An Evidence-Based Critical Review of The Mind-Brain Identity Theory

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Abstract

In the philosophy of mind, the causal relationship between phenomenal consciousness, mentation, and brain states has always been a matter of debate. On the one hand, material monism posits consciousness and mind as pure brain epiphenomena. One of its most stringent lines of reasoning relies on the premise that since brain lesions and neurochemical modifications lead to cognitive impairment and/or altered states of consciousness, there is no reason to doubt the mind-brain identity. On the other hand, dualism or idealism (in one form or another) regard consciousness and mind as something other than the sole product of cerebral activity pointing at the ineffable, undefinable, and seemingly unphysical nature of our subjective qualitative experiences and its related mental dimension. Here, we argue that the premise of material monism is based on a logical correlation-causation fallacy and, without resorting to exclusively philosophical arguments, we will review some neuroscientific findings that question the idea that posits phenomenal experience as an emergent property of brain activity. While these (mostly ignored) findings, if considered separately from each other, could, in principle, be recast into a physicalist paradigm, once viewed from an integral perspective, they substantiate equally well, if not even more effectively, an ontology that posits mind and consciousness as a primal phenomenon.

Keywords Philosophy of mind · Mind-body problem · Neuroscience · Material monism · Physicalism · Dualism

Introduction

Since the times of René Descartes in the 17th century, the mind-body problem has been one of the central debates in the philosophy of mind. The conventional Cartesian dualism is no longer considered tenable but other forms of dualism, or theoretical frameworks of philosophical idealism, or more generally, non-physicalist ontologies, state that mind and consciousness cannot be explained as a mere result of neural processes.

Dualism is opposed by an identity theory, which, instead, considers mind processes identical to brain processes, and consciousness as nothing other than an emergent epiphenomenon arising from the collective interaction of the neuronal activity. Sentience, with all its subjective dimensions of experiences, feelings, and thoughts *is* a physical process determined only by the laws of physics. Qualia–the subjective, phenomenal, and mental experiences we can only access introspectively, such as the perception of color, or that of pain and pleasure–*are* physical brain states, while any speculation concerning an immaterial mind or consciousness is considered an unnecessary hypothesis.

Dualists and monists have different schools of thought but, despite the variety of opinions, it is fair to say that most scientists and philosophers consider themselves to be material monists.

However, there is now a growing awareness that a mere functional investigation will not answer questions of a more philosophical nature. The belief that the progress of modern neurosciences would soon shed light on David Chalmer's notorious 'hard problem of consciousness' (Chalmers, 2015) has turned out to be too optimistic. This is because, unlike other physical processes, in which causes and effects can both be observed from a third-person perspective, in consciousness studies one is confronted with a cause–the brain activity–that one can still analyze from a third-person perspective that, however, apparently produces an effect we call 'conscious experience', or just 'sentience', which can be apprehended only from a first-person perspective. This ‘perspectival asymmetry’ makes consciousness in its subjective and experiential dimension stand out as a phenomenon alien to any attempt of conceptual causal and ontological scientific reduction. Inside a naturalistic framework, the origin and ontology of the phenomenal subjective conscious experience remain unclear.

While most arguments were based on a philosophical line of reasoning, we will show that there are also empiric facts that have not received sufficient appreciation and that give us good reasons to look upon the physicalist assumptions with a more critical eye. Non-neurocentric paradigms of consciousness that posit mind and consciousness as a fundamental primitive, rather than matter, remain a viable option. We don’t necessarily favor any particular dualistic, panpsychist, Eastern philosophical, or whatever metaphysical scheme, but rather argue that a variety of findings, especially when seen comprehensively and in their relationship to each other, could be suggestive of other possible ways of interpreting the neuroscientific findings, and that might even have more explanatory power in terms of an underlying non-materialistic ontology.

We will first examine more closely the logical framework that sustains a mechanistic conception by pointing out some conventional causation-correlation fallacies. Then, a review of old and new neuroscientific findings will illustrate the weaknesses of a mind-consciousness-brain identity theory and that ask for clarification if one wants to save the orthodox physicalist paradigm. A brief section will focus on the emergent fields of the study of plant and cellular ‘basal cognition.’ Conclusive remarks will follow.

I. Neurological causation-correlation fallacies

Let us first question some basic assumptions. Does the physical change of a brain state leading to cognitive impairment or altered states of consciousness provide a necessary and sufficient logical proof that mind and consciousness are an emergent cerebral phenomenon?

After all, it is undeniable that there is a direct relation between the physical state of our brains and our subjective experiences. Dopamine is a neurotransmitter molecule that enables biochemical transmission among neurons and which is responsible for the effects of a drug like cocaine. We know that psychedelic drugs can lead to intense subjective effects. It is a well-known fact that brain damage can lead to severe cognitive impairments. If the Broca's area, a left cerebral hemisphere area, is lesioned, one loses the ability to speak (interestingly, however, not the ability to comprehend language). Someone being anesthetized using anesthetic drugs (seemingly) 'loses' consciousness. And nowadays, we have a whole bunch of sophisticated brain scan technologies that make it clear, beyond any reasonable doubt, how for every conscious experience, there exists a neural correlate in our brains.

Thus, apparently, a neuroscience based on brain chemistry and lesion studies, leaves no place for any form of dualism. Mind seems to emerge from matter; there is no distinction. Our personalities, identities, moods, and states of consciousness seem to depend on the biophysical state of our brains.

And yet, few further critical thoughts should make it clear that such a correlation is not a sufficiency criterion. One has to secure one’s theoretical framework from a possible logical fallacy that believes that correlation implies causation. The fact that two events are always coincidental or always happen shortly, one after the other, doesn't imply that the first event caused the second event to happen. If from event A always follows event B we are not entitled to conclude that the cause of B is A. These sorts of logical fallacies are known as 'post-hoc fallacies'. A simple example could be that of a fallacious link between the observation of how subjects with low vitamin D correlate with an increase in mortality, and therefrom conclude that low vitamin D increases the risk of mortality. However, there is no evidence that vitamin D supplementation lessens mortality risks. In fact, it turns out that vitamin D declines in acute and chronic diseases. This is one of the several examples of reverse causality that are more common than imagined in medical sciences (e.g., for an overview of how this methodological deception isn’t uncommon in cardiovascular epidemiological see (Sattar & Preiss, 2017).)

