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BIOLOGICAL SCIENCES

Why Psi is not a legitimate topic of study

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ABSTRACT

The study of phenomena like precognition, telepathy or clairvoyance has always been intertwined with mainstream psychology research. And so it should: premonitions and other uncanny sensations undoubtedly form part of the repertoire of common human experience and a better understanding of how such experiences arise will help us advance our understanding of the human mind and brain. However, in my view such research suffers from a confirmation bias that hampers the advancement of scientific knowledge. Often categorically referred to as Psi*, these studies use the apparent existence of these unexplained phenomena as evidence for processes that violate the conventional understanding of physical laws. I have previously argued why this research approach is misguided and why this is not a legitimate topic of study. Critically, this problem is not specific to Psi research rather this merely exemplifies a wider problem with scientific research. My primary aim is to point out the folly of clinging to pet theories. Science would be better served by a Popperian approach in which we seek to disprove our own hypotheses.*

RETROCAUSAL EFFECTS IN BIOLOGY ARE EXTREMELY IMPLAUSIBLE

Mossbridge and colleagues recently wrote a response (J. Mossbridge et al. 2015) to my earlier critique of their research (Schwarzkopf 2014). These authors investigate so-called “presentiment” effects in which a physiological marker (e.g. changes in skin conductance) apparently signals the imminent presentation of an emotional stimulus. Furthermore, a letter by Jolij (Jolij 2015) argues that criticisms of Psi research by others and myself erroneously assume that Psi is impossible. Here I respond to both articles and clarify my previous argument.

I never personally claimed that “time symmetric” or retrocausal effects in biology and psychology are *impossible*. Rather I questioned the general validity of the Psi hypothesis and argued that the conclusions drawn by many authors in the Psi literature discord with the principle of parsimony. Just because something is theoretically conceivable does not mean it exists, let alone that it is likely. We can construct all manner of thought experiments and they can help formulate new theories or design new practical studies. However, in so far as the advancement of scientific knowledge is concerned a hypothesis must be falsifiable to really provide new evidence.

PHYSICAL IMPLAUSIBILITY

Both Jolij and Mossbridge point out that time symmetry is inherent to physical laws and that the second law of thermodynamics is a statistical law. Therefore it does not entirely rule out spontaneous decreases in entropy. As I have argued previously (sampendu.wordpress.com/physics-methods-and-psi), it is theoretically possible that my cold coffee suddenly heats up by itself in the cup – but it is extremely improbable. In fact, Jolij himself describes this as “impossibly unlikely.” It remains unclear to

me in how far this is an oxymoron and I do not believe Jolij's argument follows logically from this statement.

It is difficult to pin the possibility of retrocausal effects like presentiment down in numbers, especially in the absence of any conclusive theory about Psi. However, even if time symmetric events occur at a macroscopic scale, the combination of highly unlikely effects at the molecular, atomic or subatomic scale, and the absence of a firm theoretical prediction for how and when these effects should manifest, must result in a vanishingly small probability that we will observe them.

Imagine for instance that a tiny fraction of neuronal processes is time symmetric, say, every 1000th action potential of a sensory neuron fires prior to stimulus onset (my guess is this rate is a massive overestimate of the true probability). It is unclear why this should happen. Action potentials are mediated by the flux of ions between the intra- and extracellular media. They are triggered and transmitted by the changes of voltage-gated ion channels in the cellular membrane. How exactly do the time symmetric effects trigger these events?

Even assuming that they do, could this kind of time symmetric neuronal processing provide a strong enough signal against the noisy background of spontaneous neuronal firing by billions of neurons in the brain? Even more critically, to my knowledge no proponent of Psi effects has given a satisfactory answer to the question why such effects should occur in the highly specific situations reported in Psi experiments. Why does this effect relate to emotional events only as is suggested both by studies on presentiment (J. A. Mossbridge et al. 2014; J. Mossbridge, Tressoldi, and Utts 2012) and precognition (D. J. Bem 2011; D. Bem et al. 2014)?

