life with half the brain!', published not only in an academic journal but on the first pages of every major newspaper in the world, and extensively discussed in professional journals. No such discussion has ever taken place. Already two years before the appearance of this picture a book was published about a very similar case, written by a neurosurgeon who performed a similar operation on a — at the time — three-year-old boy (Battro, 2000). The author of the book writes that the encounter with the boy has changed his views on the brain, education, and mental development (*ibid.*, p. XII). Yet as far as I can tell neither this book nor any similar account has become a bestseller and neither has it changed the majority view on the relationship between the brain and the mind. Furthermore, Battro wrote in 2000 that at that time there were approximately 100 people in the world with a similar condition, but each case was 'unique'. Indeed, a follow-up study of 33 children and adolescents (age at surgery 0.33–17 years, median 4.25; median follow-up length 3.4 years) who underwent hemispherectomy at Great Ormond Street Hospital in London between 1991 and 1997 states that apart from the fact that (predictably) the great majority of the patients experienced significant reduction in the frequency of seizure as a result of the operation, hemiplegia remained unchanged in 22 out of 33 children, was worse in six, and improved in five. Moreover, no significant cognitive deterioration or loss of language occurred in any of the children, and four children showed significant cognitive improvement (Devlin *et al.*, 2003, p. 556).

In 2007, a brief account of another fascinating case was published, again in *The Lancet* (Feuillet *et al.*, 2007). It was the story of a 44-year-old French civil servant and father of two who led an apparently fairly normal life, but when examined on account of a persistent weakness of the left leg turned out to have a massive enlargement of the ventricles which reduced his brain to a thin mantle squashed against the skull (Figure 2). Again, all that was reported about the case is reproduced in Figure 2, and as far as I am aware no discussion of this amazing case has ever taken place in that journal or anywhere else. More recently, in 2009, *The Proceedings of the National Academy of Sciences* published a study of aspects of cognitive functioning of a girl who at the age of three was discovered to have been born with only one hemisphere (Muckli *et al.*, 2009; Figure 3). Interestingly enough, the study is concerned with the development of bilateral field maps in a person with only one hemisphere, and does not address the 'miracle' of that person's normal functioning at all. The authors merely dryly state that the girl did not have the right hemisphere at birth, but take this fact more or less for granted:

> The loss of AH's right hemisphere had been discovered when she was 3 1/2 years old and underwent an MRI scan because of myoclonic seizures (brief, involuntary twitching) on the left side. Apart from these successfully treated seizures and a hemiparesis, AH's developmental

and medical history was normal. She successfully attends a regular school and masters activities requiring bilateral coordination such as roller skating and bike riding. Our structural MRI measurements at the age of 10 confirmed the complete loss of AH's right cerebral hemisphere including the telencephalon and almost the entire diencephalon. (*Ibid.*, p. 13035)

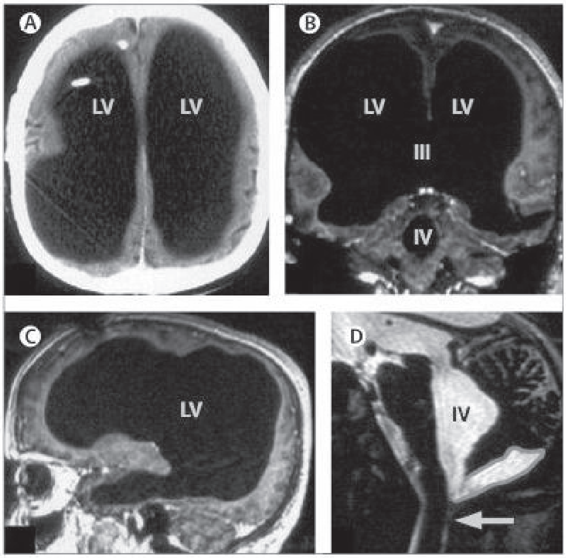

Figure: Massive ventricular enlargement, in a patient with normal social functioning
(A) CT; (B, C) T1-weighted MRI, with gadolinium contrast; (D) T2-weighted MRI. LV=lateral ventricle. III=third ventricle. IV=fourth ventricle. Arrow=Magendie's foramen. The posterior fossa cyst is outlined in (D).

Figure 2. Picture published in *The Lancet*, 21 July 2007 (Feuillet *et al.*, 2007; reprinted with permission).