Nevertheless, the necessity and sufficiency that the explanation of our qualitative experiential dimension is to be chiefly found in neural circuits, remains a rarely questioned belief (with few exceptions, e.g. in the field of behavioral processes (Gomez-Marin, 2017).) There is a general tendency to believe that causal mechanistic explanations based on neural lower-level properties are better than higher-level behavioral accounts. For example, Krakauer et al. pointed out that frequently neuroscientists (and, we would add, most analytical philosophers of mind as well), use language to hide more than to reveal, by assuming that a neural causal efficacy equals understanding–that is, charging it with an explanatory power it doesn't have. The result that "neural activity X is necessary and sufficient for behavior Y to occur" allows a causal claim often added by an additional explanatory sentence that rearticulates the same causal result employing 'filter verbs' (such as "produces, "generates", "enables", etc.) and that, however, masks the faulty logic to make a metaphysical position pass as empirical data (Krakauer et al., 2017).

But, what are the alternatives to the mind-body identification that could be in line with the above correlation between mental states and physical neural correlates of consciousness?

In fact, the metaphor most idealists prefer is the 'filter theory of consciousness,' which dates back to an original idea of William James, who stated: *"My thesis is now this: that, when we think of the law that thought is a function of the brain, we are not required to think of productive function only;* ***we are entitled also to consider permissive or transmissive function****. And the ordinary psycho-physiologist leaves this out of his account*" (emphasis in the original text) (James, 1898).

James thought of the brain and consciousness in the frame of a 'bidirectional transducer theory' using the analogy of the prism separating white light into colored beams, respectively. If a broken prism fails in its function to 'reveal' the colored light beams, this should not lure us into the logical correlation-causation fallacy that the prism 'produces' colored light. The material and structural modification of the optical medium modifies the refractive gradient that 'transduces' light with a different chromatic dispersion but does not 'create' it. A prism is just an object with a transmissive or transducing function; it doesn't 'generate' anything.

Aldous Huxley expressed a similar idea and proposed that the brain is a 'reducing valve' of what he called a 'Mind at large,' a universal or cosmic Mind that comprises all of reality with all ideas and all thoughts. According to Huxley our mind filters reality under normal conditions because, otherwise, we would be overwhelmed by the knowledge of this universal Mind. Psychedelic drugs can remove the filter and bring us into contact with the Mind at large, leading to the experiences that several mystics describe. In his words: *"To make survival possible biologically, Mind at large has to be funneled through the reducing valve of the brain and nervous system"* (Huxley, 1954). For Huxley the brain was a material 'connecting device', an 'interface' or 'relay station'. In this view, the human consciousness is a localization of a universe-wide consciousness projected into our brains. The limited brain filters and suppresses this universal consciousness, but does not 'produce' it.

An understanding of the mind-brain relationship reminiscent of Eastern philosophies, and that maintain similar views, as neatly summarized by the Indian mystic and poet Sri Aurobindo: *"Our physical organism no more causes or explains thought and consciousness than the construction of an engine causes or explains the motive-power of steam or electricity. The force is anterior, not the physical instrument."* (Aurobindo, 1919)

From these perspectives, mind uses the brain as an instrument as a means of expression, and by which it is more or less limited and interdependent but isn't generated by the instrument itself.

Notice how this standpoint is not entirely alien to our ordinary understanding of how a digital computer works. Knowing everything about its hardware, and recreating its physical structure exactly in every detail, would not lead us to a machine making anything meaningful or useful. The software– that is, a running code written by an intelligent external agent– is needed. Here also a computer is only an instrument, a means of expression for a cognitive entity, not its origin or source. In fact, studying a microprocessor with the same criteria employed by modern neuroscience, trying to reverse-engineer its functions by analyzing local field potentials, or selectively lesioning its units by correlating this with its behavior, would fail: We would not be able to explain how it works, let alone reveal anything about the running code, and which is the real 'agent' that causes the behavior of the machine (Jonas & Kording, 2017).

Thus, neural correlates of consciousness, or lesion-based studies. do not constitute a sufficient logical foundation for a mind-brain identity theory. We have the right to maintain the contrary hypothesis: Consciousness, mental states, and emotional states are more or less 'funneled through' depending on the physical state of a brain. The brain could equally well be seen as a physical substrate *through which* these conscious states manifest without leading to any inconsistency with the current scientific knowledge.

II. The search for the ‘seat of consciousness’

There is no evidence, not even indirect or circumstantial, of a single brain region, area, organ, anatomical feature, or Cartesian pineal gland that takes charge of this mysterious job of ‘producing’ or ‘generating’ consciousness. Most of the brain is busy processing sensory inputs, motor tasks, and automatic and sub- or unconscious physiological regulations (such as the heartbeat, breathing, the control of blood pressure and temperature, motor control, etc.), and that do not lead to qualitative experiences. Neural activity alone cannot be a sufficient condition to lead to phenomenal consciousness. Since the vast majority of things a brain does are unconscious, this raises the question: What distinguishes a neural process that leads to a conscious experience from that which does not?

For example, the cerebellum is almost exclusively dedicated to motor control functions, and its impairment leads to equilibrium and movement disorders. However, it does not affect one’s state of consciousness. Its role in ‘generating’ experience seems to be marginal, if any. There are also rare cases of people who live without cerebellum (‘cerebellar agenesis’) and have only mild or moderate motor deficits or other types of disorders (Feng & al., 2105). This is a fact that seemingly confirms the brain’s proverbial neuro-plasticity, which we will see next through other extraordinary examples.

Fig. 1 Case of cerebellar agenesis: Living (and walking) without the cerebellum. Credit: (Feng & al., 2105).

It may be worth recalling that the neuronal architecture in our bodies is not confined to the brain—that is, it goes far beyond our heads, through the brain stem, and down through the spinal cord. The central nervous system is made up of the brain and the spinal cord. The latter is responsible for the transmission of nerve signals from and to the motor cortex, and as is well known, injuries can result in paralysis. But, again, no cognitive deficit or state of consciousness is altered by impairments of the spinal cord. This leaves only one option: If there is a ‘seat of consciousness,’ it must be identified somewhere in the cerebral cortex or subcortical areas of the brain.

Another interesting example of how the correlation-causation fallacy conditions scientific and popular understanding of the mind-body problem can be illustrated by an interesting experimental finding that showed how the stimulation of the thalamus arouses macaques from stable anesthesia (Redinbaugh & al., 2020). The awake, sleeping, and anesthetized states could be aroused with the stimulation of the central lateral thalamus. The straightforward conclusion seemed to be clear. The ultimate origin and switch ‘modulating’ consciousness was discovered. If your consciousness ‘depends’ on the state of your thalamus, just by ‘switching’ it on and off by the touch of a button, then the thalamus must be the ‘seat of consciousness.’ Does this apparently unavoidable conclusion need further reflection?