One might argue that presentiment is only measured for emotional events because these cause strong neuronal responses whereas baseline/control stimuli do not. While this reasoning may appear logical at first glance, it places some undue significance on emotional processing. A typical neuron in primary visual cortex is tuned to the orientation of a visual stimulus. This means it may fire strongly in response to a vertical bar of light but remains unresponsive when the bar is oriented horizontally. If presentiment really only depends on the strength of the subsequent response and arises due to some elusive time symmetric effects in neuronal processing, it should be observable also for such simple neurons in the early sensory cortices or even in the peripheral nervous system.

To my knowledge such evidence has never been reported. Instead Psi researchers focus on emotional responses and other seemingly arbitrary factors like the participant's gender without any compelling reason why these factors should possibly matter. Do the physical laws governing the universe care about the emotional state or gender of an organism?

BIOLOGICAL IMPLAUSIBILITY

Another point I raised (Schwarzkopf 2014) was the biological implausibility of presentiment. The meta-analysis by Mossbridge and colleagues discusses physiological markers of emotional stimuli prior to stimulus onset using a surprisingly broad range of measurement modalities. Apparently, presentiment effects can be observed using electroencephalography (EEG), galvanic skin responses (GSR), functional magnetic resonance imaging (fMRI), and pupilometry. All of these measurements vary in terms of their physiological time course and in the degree to which they are linked with underlying neuronal activity. While EEG is a fast aggregate measure of underlying neuronal population activity, measures like fMRI, GSR and even pupil dilation lag behind neuronal responses by a considerable amount.

Even if one accepts that actual neuronal events exhibit time symmetry, it is far from clear why this should also translate to time symmetry in these metabolic, hemodynamic, and physiological measures. Consider a population of neurons in visual cortex responding to an emotional stimulus. It is conceivable that through time symmetry they begin to fire prior to stimulus onset. However, the change in blood oxygenation in response to the metabolic demands of such neuronal firing should still follow *after* the neuronal event.

Perhaps even these hemodynamic and metabolic processes themselves exhibit time symmetry? I deem this possibility even more unlikely than observing such effects in neuronal firing because these metabolic and hemodynamic events occur at a much larger spatial scale and over much longer time courses than neuronal action potentials. But even in this situation, there must still be a *causal response to the neuronal firing* that occurred prior to stimulus onset. This implies that the entire time course is continuously swamped by causal and retrocausal responses. Not only does this upend an entire neuroscience literature based on the assumption of a causal relationship between stimulus and response, but it should also make it nigh impossible to measure any response to sensory stimuli because pre-stimulus epochs would always be massively contaminated by retrocausal stimulus effects.

UNREALISTIC EFFECTS

Of course, these problems do not necessarily rule out the existence of such effects. However, as far as the claims currently stand, none of these Psi effects are very plausible. Retrocausation is certainly not a more parsimonious explanation for these effects than simpler alternatives, such as analytical artifacts, hysteresis, or expectation bias. While the response by Mossbridge and colleagues (J. Mossbridge et al. 2015) addresses some specific points I raised regarding expectation effects in presentiment, they do not actually address the true concern: is retrocausality *a priori* more likely than simpler, artifactual explanations?

In the absence of any clearer theory how presentiment works, the effect size one should expect for a truly time symmetric effect is orders of magnitude smaller than what is observed in most of the experiments included in Mossbridge's meta-analysis. In fact, for some measures such as fMRI not only is the effect size implausible, but the *direction* of the presentiment effect should have the opposite sign as the stimulus-evoked response.

A typical fMRI response rises slowly after stimulus onset for approximately 6 s after which is decays back to baseline. This late phase often also includes a pronounced negative component. Under classical assumptions, the hemodynamic response thus lags behind the neuronal event and, if the interval between successive trials is shorter than 30 s, the response to any given trial is likely to be affected by the preceding one. Typical data analysis methods take this into account at least to some approximation.