Thus it seems that there are a large number of empirical facts clearly demonstrating our nearly miraculous ability to somehow substitute for the lost parts of the brain without any significant loss of function. It is of course possible to attempt to reduce the amazement with which such facts should be viewed to a platitude by recourse to the well-known ability of the brain to change and modify the connections between individual neurons as well as produce new neurons, at least in some parts of the brain such as the hippocampus (*cf.* e.g. Eisch *et al.*, 2008), the ability generally subsumed under the term *plasticity* of the brain. However, the weakness of such a manoeuvre lies in the fact that the current understanding of the functioning of the brain is firmly

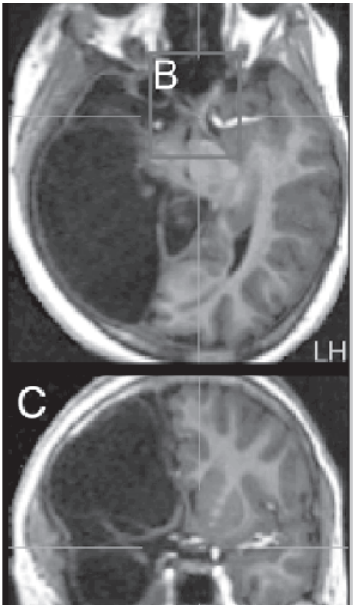

Figure 3. Image published in *The Proceedings of the National Academy of Sciences*, 2009 (Muckli *et al.*, 2009, *PNAS*, **106**, pp. 13034–9).

rooted in the assumption that structure dictates function (*cf.* e.g. Persinger, 2001, p. 515; Buzsáki, 2006, pp. 29–30), i.e. that thanks to the development of specific brain structures certain mental functions become possible. Indeed, such a form of reductionism appears necessary if one wants to claim that the brain produces (causes) mental life, for under such an assumption it must be the case that it is the brain structures and their functions that give rise to mental phenomena and functions. But if so, it is entirely unclear why in the absence of a specific brain structure another structure takes over the functions of the 'missing man'. Such a phenomenon would require the existence of some higher control centre able to detect the gap and initiate steps leading to its closure, i.e. to the transforming of the existing structures in such a way that they develop a novel ability to perform the tasks of the missing or damaged parts. Yet nothing is known of the existence of such a structure in the brain, and indeed, knowing the decentralized form of the organization of the brain, it is exceedingly difficult to imagine where such a structure should reside. It can be claimed that such a structure is not necessary at all for the brain possesses resources untapped in normal situations. Thus, for example, it seems that under normal circumstances the left hemisphere inhibits the right hemisphere from processing language and algebra, even though the right hemisphere would be capable of such processing. If so, it should not be surprising that, following the hemispherectomy of the dominant hemisphere, the hitherto hidden potential of the right hemisphere becomes manifest.[4] However, even though the data of the study referred to above (Devlin *et al.*, 2003) seem to support the contention that, following hemispherectomy, the remaining hemisphere unfolds its potential hitherto suppressed by the other hemisphere (the authors report no significant cognitive deterioration or loss of language in any of the children operated on), the situation is very different as far as motor skills are concerned. As mentioned above, hemiplegia remained unchanged following surgery in 22 out of 33 children, became worse in six, and improved only in five. This clearly indicates that improvement of motor skills after hemispherectomy is anything but self-explanatory. I am not aware of any plausible explanation of how such improvement can come about.[5] Moreover, the above study was limited to children and adolescents (the oldest patient was 17 years old). If one looks at the outcome of hemispherectomy in adults, they turn out to be markedly different. A recent report (the first one of the sort) concerning the outcomes of hemispherectomy performed on nine adult patients (McClelland and Maxwell, 2007) states that all patients had unilateral hemiplegia and visual field loss following the operation (*ibid.*, p. 372). Moreover, all patients whose left hemisphere was removed without consequences for their speech facility had been found prior to the operation to have right-sided hemisphere dominance for language (*ibid.*, p. 374) so it is not possible to ascertain how the removal of the hemisphere with the speech centre would affect their speech facility, and the care taken to make sure that the speech hemisphere is not removed indicates that one is concerned that its removal might lead to speech loss, or at least some form of dysphasia. Now, even assuming that small children and adolescents show high ability to remodel the functions of the brain after hemispherectomy

[4] I owe this suggestion to an anonymous referee of my paper.

[5] Various mechanisms driving the known plasticity of the brain can of course be postulated. As early as 1988, Sur *et al.* redirected retinal afferents of newborn ferrets to the medial geniculate nucleus (the principal auditory thalamic nucleus), and demonstrated that many cells in this nucleus then responded to input from retinal ganglion cells (Sur *et al.*, 1988, p. 1440). However, in contrast to the study of Sur *et al.*, in the case of hemispherectomy of, say, the left hemisphere, there are no neural pathways from the right side of the body sending signals to the remaining hemisphere — thus there is no ability to modify it in such a way as to restore, for example, the motor control of the right arm and leg. Moreover, it is difficult to imagine what neuronal input could drive the establishment of the speech centre in the non-dominant hemisphere.

'as a matter of course', such ability is in need of explanation if it disappears or is severely curtailed later in life.