First of all, observing from a third-person perspective the absence of an external physiological signature as evidence for a lack of internal first-person sentience is yet another correlation-causation fallacy that has too frequently led to unwarranted conclusions. For example, if anesthesia induces an unconscious state with the patient having no whatsoever subjective experience is far from obvious. We simply don’t know if it really induces a completely unconscious state or a conscious but non-metacognitive no-report state that makes one unable to recall past experiences once back in the waking state. The former assumption is, unfortunately, taken in most cases as the standard scientific approach. Whereas, there are indications suggesting that anesthetic-induced unresponsiveness does not induce complete disconnectedness ((Anon., 2018), (Radek, 2018).) Interestingly in this regard is also the so-called twilight anesthesia, an anesthetic technique that sedates patients only mildly and induces amnesia but no loss of consciousness (Scheinin & al., 2020). During this 'twilight state,' they are responsive and can be asked to perform some tasks that they would not be able to recollect after the surgery. This case alone shows that the inability to recall events during sedation is no proof of unconsciousness.

Moreover, there is now a non-negligible amount of scientific literature that presents empiric evidence on parasomnia (sleepwalking), hypnosis, non-REM sleep, and on subjects in a vegetative state that some form of conscious awareness is present also in all these non-responsive states of consciousness (e.g. (Oudiette & al., 2009), (Siclari et al., 2018), (Owen & Coleman, 2006), (Cruse & al., 2011) (Mackenzie, 2019).) Arguing and extrapolating from the lack of superficial physical cues and mnemonic retention to a verdict that declares someone to be ‘unconscious’–that is, having no subjective phenomenal experience–is, at least from the philosophical perspective, again betraying a logical correlation-causation fallacy.

But even if we assume that there is no internal experience when we are anesthetized, the relevant question remains whether these sorts of experimental findings confirm that the thalamus is the 'seat of consciousness.' Is it a sort of modern replacement for Descartes' pineal gland in its mechanistic-material monist version?

The thalamus is responsible for sensory information processing. It is known that its main job is to function as a relay and feedback station between sensory brain areas and the cerebral cortex. For example, it functions as a hub between the optical nerves that transport the visual information coming from our eye retinas to the visual cortex. Even if one would remain conscious by turning down the functionality of the thalamus, one would no longer see anything because the neural pathways between the retina and the visual cortex are interrupted. From that, however, nobody would conclude that the thalamus is the seat of the visual experience for which the visual cortex is responsible. Because we know that it is a 'hub', a 'transducer' or a 'filter'. From this perspective, the thalamus' function is to 'integrate' the information flow of the several brain areas and, if disrupted, consequently lead to a 'loss' of consciousness.

Thus, these findings don't tell us much about the generation of conscious experience but, if there is not one single 'seat of consciousness,' could it be that the combination and activity of some or all the different brain areas do 'produce' the subjective experience? Considerable attention in this direction receive theories such as the 'Integrated Information Theory' (IIT) ((Oizumi et al., 2014) (Tononi, 2015),) and the 'Global Workspace Theory' (GWT) (Baars, 1988), according to which it is the amount and integration of information and the momentarily active and accessible memory that determine the level of consciousness leading to a conscious entity. A process of integrating the information and the memory coming from all the brain areas may be the efficient cause of our experiential richness. In fact, we have sufficient evidence that must compel us to abandon this simplistic view of a compartmentalized brain, with modern neuroscience thinking more in terms of network science, where several brain regions are highly interconnected and interdependent. There is no brain region doing only one thing, and there are no neurons supposedly having only one function. Most neurons have several jobs, not a single purpose. It turns out that whenever we hear a sound, have a visual experience, have feelings or emotions, or perform some motoric task, the whole brain is involved. Even such an apparently highly specialized brain region as the primary visual cortex carries out information processes related to hearing, touch, and movement ((Liang & al., 2013) (Merabet & al., 2008).) The reason why we nevertheless tend to associate specific brain regions with specific cognitive, sensorial, or motoric functions is that brain scans show only a temporal snapshot of the brain's most intense activity. We are seeing only a few 'tips of the iceberg' and missing the overall activity in the noise. When studies are conducted using less noisy but much more expensive and complicated detection methods, most of the brain's activity becomes visible (Gonzalez-Castill & al., 2012). Therefore, it would seem plausible that if consciousness arises from the activity of a complex aggregation of neurons, that at least some brain areas must work together in a unified whole via thalamic activity.

However, how far these conjectures align with reality is questionable.

Because this would also suggest that if someone were to split your brain into two parts, and you survived, you would presumably feel somewhat less conscious and less 'yourself.' As well-known, this is a very real surgical procedure performed since the 1940s: the corpus callosotomy (although only rarely used nowadays). It is performed to treat the worst cases of epilepsy (patients having up to 30 seizures a day) that did not respond to any medical treatment. In this procedure, the corpus callosum, the nerve tract connecting the left and right brain hemispheres, is severed (in part or, in some cases, entirely cut through), thereby avoiding the spread of epileptic activity between the two halves of the brain. Its natural function is to ensure communication between the two cerebral cortexes of the two hemispheres to integrate and coordinate motor, sensory, and cognitive functions, such as moving left and right limbs, the

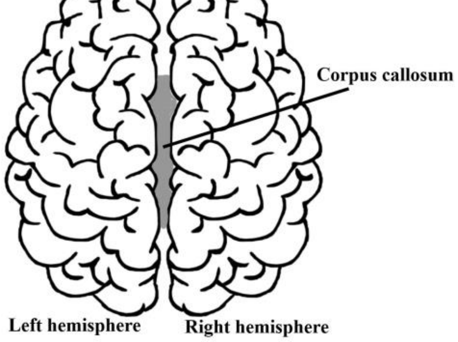

Fig. 2 Does brain-splitting cause 'self-splitting'?

visual integration of the left and right sight, etc. Because most of the brain's activity is distributed on both hemispheres, with no indication of one or the other part being responsible for generating our sense of 'self', one must wonder how the patients who have gone through such an acute surgical intervention feel. Do their split brains 'generate' a dual consciousness and split personality?

Contrary to common belief, also among neuroscientists, facts have shown that these patients do not have any symptoms of multiple personalities or display any signs of internal dissociation after surgery. Their self, mind, and conscious experience remain a unified whole of one subject and individuality. They deny being a different person from what they were before surgery. Close relatives who knew the split-brain patients before and after surgery didn't notice any personality change.

Of course, there can be more or less severe drawbacks. In some cases, the so-called 'alien-hand syndrome' can take over, where one hand appears to have a mind of its own. This occasionally happens when the two hemispheres' representations of reality come into conflict, and one wants to override the other. In these instances, decision-making and volition between the two hemispheres clash. An example is the patient's struggle to overcome an antagonistic behavior, such as knowing what cloth they want to wear, while one of their hands takes control and reaches out for another cloth they don't want at all. However, this should not be confused with two personalities competing against each other (like in the case of dissociative identity disorders), as split-brain patients identify with only one body and perceive their disobedient limb as being subjected to annoying motoric misbehavior; they do not report any sensation of some other internal personality taking control. The brain—or, more precisely, our two brains—tell us two different 'stories'. Split-brain patients seem to identify with one of the stories—that is, consciously access one of its interpretations—and keep the other in a subconscious or subliminal awareness, what the American cognitive neuroscientist Michael Gazzaniga used to call the 'left-brain interpreter.'