Consider now the alternative of a time symmetric fMRI response. In this situation, there should be a positive response at around 6 s prior to the onset of neuronal firing, which itself already starts at least a few hundred milliseconds prior to stimulus onset. Moreover, there will be a protracted *negative* phase that occurs even earlier and that contaminates the entire pre-stimulus phase. Mossbridge and colleagues (J. Mossbridge, Tressoldi, and Utts 2012) explicitly excluded this pattern of results with their assumption that presentiment effects should be homogeneous across measurement modalities and that the direction of the presentiment effect and the classical response to the stimulus should be the same.

Effect sizes in many precognition experiments, such as those reported by Daryl Bem (D. J. Bem 2011), are also unrealistically high. If these effects were indeed due to retrocausal influences from future stimuli, they should be exceedingly rare. Thus even the very small precognition effects (51-53% correct) in these experiments are orders of magnitude greater than what one would expect to occur due to time symmetry.

SCIENTIFIC SKEPTICISM

Regardless of whether this is made explicit or not, whenever the purpose of a scientific exploration is to confirm a particular hypothesis, the objectivity of that research is in jeopardy. It is easy to test straw man hypotheses to rule out alternative explanations. Instead scientists would be well served to adopt a Popperian approach in which they *seek to disprove their own assumptions*. This is all the more important when you have no compelling hypothesis for your findings. We should always remain skeptical of our own results lest we "fool" ourselves, as Richard Feynman put it (Feynman 2010).

Psi is not a legitimate topic of study because *Psi is not a real hypothesis*. It posits that there are some effects that are hitherto unexplained by conventional knowledge. That is not a theory but it is stating the obvious. There will always be unexplained phenomena. The purpose of research should be to seek explanations, not to confirm the gaps in our understanding.

Note that this does not mean that the phenomena described as Psi, like premonitions or purported telepathic communications, cannot or should not be investigated. Since such phenomena form part of common human experience, a better understanding of them will doubtless advance our understanding of the human mind and brain. However, there is a distinct difference between the open-minded study of such phenomena and their causes, and the study of Psi. The latter *presupposes* the existence of highly implausible, anomalous effects and is thus circular.

I am completely aware of the possibility that I could be wrong about precognition or telepathy. I do not know what is and isn't possible. Neither does anybody else. You are free to posit a hypothesis and set out to test it. However, we should always ask whether our hypothesis is falsifiable, how plausible it is in comparison to more trivial accounts, and formulate what predictions it makes as accurately as possible.

My main point is that *this applies to all science*. It is merely because precognition, presentiment, and telepathy are so scientifically implausible given our current knowledge of the universe that Psi research serves as a perfect illustration how wishful thinking in research can go awry. However, the same problems affect any scientific endeavor, whether it is seeking evidence for (or against!) the expansion of the universe, unconscious stimulus processing, structural brain-behavior correlations, or even seemingly plausible hypotheses like the effects of selective attention on stimulus processing.

We should encourage scientific skepticism rather than focusing on impact or media attention. We should reward science that seeks the truth rather than impressive findings. We need to educate the next generation of scientists to value theoretical predictions and methodological rigor over publishing papers. I don't honestly know how to effect a positive change in research culture. Some promote open science and data sharing, preregistration of experimental protocols, and abandoning significance tests. To me any of these ideas can at best cure the symptoms of the problem rather than its cause, and they may even have unforeseen adverse effects.

I believe that above all it is a personal quest and all about being honest toyourself. Each researcher needs to contemplate what attracted us to do science. Our research should help advance our understanding of the cosmos. If you find that your main aim is personal gain, reputation, and *defending* your pet theory, you may be in the wrong profession. Critically, this warning works both ways: if your main purpose is to refute other people's findings you just can't believe, your research practices are just as questionable as those of the scientists you fail to replicate.

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