On top of these empirical difficulties there is a conceptual point against concluding that the brain is the producer of our mental life from the fact that damage to the brain (normally, generally) results in loss of mental function. A pianist cannot play a piano concerto when his piano gets damaged, or at least his performance is impaired by the damaged to his instrument. Yet it would be absurd to claim that the piano is the cause of the concerto. It is merely *a necessary condition* for its performance, not its cause. Similarly, it is a fallacy to claim that the loss of a mental function as a result of brain damage *proves* that the brain plays the causal role in producing this mental function. It is a fallacy to take a merely (under normal circumstances) *necessary* condition of an event to be the *cause* of this event, for a cause of an event is not identical with a necessary condition of it (*cf.* Sosa and Tooley, 1993, p. 7). It may very well be that the brain is (under normal circumstances) a necessary condition for consciousness, but this does not prove that it is its cause. The brain may turn out to be a mere piano on which some pianist is able to play her concert.

Changes to Mental Events Following Artificial Brain Stimulation not Sufficient to Establish the Causal Role of the Brain in Producing Consciousness

Stimulate the brain and you produce a change of a conscious state. Yet stimulation is not sufficient to produce the 'normal' mental experience. Wilder Penfield in the 50s (Penfield and Jasper, 1954; *cf.* also Penfield, 1975), and Benjamin Libet in the 70s of the last century (Libet, 1973) have discovered that it is indeed possible to evoke some form of perception using electrical stimulation of the appropriate areas of the brain, but they were forced to realize at the same time that these 'perceptions' were far removed from our normal sensory experience. They are described as having parasthesia-like character (tingling, electric shock) rather than the experience of a tree growing in your garden (Libet, 1973, pp. 102–6). These discoveries have been confirmed in a recent study using the most modern technology to makes sure that the stimulated area and the form of stimulation are precisely delineated (Murphey *et al.*, 2009). The study revealed that even if one stimulates higher visual areas such as the fusiform face area (FFA), one can produce, at best, impressions of simple shapes and colours (and even these not always), but not of faces or of other elaborate percepts.

Against these observations it can be argued that other forms of artificial stimulation of the brain, in particular chemical stimulation resulting, for example, from drug consumption, or stimulation with electromagnetic fields, as in transcranial magnetic stimulation (TMS), can produce elaborate conscious experiences which can fairly closely mimic if not normal sensory perception then at least normal dreams, or normal play or fantasy. However, it is important to point out that experiments aimed at ascertaining the effects of such forms of external stimulation (as well as those with direct electrical stimulation of the cortex) are necessarily conducted on awake subjects. This is of course necessary if one wants to elicit a report of changes to consciousness resulting from applying any form of stimulation to the brain. Yet in our context this feature of such experiments constitutes also their major methodological weakness: for it is immediately evident that the most they can demonstrate is not that the stimulation applied *causes* conscious experience, but merely that it *modifies* a (pre-existing) conscious state. In order to be able to support the stronger claim (stimulation *causes* consciousness) one would have to be able to demonstrate that the relevant stimulation applied to the brain of a sleeping (not dreaming) person is able to evoke conscious experience. Thus, in effect, to cause conscious experience in a sleeping person is to wake her up or at least to make her dream something. Yet it is only too obvious that applying stimulation to the brain of a sleeping person does not necessarily have such an effect. I am not aware of the existence of any study designed specifically to test this contention (perhaps because it is too obvious to deserve the effort), but incidental evidence to this effect is overwhelming. Consider the fact that loud snoring does not necessarily wake up the snorer (in fact hardly ever does), even though it can be so loud as to wake up his/her neighbours. Consider also the recent study by Issa and Wang (2008) who have demonstrated that the activation of the sensory (auditory) areas of the brain during sleep is essentially the same as during waking.

Indeed, it is possible to argue that an adherent of neuronal reductionism would have to substantiate an even stronger claim, *viz.* that the relevant stimulation of the brain is capable of producing conscious experience in the dead person (effectively resurrecting her!) For even if some form of conscious phenomena could be evoked in the (deeply) sleeping person, these phenomena would be produced against the background of considerable background brain activity always present even during the phases of deep sleep. However, it is not possible to ascertain with certainty whether this activity is the product of the brain itself, or is imposed on it from outside of its structures.