Recent investigations also question the canonical textbook findings ((Pinto & al., 2017), (Pinto & al., 2020). While it is confirmed that a corpus callosotomy splits the visual perception of the environment in two, several patients can nevertheless see them both and report it to the outside world—that is, they can access their language centers. Moreover, there is no evidence of memory loss.

The confusion surrounding split-brain psychology arises, only if we conflate mind with consciousness and the sense of selfhood. If we don't confuse mental states as being the origin or efficient cause for consciousness, then any apparent paradox dissipates. Split-brainers may have two (eventually even conflicting) hemispheric and motor-sensory mental states (something not entirely unusual in healthy subjects too) but, even if one argues and provides evidence for a 'two-minds' model, that wouldn't imply a split sense of identity or self-awareness.

If our subjective and conscious experience is generated by the integrated activity of the whole brain, why doesn't such a radical bisection lead to any modification of our state of awareness? In severing the corpus callosum of a brain one would expect a loss or at least a diminishing of conscious awareness because there would be a loss of working memory and of information integration. But nothing like this happens. The 'unity of consciousness' remains unaffected and, thereby, unexplained.

To save the paradigm, the materialists point out that in not all documented cases was a complete transection of the corpus callosum performed. The truth, however, is that in several cases, the complete sectioning was performed and was even confirmed by MRI imaging or radiological means (Gazzaniga, 1985).

However, one may still point out that a complete transection still leaves some residual subcortical structures intact, and that still allow for some communication between the two hemispheres, potentially maintaining the 'self' of the patients.

To further substantiate the contrary hypothesis, we could mention the cases where there is no second hemisphere to communicate with in the first place. To treat epilepsy, the most extreme surgical intervention is to remove an entire brain hemisphere, that is, by hemispherectomy. Usually, this is done only in childhood because, supposedly, young brains can rewire themselves much more efficiently than older ones. Fig. 3 shows a scan of the brain of an adult who had an entire hemisphere removed during childhood because of epilepsy (Kliemann & al., 2019).

Interestingly, Nature seems to take the left/right distinction and early plasticity hypothesis not so seriously. That the left-right brain task distribution is not an inescapable neurological dogma is testified by people born with only one hemisphere. For example, while in healthy subjects the left visual field is represented in the right hemisphere and vice versa, someone born with only one hemisphere can develop maps of both visual fields in it (Muckli & al., 2009). Hemispherectomy on adults older than 18 years turns out to be safe and effective as in early childhood (McGovern & al., 2019). Even in the case of a left hemispherectomy, Broca's language area—which in normal conditions, is in the left hemisphere — can be recovered in the right part of the brain (Vargha-Khadem & al., 1997).

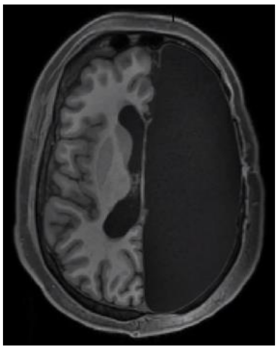

Fig. 3 Hemispherectomy. Living (quite well) with only half of the brain. Credit: (Kliemann & al., 2019)

Further evidence reports of subjects where the frontal lobe was missing from childhood without any measurable linguistic impairments, as shown by a case of a woman who grew up without her left temporal lobe, but speaks in English and Russian (Tuckute & al., 2022). This doesn't mean that persons missing a hemisphere don't suffer consequences– there is suboptimal word and face recognition (Granovetter et al., 2022), but it doesn't play any role for the unity of consciousness.

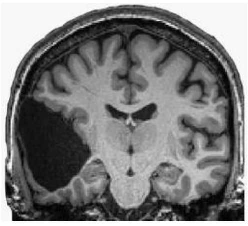

Fig. 4 Speaking without the brain's language area. Credit: (Tuckute & al., 2022)

A possible explanation is that because these patients already had severe seizures originating in one of the hemispheres, the functional rewiring on the other hemisphere began before the surgery. The findings tend to disconfirm this easy way out. Though interconnectivity inside the brain networks increased, the interconnectivity between brain regions with the same function after hemispherectomy does not differ from that of two hemispheric control subjects (Kliemann & al., 2019). That plasticity alone can explain this state of affairs is far from proven (more on this later on.)

However it is, most patients become seizure-free, and their cognition is relatively unchanged after surgery (some motoric and cognitive functions decrease, but others improve). Overall, these patients appear to be 'normal.' Before and after surgery, there is no substantial change in IQ scores, and in everyday life, one could not tell the difference between humans having a brain or only half of one. And, most notably, no whatsoever 'half-self', 'half-awareness,' or 'half-consciousness' is reported by the subjects.

If the mind-brain identity theory is correct, and consciousness emerges as an integration of functional centers, with no particular 'seat of consciousness', then only one brain hemisphere must be sufficient to accomplish the job.

But instances are found where both hemispheres are severely damaged where there isn't left much to integrate. Worth a reminder is how, in 1980, the British pediatrician John Lorber reported that some adults cured of childhood hydrocephaly had no more than 5% volume of brain tissue with a cerebral cortex as thin as 1mm (Lewin, 1980). While some had cognitive and perceptual disorders and several developed epilepsy, others were surprisingly asymptomatic and even of above-average intelligence.

Then, in 2007, in Marseille, France, a 44-year-old man complaining of weakness in his left leg was submitted to an MRI brain scan (Feuillet & al., 2007). As Fig. 4 shows, the skull is abnormally filled with cerebrospinal fluid, leaving only a thin sheet of actual brain tissue. As an infant, he had a shunt inserted into his head to drain the fluid, but it was removed at the age of 14. Evidently, the cerebrospinal fluid build-up didn't stop and ended up reducing the brain's size to 50-75% compared to its normal volume. Though he had a below-average IQ (75/100), this man had a job, a family, and a normal life.

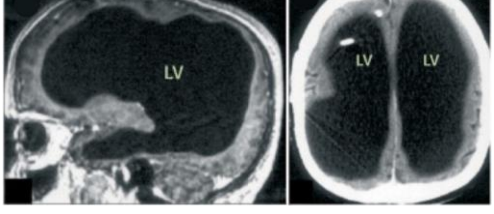

Fig. 5 MRI image of a hydrocephalus brain. Credit: (Feuillet & al., 2007).