This initially puzzling point will be better appreciated if one considers the following scenario. When you switch on your TV set you can watch a film. But it would be absurd to claim that the TV set is the cause of the film (including the actors performing in it). It is not a producer, but merely a receiver of the relevant information. Herein lies a *conceptual* argument against the validity of using our ability to produce such changes to support the reductionist thesis that the brain causes conscious sensation: just as it is patently wrong to claim that switching the TV set on causes the film you watch on it (it is as a matter of fact merely a necessary condition for watching it), so also it is a fallacy to conclude from the fact that an appropriate form of stimulation of the brain leads to changes in the conscious state of the person whose brain was so stimulated that the stimulation was the cause of the conscious state.[6]

(Alleged) Power to Predict Mental States from Neuronal Data not Sufficient to Establish the Causal Role of the Brain in Producing Consciousness

As for our power of prediction of mental activity from the neuronal data, the weaknesses of this argument for neuronal reductionism are easy to see, too. Our ability to predict mental events on the basis of neuronal ones is based on the fact that we have learnt that activity in a specific part of the brain is *correlated* with a specific form of mental phenomena. In reality what we are saying when we are 'reading' somebody's thoughts is merely something like this: since concepts related to x are associated with the brain area X, and this area is active at the moment, the person must be thinking about something related to x. But it is well known that a correlation between two events is not sufficient to establish a causal relationship between them, and still less to determine the direction of such purported causal relationship: is it bottom to top (brain causing conscious processes), or top to bottom (conscious processes causing changes in the brain state). Thus, our ability to make successful predictions of the content of mental phenomena from the localization of neural activity demonstrates at best that a

[6] The metaphor of the brain as a TV receiver has also been used by the leading Canadian neuroscientist, Mario Beauregard (Beauregard and O'Leary, 2008, p. 292–3), by Pim van Lommel, the well-known Dutch researcher of Near Death Experiences (van Lommel, 2009, p. 286–7), as well as by the renowned American cell biologist, Bruce Lipton (Lipton, 2008, p. 160), and most recently by Emeritus Professor of Biomedical Engineering at Tulane University, New Orleans, Paul Nunez (Nunez, 2010, p. 274). Incidentally, it is possible to show that interpreting the brain as a mere receiver of consciousness, rather than its producer, does not necessarily imply substance dualism. I shall attempt to do so in a follow-up article.

specific part of the brain is strongly correlated with a specific form of mental activity, which in turn can be interpreted as implying that such a specific part of the brain is *necessary* (under normal circumstances) for this activity, which in effect boils down to the argument (1) above.

(Alleged) Power to Translate Thoughts into Actions not Sufficient to Establish the Causal Role of the Brain in Producing Consciousness

As to our ability to 'transform thoughts into action', it is even less suitable to serve as support for the claims of neuronal reductionism. In effect this ability relies on something essentially very similar to the ability to 'read thoughts': we have discovered that a specific form of mental activity (say, intention to raise the right hand) is associated with a specific form of neural activity in a specific part of the brain. Thus, if we are able to detect this neural activity, we can 'translate' it into the movement of a cursor on the computer screen or into the movements of a prosthetic hand of various degrees of complexity (*cf.* Hochberg *et al.*, 2006; Velliste *et al.*, 2008). We are even able to 'bridge' the spinal cord and stimulate specific muscles of the real hand in a specific way to perform desired movements (Moritz *et al.*, 2008). However, these technical accomplishments do not demonstrate anything beyond the well established fact that there is a strong correlation between a specific brain area and a specific form of mental phenomena. In particular they do not allow us to draw conclusions about the *direction* of causal relationship (if any) between the two sets of phenomena.

Worse still, recent findings suggest that it is possible to construct a device able to translate patterns of neuronal activity into specific muscular movements even when: 1) the neuronal activity pattern detected was produced by a single neuron (Moritz *et al.*, 2008), which in itself is deeply puzzling in terms of current explanations of the mechanisms of neuronal control of movement as no one would like to claim that the activity of only a couple of neurons is sufficient to steer complex motor behaviour;[7] 2) the pattern of activity was produced in neurons which were previously *not* associated with the control of movement that was the ultimate target of the experiment (Moritz *et al.*, 2008, pp. 639, 641, 642). Moritz *et al.* have demonstrated that 'monkeys can

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[7] It is generally assumed that discharges of single neurons within M1 correlate with the activity of a single muscle, and that clusters of neurons are needed to 'orchestrate' activity of a distinct group of muscles with a recognizable functional role (*cf.* e.g. Holderfer and Miller, 2002, p. 234).

learn to use direct artificial connections from arbitrary motor cortex cells to grade stimulation delivered to multiple muscles and restore goal-directed movement to a paralysed arm' (*ibid.*, p. 639).

Now, these findings suggest that the association of our technologically enhanced ability to mimic normal muscular movements with a specific form of activity of the *motor* cortex is spurious. It may very well turn out that it might be possible to produce devices able to achieve such mimicry on detection of any specific reproducible pattern of activity anywhere in the brain. The process here seems to be comparable to someone pressing a button to set a complex machine in motion: it is enough to make the simple movement of pressing a button in order to obtain a very complex result. Given a sufficient number of distinct buttons, a variety of complex end results may be obtained. A specific detectable form of neuronal activity somewhere in the brain may be sufficient to serve as a distinct button. Yet the fact that when a pilot presses a button the automatic pilot takes over tells us nothing about the processes which enable the real pilot to operate the controls of the plane.

Moreover, as indicated above, the existence of a correlation between a specific pattern of brain activity and the character of mental phenomena associated with this activity does not tell us anything about the direction of causality between the mind and the brain: it does not tell us if it is the brain that produces the activity which can be 'interpreted' by a computer program as a signal for action, or whether the mind does it. If anything, the possibility of translating reproducible patterns of neuronal activity into patterns of movement of either muscles or mechanical devices would seem to point to the priority of the mind: a person *voluntarily* thinks certain thoughts which produce a specific, regular, reproducible pattern of activity in a certain neuron or a small group of neurons; or a monkey learns to evoke reproducible patterns of neuronal activity, presumably by invoking repeatedly the same mental image, the computer program is able to detect this form of activity and, on detecting it, sends appropriate impulses to the muscles or prosthetic devices, which makes them carry out certain movements. Furthermore, the ease with which the monkeys in the Moritz *et al.* study managed to achieve the desired control over the pattern of their neuronal activity (they achieved it within the first 10-minute practice session — Moritz *et al.*, 2008, p. 639) strengthens the impression that it is the conscious intention of the monkey to achieve a certain objective (specific position of the cursor on a monitor) and not some higher motor circuit in the prefrontal, pre-motor, or anterior cingulate areas of the cortex that is controlling the activity of a specific neuron in the motor cortex. It is highly improbable that these higher centres of the brain should produce specific neural states spontaneously and exactly when their 'owner' wants them to be produced. Indeed, the authors of the study referred to revealingly write themselves that monkeys demonstrated *volitional* control of the discharge rates of nearly all cells tested (*ibid.*).

Empirical Puzzles

I hope that this brief discussion of the main empirical arguments currently adduced in favour of neuronal reductionism is sufficient to demonstrate that they are too weak to establish the claims of neuronal reductionism. However, these are not its only difficulties. Current scientific literature contains numerous empirical findings which pose further difficulties for this position by raising deep doubts about the adequacy of a number of currents assumptions about the functioning of the brain in producing our mental life. It will not be possible to review all such findings in detail here, but let me briefly mention at least some of them.

(1) It is well known that neurons are electrically active also when idle (*cf.* e.g. Fiser *et al.*, 2004; Kenet *et al.*, 2003). Such activity does not seem to have any influence on the content of consciousness. This fact can be dismissed by the adherents of neuronal reductionism by claiming that certainly not all aspects of neuronal activity have to be represented in consciousness. Fair enough, yet in certain situations one can detect *large scale* activation in the cortex, spontaneous waves of electrical activity not produced by any external stimuli (Tsodyks *et al.*, 1999). In such a case, due to the scale of brain activity, it is more difficult to explain away the fact that it finds no echo whatsoever in conscious experience.

(2) The authors of a recently published study mentioned above (Fiser *et al.*, 2004) went as far as to assert that the changes in electrical activity of a specific brain centre produced as a result of stimulation by an external stimulus are, generally speaking, drowned in the spontaneous activity of this centre,[8] which motivated them to postulate that the external stimulation serves merely to modify the spontaneous activity of brain centres: 'We propose that during sensory coding, stimulus-evoked activity in the visual cortex principally reflects the modulation and triggering of intrinsic circuit

[8] 'Even when stimulated by input signals with diverse statistical properties, the firing patterns of visual cortical neurons are dominated by the intrinsic dynamical properties of the cortical circuit rather than the signal statistics' (Fiser *et al.*, 2004, p. 576).

dynamical behaviour by sensory signals, instead of directly encoding the structure of the input signal itself. In this framework, ongoing activity may not be noise upon which visual responses are superimposed, but rather an integral component of sensory processing' (*ibid.*, p. 577).

Thus, the situation 'on the ground' of the sensory centres of the brain seems to be comparable to someone trying to listen to a very distant short wave transmitter in the middle of the day: you hear mostly noises, and with great difficulty can make the broadcasted message out. Yet this is manifestly not our conscious experience. For our conscious experience is most certainly that of very strong 'signal' and very little 'noise'. Thus the question arises how such 'noise-free' conscious experience is possible if on the neuronal level 'noise' predominates?

(3) Furthermore, it is well known that overall brain activity decreases significantly in states of diminished consciousness such as sleep or, particularly, vegetative states. Thus, it is natural to expect that states of heightened consciousness should be associated with higher rates of brain activity. Yet paradoxically, evidence has emerged recently that the spontaneous activity of specific groups of neurons is in fact higher than the activity *of the same neurons* engaged in a specific task, i.e. that the neuronal activity of a specific brain area usually associated with a certain form of mental activity *decreases*, rather than increases, when engaged in a task of the kind assumed to pertain to that brain area (Otazu *et al.*, 2009). These findings seem to contradict current assumptions which lead us to expect that the 'idle' activity of a brain centre will be substantially lower than the activity of the same brain centres engaged in 'processing information' necessary for performing a cognitive or motor task.