These remarkable cases also confirm that brain size and the number of neurons in a brain do not (or, at least, do not necessarily) measure for one's intelligence. Size matters for manipulative complexity, such as the more complex hand movements in primates, which humans can develop superbly (think of the hands of an expert musician playing piano) (Heldstab & al., 2020). But a direct correlation between brain size and mental skills is not that straightforward. We like to believe that it is our brain size that makes us human but rarely do we question what one means by 'size'. The number of neurons? The weight of the brain? Its brain to body ratio? Or its volume? Humans don't have the largest brain size in any of the aforementioned senses. The human brain has about 90 billion neurons, weights ca. 1.1 to 1.4 kg, and has a volume of 1300 cm^3. But the brain of an elephant has three times the number of neurons we have, and the weight and volume of the brain of a sperm whale are six times as much and ants have a six times larger brain to body mass ratio. A bit of an extreme example that shows how cognitive skills and brain size are decoupled is the case of mouse lemurs that have a brain that is 1/200th the size of monkeys' but perform equally well on a primate intelligence test (Fichtel et al., 2020). Therefore, brain size alone is not what makes up a more developed mind. Then what does?

It is plausible to assume that a certain degree of complexity is a mandatory factor for a brain or whatever material structure to display a form of intelligence and cognitive skills. One could think of a measure of 'brain connectivity'—that is, the number of wirings between neurons (through their axons, dendrites, and synapses) and the speed at which they transmit and receive signals—as an indicator of its complexity, and see if it somehow scales with the cognitive functionality. However, MRI studies reveal that all mammals, including humans, share equal brain overall connectivity (Assaf & al., 2020). The efficiency of information transfer through the neural network in a human is comparable to that of a mouse. It is independent of the structure or size of the brain and does not vary from species to species. So, things can't be as easy as that.

However, what the above-mentioned clinical cases have in common, is the presence of cerebral cortex. In fact, some neurologists or cognitive scientists conjecture that phenomenal consciousness resides in the cerebral cortex. This belief, however, isn't unproblematic either.

First of all, since the neocortex exists only in humans and other mammals, one must conclude that birds, fish, octopuses, amphibians, and reptiles are, per definition, all 'unconscious' and incapable of having some, more or less elementary form of conscious subjective experience. There is no sentience; they don't feel pain, fear, or pleasure or have whatever feeling. They are considered Cartesian automatons or philosophical zombies.

But evidence is beginning to emerge that, for example, the neural correlate patterns of sensory consciousness in a corvid bird aren't substantially different from the neural correlates in humans having a similar sensory conscious subjective experience (Nieder et al., 2020). Moreover, one wonders how some birds can also perform amazing cognitive feats despite their forebrains consisting of lumps of grey cells. It turns out that cortex-like circuits in avian birds exist that are reminiscent of the mammalian forebrains, and the idea that advanced cognitive skills are possible only because of the evolution of the highly complex cerebral cortex in mammals is becoming less plausible (Stacho & al., 2020). There is sufficiently strong evidence to conclude that both cephalopods and crustaceans are sentient (Cox & al, 2021). After all, this is unsurprising: Common sense doesn't really need any scientific proof to accept that ravens, crows, octopuses or lobsters are sentient beings.

Another example that should raise doubts is the cases of children in a developmental vegetative state — that is, what is officially considered by the American Academy of Neurology (as declared in its guideline report in 1995 and confirmed in 2018) as being a neurovegetative state in which there is *"no evidence of purposeful behavior suggesting awareness of self or environment"* (Nuerology, 2018). In other words: a universal rule that reduces them to unconscious children who cannot suffer because this supposedly requires a functioning cerebral cortex.

Nevertheless, only one case that shows the contrary should be sufficient to disprove a universal rule. Four such cases were brought to light in 1999 by a group led by D. Alan Shewmoon (Shewmon et al., 1999). They studied the states of awareness in congenitally decorticate children—that is, the cases of four children who were almost completely lacking the cortical tissue and were neurologically certified as being in a vegetative state. Yet, the loving care of their mothers (or of someone who adopted them and bonded with them via dedicated full-time caring) could gradually 'awaken' in them a conscious awareness. From an initially unresponsive state, they showed clear signs of having developed auditory perception and visual awareness (despite the total absence of the occipital lobe that, in normal conditions, hosts the visual areas). For example, they tracked faces and toys, looked after persons they recognized and could distinguish from their mothers or caretakers, listened to music for which they manifested preferences with their facial expressions, including smiling and crying, and, at least in one case, gave clear indications of self-recognition in a mirror. Shewmoon notes: *"Were they* [the decorticate children] *not humans studied by clinicians but rather animals studied by ethologists, no one would object to attributing to them 'consciousness' (or ability to 'experience' pain or suffering) based on their evident adaptive interaction with the environment."*

These cases seem to contradict the prevailing theory according to which the cerebral cortex generates consciousness. However, one can still point out that the children were not completely decorticated, as some cortical tissue was still left (for, example, Fig. 6 shows that a remnant of the frontal lobe is still present) possibly producing the conscious awareness. But neural mechanisms of conscious function cannot be confined to the cerebral cortex alone (Merker, 2007).

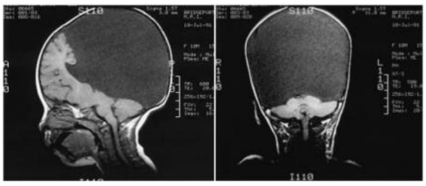

Fig. 6 Congenitally decorticate children MRI brain scan (midline sagittal and posterior coronal plane).
Credit: (Shewmon et al., 1999)

Other speculations, instead, now retire to the last cerebral bastion for the seat of consciousness: the brainstem (Solms & Panksepp, 2012). Indeed, its stimulation can also trigger intense emotions and feelings. But the question is what property a neural circuitry dedicated to the most physical and basal control of cardiac, respiratory, and homeostatic functions, containing mainly neurons for motor and sensory tasks, is also able to give rise to such an apparently immaterial and completely different and unrelated 'function' or 'property' as a conscious experience. We don't know. But this is yet another fact that tells us that we have the right, at least hypothetically, to assume that they don't and are equally allowed to study these facts in the light of a different paradigm that that of a mind-brain identity.

Overall, the cases mentioned above, with the exception of congenitally decorticate children, of people who have undergone corpus callosotomy or hemispherectomy, or people suffering from hydrocephalus, cerebellar agenesis, or several other types of brain damage, show how surprisingly intact their higher cognitive functions remain. One would expect that the first victims of such invasive neurological changes or surgical interventions would be those complex and high-demanding cognitive functions so characteristic of the mind, such as intellectual skills, abstract thinking, decision-making, reason, logically and willfully planning actions, and so on. Instead, it turns out that even if large brain masses are injured or absent, the cognitive skills of the subject remain substantially unaltered.