(4) As mentioned above, it has been demonstrated recently that the activation of the sensory (auditory) areas of the brain during sleep is essentially the same as during waking (Issa and Wang, 2008). How come then that we are not aware of the sounds around us when we are asleep?

(5) It is well known, or at least it has been assumed as established beyond any doubt, that increase in neuronal activity leads to an increase of blood flow in the stimulated area of the brain (to supply the oxygen needed for the increased metabolism of the active part of the brain). It turns out, however, that the increase of blood flow to a specific area may arise without any increase in the electrical neuronal activity in this area but in response to the mental

task in which the experimental subject is engaged (Sirotin and Das, 2009; *cf.* also Leopold, 2009). This is of course deeply puzzling: the neurons do not seem to be active, yet blood flow responds to the mental activity of the subject. How is it at all possible?

(6) Crows and rooks have been repeatedly demonstrated to have the capacity to solve problems and use tools on a level with higher apes such as chimpanzees and gorillas (*cf.* e.g. Hund, 1996; Weir *et al.*, 2002; Taylor *et al.*, 2007; Bird and Emery, 2009a,b). But they have evidently very small brains, small even relatively to their body weight. How come they can be so clever? Moreover, it has recently been reported that octopuses exhibit behaviours which can be interpreted as tool use (Finn *et al.*, 2009). Until now, invertebrates have generally been regarded as lacking the cognitive skills necessary to engage in such complex behaviours. How can octopuses, with their relatively unsophisticated nervous system, be so clever?

(7) Within the framework of neuronal reductionism it would be natural to assume that when we move our legs or hands some centre in the brain, presumably located somewhere within the so-called motor cortex, sends appropriate impulses to the limb concerned, signals that ‘get the limb going’. The exact mechanism which makes it happen is still unknown, but the attribution of the stimulus for a complex movement of a limb to a brain centre seems to be uncontroversial. However, a recent study of the octopus raises interesting questions in this regard (Zullo *et al.*, 2009). The authors of this study report that by applying stimulation in the range of between 3 to 30 V they were able to induce changes in skin colour or texture over part of the skin or over the entire body of the octopus, as well as weak motor responses (e.g. small movement of eyelids, neck, etc.). By applying stronger current (3 to 80 V) they succeeded in eliciting more complex responses such as arm extension displays, crawling, jet-propelled swimming, and inking. They failed, however, to evoke certain movements of the animal’s natural behavioural repertoire, such as the stereotypic fetching movement, and they found no single stimulation site whose stimulation could elicit movements of a (whole) single arm or body part of the octopus. The authors concluded that the areas responsible for various segments of complex movements have no topographical organization, but are distributed over wide regions. But if this is so, how does the octopus manage to move its tentacles in an orderly fashion at all?

> There is, however, a further difficulty with these results. The current used for inducing more complex movements of the octopus had, as mentioned above, a very high voltage indeed, a voltage that exceeded by far the parameters of the electric current which could be induced in the nervous system of the octopus under normal physiological conditions. Thus the question arises if the results produced under these conditions can at all be regarded as equivalent to the processes taking place in the animal under 'life' circumstances, or should it not rather be assumed that the responses evoked were a form of reaction of the poor creatures to the *pain* caused by the stimulation meted out to them by the researchers? If this was the case, then it is possible to surmise that the stimulated centre had perhaps no or at least little role to play in eliciting *spontaneous* movements of the octopus. Whether you pinch me hard on my nose or on my ear my reaction will be the same: I'll try to punch you (or, depending on my temperament, scream). And if you repeatedly pinch me on the ear I will repeatedly try to punch you. Yet neither the nose nor the ear are directly causally responsible for producing my punching movement (or my screaming). But if this is so, none of the centres identified by the researchers would be in fact responsible for producing the movements of the octopus under physiological conditions. Thus the question arises: where do its movements originate from under the normal life conditions of the octopus?

These are just some examples of relatively recent puzzling neurobiological discoveries. This list can be extended. In fact almost every week brings to light new facts which can hardly be reconciled with the cherished assumptions of neuronal reductionism.

Conceptual Problems of Neuronal Reductionism

Let us now move on to a brief discussion of some deep *conceptual* problems involved in the assumption that the brain causes mental events. Brain events have entirely different character than mental events do. Imagine a triangle. This can be done easily. Now, ask yourself the question how long is the triangle you are imagining? This can also be done even if not very precisely. But now ask yourself how long the *concept of the triangle* is? The concept is evidently not identical with the image of the specific triangle that you might have in mind. If you consider this question longer you will realize that the question is absurd. It does not make sense to pose the question about the length of a concept because concepts do not have any spatial dimensions. To use Ryle's famous term, such a question would be a *category mistake* (Ryle, 1949, pp. 16–8). It was Gottlob Frege who, at the end of the nineteenth century, vigorously drew attention to this problem. In his famous essay 'Der Gedanke' (The Thought) he pointed out that if a thought, e.g. the thought T, with the content $a^2 + b^2 = c^2$ were present only in my consciousness, and in the consciousness of another person were present a thought T_1 whose content corresponded to the content of my thought T, yet which were numerically different from this thought of mine, then it would not be possible to speak of 'the Pythagorean theorem', and one could not claim that 'the Pythagorean theorem' is true, but one would have to claim that all Pythagorean theorem*s*, each present in the mind of a different person, *are* true (Frege, 1966). On the basis of these considerations Frege concluded that thoughts can neither be things of the outer world, nor can they be mere images (in German: Vorstellungen), for these always require a concrete bearer. Therefore, he came to the conclusion that one has to acknowledge the existence of a *third world* (over and above the world of outer objects and the world of mental images), the world in which thoughts as such, their contents, exist: 'A third world has to be acknowledged. Whatever belongs to this world corresponds to mental images (Vorstellungen) inasmuch as it cannot be perceived through the senses, and to the things [of the outside world] inasmuch as it does not require any carrier to whose consciousness it belongs. Thus e.g. the thought which we expressed concerning the Phythagorean theorem is true timelessly, true irrespective of whether someone considers it to be true. This thought does not require any carrier [to exist]' (Frege, 1966, pp. 43–4, my translation).

It is pretty clear that Frege means here a world whose 'inhabitants' are characterized by the fact that they are space- and timeless entities. Although Frege exercised considerable influence on such prominent philosophers as Rudolf Carnap (Frege's direct pupil), Bertrand Russell, Ludwig Wittgenstein, and Edmund Husserl, and even though Husserl was also adamant in stressing that the content of thoughts must be clearly distinguished from the form of their appearances in the mind (Husserl, 1992, pp. 173–4), the idea of the 'third world' became more or less forgotten until Karl Popper 'resurrected' it in his own way in 1973 (Popper, 1979, *cf.* pp. 152–61). However, some two decades later several philosophers drew attention to the fact that thought contents, and indeed contents of sensory perceptions and of feelings, are space- and perhaps even timeless entities. Thus Colin McGinn wrote some years ago: '[O]ur consciousness appears to us as in its nature not spatial… To ask… about spatial properties of [visual experiences] means to commit a kind of category mistake, analogous to the question of spatial properties of numbers' (McGinn, 1996, p. 183, *cf.* also 198).[9] The prominent German philosopher, Robert Spaemann, wrote some years ago that all intentional phenomena (including thoughts) can exist neither inside, nor outside of our bodies (Spaemann, 1998, pp. 57–8), and that intentional acts are — as far as their essential nature (German: Dasein) is concerned — timeless, and merely appear (German: ihrem Sosein nach) to be events in time (*ibid.*, p. 72). Interestingly, even the radically materialistically oriented German philosopher of mind, Thomas Metzinger, maintains that at least some mental phenomena, e.g. what he calls our 'mental models of ourselves', do not have spatial properties (Metzinger, 1999, pp. 163–4).

More recently, such leading contemporary philosophers as Richard Rorty and Jürgen Habermas were led to claim that thoughts cannot be represented in the brain:

> The main reason for thinking that the *Natur-Geist* distinction will remain as important as it has always been is that intentional ascription is holistic: beliefs cannot be individuated in such a way as to correlate with neural states. Convincing arguments for this thesis have been afforded by, among others, Davidson, Arthur Collins, Lynn Baker, and Helen Steward. They have shown why we cannot hope to map beliefs onto neural states, though such mapping might work for, for example, mental images, or surges of lust. If there is nothing interesting to be discovered about how changes in belief are related to neurological mechanisms, it is hard to see how studies of what Chomsky calls 'the brain/mind' can be expected to interact with studies of culture. (Rorty, 2004, p. 231)

> Thoughts which we can express in mentalistic vocabulary cannot be translated without a semantic leftover into a vocabulary tailored to rendering things and events. Therein lies the crux of those research traditions which have to accomplish exactly such translation if they want to achieve their aim of naturalizing the mind in compliance with ordinary scientific standards… [O]n the level of the core concepts attempts at naturalizing the mind fail on the necessity of such translation… This is not surprising, since incompatible ontologies are built into the grammars of both language games. Since Frege and Husserl we have known that the propositional contents and intentional objects cannot be individuated in

[9] Translated from German by M.B.M. The article was written initially in English specifically for the collection of essays on consciousness in which it was published. However, as it was the intention of the editor to let the whole volume appear in German, all English contributions were translated into German. McGinn's paper was translated by Antonia Barke.