All these findings require an explanation from the physicalist viewpoint, which identifies the mind with the brain.

Of course, one could resort to the usual conjecture that neural plasticity explains all things. Neural plasticity certainly plays a role and undoubtedly has its explanatory power. But, in most cases, remains conjectural and is invoked to fill the gaps that save the paradigm. Some caution would be appropriate. For example, a recent study challenges the idea of adaptive circuit plasticity according to which the brain recruits existing neurons to take over for those that are lost from stroke. Definitive evidence for functional remapping after stroke remains lacking. Undamaged neurons do not change their function after a stroke to compensate for damaged ones, as the conventional re-mapping hypothesis believed (Zeiger et al., 2021).

Moreover, it is observed that when a brain injury occurs, causing some form of amnesia, what was thought to be lost forever may remerge into awareness, sometimes after years. Those whose loved ones suffered from dementia may have noted how memory and clarity of thought may suddenly and quite surprisingly reappear in a brief moment of lucidity, called 'paradoxical lucidity,' or, even 'terminal lucidity.' There can be bursts of mental clarity that sometimes occur shortly before people die. Credible reports document of cases in which people with dementia, advanced Alzheimer's, schizophrenia, and even severe brain damage, suddenly return briefly to a normal cognitive state (for a review see (Nahm et al., 2012), for some more recent findings see (Batthyány & Greyson, 2021).) It is hard to recast these brief episodes of lucidity, and that last less than one hour or even few minutes, by resorting to brain plasticity.

Another question is also why sensory or motoric functions are much more prone to be disrupted than mental ones. The IQ and abstract thinking of subjects with brain lesions seem not to be affected (for a review of the discrepancy between cerebral structure and cognitive functioning see (Nahm et al., 2017). These recent findings confirm what was already known from the studies of American neurosurgeon Wilder Penfield. His surgical specialty was the mapping of seizure foci by stimulating the brain regions of locally anesthetized but awake patients. Observing the patient's response, he was able to show how different brain electrical stimulations would cause a seizure or evoke a sensation, a perception, a movement of muscles, a memory, or even a vivid emotion but, interestingly, never evoked or inhibited thinking (Penfield, 1975). The normal reasoning functions, those of mind, intellectual skills, and rational analytic thought, were never affected by whatever stimulation. From a third-person perspective, thought can seemingly be switched off entirely by triggering a seizure or by anesthesia, but it can't be weakened or enforced by weakening or enforcing the activity of any brain area.

Furthermore, if the human's analytic and rational functions are a mere cerebral product, one would expect to find some observable difference between the ordinary brain of someone with a low IQ and that of a genius like Einstein. Notoriously, Einstein's brain was removed after his death and has been conserved until nowadays for analysis to find some cerebral signature that could account for his extraordinary intellectual achievements. Yet, nothing relevant was found, and Einstein's genius remains a mystery. More recently, a study evidenced that his corpus callosum was thicker than average, indicating that the connectivity between the two hemispheres of Einstein's brain was generally enhanced compared to other 'normal' brains (Men & al., 2014). But, if the connectivity between brain hemispheres accounts for someone's intelligence, this immediately raises the question, again, in light of what we have discussed above: Why does a corpus callosotomy or hemispherectomy not lead to a loss of IQ or no substantial psychological and behavioral change? From a metaphysical perspective which does not conceive of mind and brain as completely identical, but mental and physical functions as separate, or only partially inter-dependent, these facts could appear less surprising.

One might also question if, besides the spatial distribution or localization of the neural correlates of consciousness, the intensity of its metabolic activity might also play a role in generating a conscious experience. For example, it is well known how drugs can change our brain chemistry and give rise to subjective psychedelic experiences. From the perspective of the material monist, which equates mind and brain as being one and the same thing, one assumes that the intensity of 'mind-expanding' psychedelics must be directly proportional to an increase in neural activity and connectivity. A dead brain, in which case we assume there is no consciousness left, is the cessation of any cerebral activity, while an intense subjective experience presumably involves a high neural activity. One would, therefore, expect to find that the subjectively felt intensity of a hallucinogen proportionally correlates with neuronal activity.

However, the contrary turned out to be the case. A BOLD-fMRI study reported a significant decrease of brain activity—that is, a decreased blood flow and venous oxygenation as being inversely proportional to the intensity of the subjective experience reported by the test subjects (Robert & et al., 2012). The authors of this research pointed out how this is consistent with Aldous Huxley's 'reducing valve' metaphor in the brain that acts to limit our perceptions in an ordinary state of consciousness (see also K. Koch's take on this (Koch, 2012).) These findings were later confirmed by further studies with other hallucinogenic drugs such as LSD and ayahuasca (Palhano-Fontes & et al., 2015), (Robin, 2016), (Lewis, 2017).

It might also be worth a mention that there is now an increasing consensus that consciousness is subjected to the effects of organic activity in several bodily regions, not only in the brain. By 'organic activity,' we mean not only neuronal activity but, in general, any biological process. Mounting evidence shows how our consciousness is, if not 'generated,' at least 'modulated' by other parts of the body.

For example, gut microbes (microbiota) influence our cognition, emotional state, and memory. There is a relationship between them and pathological states, like anxiety, mood disorders, or developmental disorders such as autism. The amount and diversity of microorganisms inhabiting our intestines affect how we think, perceive, and experience the world (Hooks et al., 2018). This physiological evidence suggests how our emotional states cannot be reduced to only a brain-centric view but arise due to a complex interaction between the brain and the rest of the body (Colombetti & Zavala, 2019). Moreover, it is a widely accepted fact that a sort of enteric brain exists—that is, a nervous system of neurons that governs the function of the gastrointestinal tract independent of the brain, the spinal cord, and the brain stem. If we assume that emotions are 'generated' by the limbic system because, for example, changes in the structure of the amygdala 'elicit' mood and anxiety disorders, why can't we say the same for our gut, as its microbiota ‘generate’ similar effects? If we don’t consider our guts the seat of consciousness that’s because, besides the unappetizing idea, none of its physiological change induces ‘unconscious’ states.