> the framework of causally effective, spatially and temporarily identifiable events and states. (Habermas, 2004, p. 882, my translation)

Yet, the seemingly insurmountable difficulty of representing non-spatial and non-temporal contents in an evidently spatio-temporal structure such as the brain is not the last conceptual hurdle which has to be faced by adherents of neuronal reductionism. Another major difficulty for the supporters of neuronal reductionism relates to one of the central features of our conceptual life: the *constancy of meaning* of concepts. The meaning of the term 'triangle' is essentially the same to me today as it was when I first learnt it at school, and as it will be in twenty or thirty year's time, when I am about to die. There is no doubt that the meaning associated with a particular concept by a particular individual changes with time to some extent, and especially that it undergoes major transformations from the time when a person learns to understand the concept for the first time until the same person achieves some form of a mature comprehension of the given term, but from that point onward the core meaning of that term or concept remains essentially stable, barring unusual occurrences, such as, for example, the breakdown of the original understanding of the term 'atom' (from Greek 'indivisible', the smallest unit of matter) at the turn of the nineteenth century, or more recently the perturbations around the meaning of the concept 'gene', which until some years ago was understood to be, basically, a continuous section of chromosomal DNA responsible for the synthesis of a specific protein and is recognized today as nothing of the sort (Pearson, 2006); and barring rich associations which can accrue around this core meaning through ever growing and ever richer life experience of a particular individual. The problem for representing this conceptual constancy in the brain arises from the evident fact that the reality of the living brain is anything but stable. As pointed out above, repeated exposure to the same stimulus results in varied responses of the same neuron. Moreover, we have learnt that the brain undergoes constant transformations with experience, that practically every prolonged new stimulation leads to a rearrangement of the pattern of connections between the individual neurons, or even to structural changes in the brain. Thus it could be surmised, even though it would be exceedingly difficult to prove this point experimentally, that no two temporally discreet states of the brain, or even of its small subsections such as neuronal assemblies, are exactly identical. In the brain everything is in constant motion and undergoes constant changes, '*panta rei*'. But if this is so, how come we can experience the conceptual constancy we most evidently experience? Indeed, how come we can have the concept of identity at all, if no two brain states are and never can be identical?[10]

Conclusions

Taking the weight of the preceding considerations in its entirety it seem fair to say that they amount to a radical challenge to the currently dominant view of the origin of consciousness. In view of these considerations it appears that the theory that electrical impulses recorded in the brain are traces of 'information processing' taking place within individual neurons and/or in neuronal assemblies, and ultimately leading to the emergence of consciousness in its varied and rich facets, is a fairy tale. There was a time, not very long ago, when serious scientists of the period adhered to the doctrine of abiogenesis, i.e. were convinced that life can arise spontaneously from inorganic matter. Not only did the great, but from today's perspective rather ancient, Aristotle think that it was a 'readily observable truth' that aphids arise from the dew which falls on plants, fleas from putrid matter, mice from dirty hay, crocodiles from rotting logs at the bottom of bodies of water, and so on (*cf.* Lennox, 2001), but still in the seventeenth century Alexander Ross wrote: 'To question [spontaneous generation] is to question reason, sense and experience. If he doubts of this let him go to Egypt, and there he will find the fields swarming with mice, begot of the mud of Nylus, to the great calamity of the inhabitants' (Ross, 1652).

We know better today, of course. It seems justified to claim that currently widespread beliefs attempting to interpret consciousness as a form of emergent property of purely physical systems are just as deeply mistaken about their subject matter as the beliefs of abiogenists concerning the origin of living organisms were about theirs. Just as mice cannot arise of the mud of the Nile, so consciousness and other more complex mental phenomena cannot arise from the 'mud' of the firings of neurons in the brain. Thus the question, 'Where can it arise from?' imposes itself on us with renewed urgency.

[10] It is important to stress that the conceptual difficulties outlined here make so-called type-B materialism (*cf.* e.g. Levin, 2008; Papineau, 2007) untenable, for they seem to demonstrate that purely material systems such as the brain are not able in principle to 'form' any concepts, let alone 'recognitional-demonstrative concepts of experience' (Levin, 2008, p. 403), which are supposed to enable a physical system to gain — introspectively — appreciation of the 'what it's like' aspect of its inner experience. I asked Professor Levin and Professor Papineau to comment on the above arguments, unfortunately I have not received any reply.

Acknowledgments

I should like to thank the reviewers of this article, in particular Professor Vimal, for their helpful comments.

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Paper received December 2009; revised April 2010.