In fact, we can stick with the brain-centric model and reshuffle everything into a gut-brain axis according to which the gut microbiome influences the brain, with the brain remaining the ultimate source of conscious experience. Communication pathways between the gut microbiome and the brain exist, reassuring the dominant paradigm. But as science advances, it becomes increasingly difficult to distinguish between causes and effects while maintaining the brain as a separate central master-organ, with all other organs and physiological processes subservient. This view is challenged by recent findings which suggest taking a perspective that considers the body as a whole—that is, a vastly more complex ecosystem of molecules, microbes, and neurons distributed throughout the entire body rather than in only a 1.5 kg clump of gray matter in our skulls ((Colombetti & Zavala, 2019), (Bastiaanssen & al., 2019).) We may inadvertently reduce the whole to one of its parts and, paradoxically, consider that part as the ultimate cause and sufficiency for the process of the whole–say, for example, regarding digestion as being driven entirely by the processes taking place only in the stomach, considering it the necessary and sufficient cause for digestion itself.[1] If at all, we should speak of a mind-body identity, rather than a mind-brain identity. And there is no structural property that compels us to believe that pyramidal neurons of the cerebral cortex have more causal efficiency in producing states of subjective awareness or qualitative experiences than the motor neurons of the spinal cord or the lower intestine escherichia coli bacteria have. We are allowed to speculate about the brain, not as a generator, but as a physical center and instrument of consciousness that uses and is influenced by the overall bodily conditions, but that doesn’t need neurons to cause, produce or generate qualia.

There remain also other aspects to be explained that escape a materialistic paradigm with a strikingly similar pattern to that of consciousness and mentation: the neural correlates of memory. Also, in this case, one thing is sure: Memory is not stored in a specific brain area like it is on a digital computer. More than a century of research for the engram cells—that is, the group of neurons supposedly responsible for the physical representation of memory–has not led to tangible results providing convincing evidence that such cells exist. This is not a new issue. It dates back to Henri Bergson’s opposition to a reductionist understanding of memory (Bergson, 1896/1912). Bergson considered memory to be of an immaterial and spiritual nature, rather than being stored in the brain.

On the one hand, it appears that some brain regions are more involved in memory consolidation than others. For example, the hippocampus, a part of the limbic system, seems to play a significant role in memorization. In the amygdala, emotional memories play a role, such as the remembrance of fearful events. Motor events are stored in the cerebellum, while the prefrontal cortex is responsible for higher-cognitive memorization tasks, such as storing words and semantic content. Neurotransmitters must also be fundamental in memory formation because they are responsible for the communication among neurons determining their synaptic strength. But, overall, the real physical, cerebral memorization mechanism continues to remain elusive, and there is still no credible theory explaining where and how experiences are memorized at a neural level.

Again, one may argue that facts show how damaging the hippocampus leads to short-memory loss, especially in object and facial recognition tasks, but this does not affect other types of memories. Moreover, a brain stroke or dementia can lead to consistent memory loss. Therefore, everything seems to indicate that memory is in the brain. What else?

This logical memory-brain identification has similar difficulties in terms of standing up to scrutiny as the presumed mind-brain identity and is prone to becoming another correlation-causation fallacy. A failure to retrieve a memory does not necessarily imply memory loss. The inability to recall something does not imply the absence of it. Using an analogy: Disconnecting a hard drive from a PC will render its memory content unavailable, but the memory is not necessarily affected. Indeed, it is well known that when a brain injury occurs, causing some form of amnesia, what was thought to be lost forever may remerge into awareness, sometimes after years. This suggests that the disease-specific structural brain changes can’t be so straightforwardly associated with the repository of memory.

[1] An analogy first suggested by French philosopher Henri Bergson.

One might assume that the information content should somehow scale with the brain size. This isn't observed, however, in hydrocephalic individuals or patients who have undergone hemispherectomy. How can it be that someone without half of the entire brain has no measurable memory impairment? Obviously, we can, as usual, explain this away by resorting to the plasticity of the brain or the functions of residual brain tissues that might save the paradigm. Or, we could conjecture that memory is stored in both hemispheres; therefore, if one hemisphere goes lost, the other remains nevertheless unimpaired (a hypothesis that could also fit well with supposed evolutionary advantages). Or because it is always the diseased hemisphere that is removed in all these cases, Nature might have provided a mechanism that transfers the memories to the healthy hemisphere before surgery. However, we should be aware that these are conjectures, hypotheses, and speculations, not scientifically established truths. Memory storage and retrieval in biological brains remains a largely unexplained mechanism, and no conclusive evidence exists that proves it to be of physical nature.

Other research that might suggest how and where memories are stored in brains comes from experiments performed on freshwater flatworms called planaria. These creatures can be trained to associate an electric shock with a flash of light. Therefore, one might expect that they must have encoded the experience in their brains.

However, experiments reveal that things can not be easy as that. Flatworm planarians have an incredible self-regeneration ability. If this worm is cut in half, each amputated body part regenerates as two new fully formed flatworms. Not only does the part with the head form a new tail, but the remaining tail also forms a new head with a brain and eyes. In 1959, James McConnel, showed that the newly-formed planaria with a new brain also maintained its conditioned behavior. The new-formed living being never received the electric shock and light flash of the training phase, and yet it reacted as if it still had a memory of the training it had never received.

How could an initially headless worm acquire a memory that is supposed to be stored only in the brain of the other worm? The shift from a mind-brain to a mind-body identity, therefore, seemed to be the obvious necessary step. Memories, if physical, may not be stored only in the brain but throughout the body, in non-neuronal tissue.

McConnel's idea was that RNA molecules could transfer memory from one planarian to another as a "memory molecule." Motivated by this idea, he then injected worms with RNA taken from those trained and reported that the training had been transferred. This seemed to support the idea that memories are encoded in the RNA structure. However, further research could not reproduce McConnel's experiments convincingly. After a period of notoriety, McConnel's experiments were dismissed and forgotten.

Until 2013, when Tal Shomrat and Michael Levin vindicated McConnel's first experiments by using a computerized training of planarians, replacing manual procedures that caused previous test attempts to fail (Shomrat & Levin, 2013). Already in 2018, A. Bédécarrats, resurrected McConnel's idea, showing how the extracted RNA from a long-term trained sea slug, the aplysia, can induce sensitization in an untrained aplysia (Bédécarrats et al., 2018). This is taken as evidence for the existence of engrams and the hypothesis that RNA-induced epigenetic changes lead to the protein synthesis required to consolidate or inhibit memory. These local translations into synaptic proteins determining the neural structure of memory are actually the mainstream engram model.

However, the problem with this hypothesis is that the fastest protein synthesis causes cellular changes in timescales of minutes. This raises the question: How could it possibly be responsible for our ability to store and recall memories almost instantaneously? Moreover, Glanzman's group challenged the idea of memory mapped as synaptic connectivity in the brain in previous research, in which they showed that it is possible to erase synaptic connections while maintaining the same conditioned behavior in mollusks. Long-term memory and synaptic changes result can, at least in some cases, be dissociated (Chen et al., 2014). It has also been shown that the brain tissue turns over at a rate of 3–4% per day, which implies a complete renewal of the brain tissue proteins within 4–5 weeks (Smeets & al., 2018). How then can the memory supposedly internalized in that tissue remain intact?

Similar challenging questions come from hibernation. Since animal brains undergoing hibernation are subjected to severe changes in structure, one would expect equally severe memory losses. Nevertheless, while ground squirrels tend to forget their conditioned tasks after hibernation, they retain their social memory (Millesi & al., 2001). Memory is retained during hibernation in Alpine marmots (Clemens et al., 2009). If memory is encoded in neural networks, bats seem to benefit from an as yet unknown neuroprotective mechanism to prevent memory loss after hibernation of their brain as well (Ruczynski & Siemers, 2011). Memory seems also to be immune from seasonal skull and brain size changes, the so called 'Dehnel's phenomenon' (Lázaro & al., 2017). For example, memories formed in the earliest embryonic states of frogs survive extensive remodeling of their brains and bodies (Hepper & Waldman, 1992). Most impressive is how moths can remember what they learned as a caterpillar despite a complete metamorphosis of its brain (Blackiston et al., 2008). During the period of this metamorphosis from larvae to moth, most of its brain tissues is literally dissolved into a messy soup–that is, into their constituent proteins ('histolysis')–and later reconstructed into that of a moth. Yet memory remains unaffected. How can brains that have been so drastically remodeled still recall their past experiences?

On the top of that, it turns out that neuronal representations and functions gradually 'drift' over timescales spanning minutes to weeks. For example, if today a cell is specialized for a specific task, tomorrow it might be dedicated to a different one (Rule & al., 2019). This neuronal reorganization is known as 'representational drift' and further complicates our understanding of the brain's activity. It causes neuronal representations to change with time challenging classical notions of engrams, at least those based on memory models that consider the stability of the engram as the basis for the persistence of memory itself. If all mnemonic cerebral configurations change over a time scale of few days how can a memory persist over much longer periods?

Last but not least, the search for engrams resorts mostly on the correlation between the memory evaluation based on fear conditioning behavioral tasks of rodents and its presumed associated neural changes. It turns out that almost all findings based on fear conditioning are vitiated by inadequate sample sizes, leading to questionable statistical correlations, which represent only weak evidence but then, contrary to the math, are presented as strong evidence for the hypothesis tested (Carneiro & al., 2018). This, again, shows how, even among trained scientists, the correlation-causation fallacy is always lurking around the corner, especially when one isn't aware of one's own confirmation bias.

However it is, the search for the neural engram will continue as what else could we look for? The physicalists can't consider alternatives such as an 'extracorporeal information storage' (for a review of this point, see (Forsdyke, 2015)). [2]

III. Discussion

As a concluding note, here we mention only briefly that an increasing body of evidence is showing that at least an elementary form of cognition is already present and working in multicellular and single-celled lifeforms, without any neural substrate. Research in plant biology demonstrates how vegetal and cellular life show elements of cognitive behavior that were not suspected or just considered impossible without a brain (Trewavas, 2017), and were thereby ignored for a long time (Gershman et al., 2021). It isn't inappropriate to speak openly of a 'minimal' or 'proto-cognition' of cells, what is now called a 'basal cognition' (Lyon & al., 2021). If and how this basal cognition may also imply instances of phenomenal consciousness–that is some form of more or less 'basal sentience'–is debatable but can be substantiated by arguments that aren't exclusively philosophical (Segundo-Ortin, 2021). This is further questions the idea of the nervous system as a sine-qua-non condition for cognitive behavior and conscious perception, allowing us to consider cognition and sentience, not as emerging properties, but as inherent 'pre-neuronal' aspects of life.

Of course, 'pre-neuronal' doesn't necessarily mean 'pre-physical.' Each of the cited neurobiological facts, when considered separately, may still be saved by several speculations inside the limitations dictated by material monism. For example, the fact that cerebellar agenesis leads to only mild or moderate motor deficits or that hydrocephalus can be quite extreme without necessarily leading to mental impairment, could be explained by neuroplasticity. The fact that corpus callosotomy and hemispherectomy keep selfhood unified, can be explained by residual subcortical structures connecting the two hemispheres prevent 'self-splitting'. Or that the search for memory encoding mechanisms in the brain remains challenging, could be justified by taking a historical approach reminding us that sometimes it needs centuries to find the answers to complicated scientific questions, it is only a matter

[2] As far as I'm aware of, the authors of the above-mentioned articles don't claim, believe or in any way support metaphysical interpretations.

of time before we will definitely proof that all memory is stored in engram cells. While the basal cognition of plants and cells may sooner or later be explained away as well by hugely complicated mechanistic cell signaling processes evolved via an adaptive behaviour determined by natural selection.

Thus, one could still believe that things can be recast into a bottom-up biochemical and biophysical non-linear complex dynamical and mechanistic paradigm. For each fact necessitating an explanation, we can imagine and conjecture about many of such explanations.

However, while we provided a list of challenges and new insights of ongoing science that do not necessarily enforce a switch in approach, they nonetheless suggest that the orthodox premises may be revised inside a different paradigm. If we see things comprehensively in a wider context–that is, without selectively limiting our attention to the single phenomenon seen in isolation–and by taking a coherent integral view in which each phenomenon is seen as the expression of an underlying deeper reality–these substantiate an ontology that doesn't need a plurality of interpretations, and in which mind and consciousness are not an epiphenomenon of matter but, rather, 'primal-phenomena' that manifest *through* the material substrate, in line with a dualistic or idealistic or other non-physicalist worldviews.

On the other hand, a return to relatively classical (and more or less simplistic and naïve) forms of dualism may not lead us further. The author would not like to force any ontology or philosophical conceptual model that is supposed to replace classic mind-matter identity theory. That could be a bidirectional 'transducer theory' a la W. James where mind and matter are in a relationship like one medium to another medium (i.e., the light and the prism analogy,) or the brain seen as a communication channel al la A. Huxley's 'reducing valve' of a Mind at large, or adopting more recent metaphysical speculations based on idealism, panpsychism, cosmopsychism, or ontologies based on Eastern philosophies, eventually added with quantum physical approaches or whatever. Science was always driven by initially simplistic assumptions first, and that only later showed to lead to discovery or failure. For the time being, positing a working premise other than the physicalist one and see where it leads us, can be the methodological approach to follow and that can furnish insights that a one-sided way of seeing can't. Maintaining a non-reductive and non-physicalist viewpoint, where mind and consciousness are not emergent properties from a neuronal machinery, but fundamental primitives of reality remains not only a valid working hypothesis, but fits better the overall picture from the bacteria to Einstein's brain. The mind-body problem and the hard problem of consciousness remain a controversial issue more than ever, but non-physical ontologies of mind and consciousness are far from having been expunged by science. We have the right to explore these as a viable option, not despite but, to the contrary, because of neuroscientific evidence which has been selectively dismissed for too long but cannot be ignored forever. If we can connect the dots.

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