Interdisciplinary Approach to the Hard Problem of Consciousness

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Abstract

The "hard problem of consciousness" arrests that with current methodology, humans will never be capable of understanding subjective experience. While this assumption might be true, the following paper will try to argue that by shining multiple lights from different levels of understanding on conscious experience that the combination of nested scientific disciplines will create a shadow of consciousness so similar between organisms that an inference of sameness can be made, providing a clever bypass to the hard problem. This paper will attempt to show how information processing systems and neural correlates represent ambiguous philosophical qualia, how adaptive unconscious reflex arcs create a chemical bridge of experience between animals and people, and how three emerging technologies can be used to explore subjective experience — all with the goal of creating overlaps between organisms that points to similarities in subjectivity.

Introduction

Many types of scholars still at this point in history are stumped by questions about conscious experience, where it is located, why it emerges in living things, and where do we draw the line on what is considered a conscious being? The philosopher and cognitive scientist David Chalmers, M.D., has proposed a thought experiment in the form of two questions that condenses the broadness of these questions into the more manageable, easy problem and the hard problem of consciousness. A summation of the first states that the brain is capable of different functions, and with enough work, these functions could be assigned physical correlates. An example of this summary would be appointing a neural system and pathway to a psychological model like the

pacemaker model used to study time perception. While this task seems beyond reach at the moment, Chalmers believes that eventually, our current methodology will be sufficient.

However, even after all the functional mechanisms of the brain have been deconstructed, this philosopher still suggests that it would give humanity little insight into what it feels like to be an independent conscious observer. The argument is that person-A will never experience the qualia of person-B, and therefore researchers can never be sure that any aspect of reality is the same between the two separate entities. Chalmers, along with many others, has little faith that our current scientific methodology is adequate to approach this hard problem. While one person might never be able to experience the qualities of another's life, this assumption fails to consider that what the two entities are experiencing is more similar than it is different. Humans are physical, chemical, and cellular expressions of life that engage in complex organismal level behaviors and ~~that~~, in actuality, each human maps on to the average human model more closely than it differs. Things like our homeostatic ranges, development, structure, and function are very much the same, not only between humans but also working backward along the eukaryotic tree. Because of these observations, this paper claims that by showing a connecting string of similarities across a wide breadth of fields that a Venn diagram of experience will begin to produce understanding.

This interdisciplinary amalgamation, which hopes to explore experience, will be constructed using snips from various scientific fields. The philosophical-neural connection of quale, the startle response zebrafish larva, and the three emerging technologies are the three sections this paper will use to cast shadows of experience, and concepts from the fields of physics, chemistry, biology, and technology will tie together pieces of the string to help overcome shortcomings and limitations of current human study methodologies. Using a vast

array of well-established ideas to approach this challenge, we can begin interlocking the fields of science, which individually describe segments of our reality, that from before our understanding, were never separate.

Bridging the Philosophical and Neurological Gap of Quale

For over two and a half millennia, if not more, generations of humans have been puzzled by consciousness (Pandya, 2011). Even with the rapid advances in technology seen recently in the twenty-first century, the answer to the question of what is consciousness, still eludes everyone who begs the question. The philosophical-zombie (p-Z) thought experiment, also proposed by David Chalmers, is the main obstacle physicalist researchers must overcome. The p-Z argument arrests that an identical duplicate of any person can exist void of consciousness experience and still behave in the world utterly identical to that person without anyone else being the wiser (Kirk, 2019). One promising critique of this problem is the inverse-zombie, described as a replica that, to an observer seems unconscious, but does have subjective experience, which is seen in scenarios of total paralysis (Mashour & LaRock, 2008). This flip allows researchers to no longer contend with if qualia are present but instead ask the question of how do scientists detect qualia, and by utilizing this logic, the philosophical problem can be explored as a physical one.

At the forefront of this exploration are neurologists trying to assign physical correlates to the subjective "I." There is evidence from lesion studies noting that the cerebrum, the two brain hemispheres, is the only area that produces alteration of experience when damaged (Tononi & Koch, 2015). While simple, this observation narrows the search giving the currently most compelling tool of neuroscience, neuroimaging, a smaller area of inquiry. Task-free functional

magnetic resonance images (fMRI) between psilocybin administered participants or a placebo control group showed decreased blood flow between the prefrontal cortex (PFC) and the posterior cingulate cortex (PCC) (Brogaard, Berit, & Electra, 2016). Overall, reinforcing the lesion study data also pointing to a relationship between the intact structure of the cerebrum and a common subjective experience. Unfortunately, the relatively simple relationship between structure and function is only the surface level of understanding quale, albeit a critical component.

As illuminating as the biological layer of the brain is with regards to connectivity or associative function, the physical aspects of this field at present only provide the ingredients of the recipe, but a logic-based neural network system proposed by scientists studying information processing looks to provide the directions. This neural informatics theory suggests that the vast amounts of physical stimuli that a body absorbs continuously are interrupted as physical and semantic information (Roger, 2017). A manageable way of understanding the duality of this theory is to imagine that a specific neural input, like the honk of a car, has a stimulus-specific output, but that because of self-contained loops in neural circuits and attractor states, highest likelihood states of a multidimensional mathematical function, that these intrinsic properties also contextualize the physical information. Another information-based theory called the integrated information theory, for which a complete analysis of this series of ideas is too large for this micro review, offers answers through a series of axiom-postulate connections that address five fundamental properties of consciousness: intrinsic existence, composition, information, integration, and exclusion (Tononi & Koch, 2015). These two promising information processing theories are beginning to connect the brain and how the information that flows through it is

interrupted to create the experience of the observer, bridging the gap between philosophy and neurology.

Biological Understanding of the Acoustic Startle Response

An auspicious knot between these biological and informational components of the brain and the behavioral analysis of psychology is the Acoustic Startle Response (ASR). ASR, while classified as an unconscious reflex, is a rapid processing system that is thought to give rise to conscious content, as well as, being a simple mechanism which can aid in the understanding of nervous systems across species (Allen, Wilkins, Gazzaley, & Morsella, 2013). Some of the newest work with ASR has been performed using zebrafish as a model organism. The validity of this work with zebrafish was established by a study that presented video-tracking evidence showing that the zebrafish Novel Tank Test (NTT) a spatial behavioral test ~~whose~~ results produced congruent patterns with the Open Field Maze tests (OFM) used in rodent modeling (Stewart, et al., 2013). The importance of linking these two models is that the OFM, which was established in 1934, has remained a staple in comparative neuropsychological research since its inception (Seibenhener & Wooten, 2015).

Moreover, while the results are similar enough to draw parallels, the zebrafish model promises to provide more. There are several benefits to using the NTT over its competitor. Speed, size, and accuracy are typically not synonymous terms while conducting research, but utilizing NTT and the Flote automated tracking software created for NTT testing brings these qualities together (Burgess & Granato, 2007). Flote is a software program that uses video to trace the movements of an organism. The paper explains that 20,000 startle responses were collected from groups of 25-30 zebrafish larva, effectively speeding up vertebrate research to an

inconceivable rate. On the other side of the coin, accuracy was also amplified. By using a camera with a capture rate of 1000 frames per second (fps), the software created precise lines of motion, which allowed researchers to observe sub second intervals and categorize variations in motor response. At this point, it is necessary to break the fourth wall, the line that is drawn by the behavior of startled or habituating fish will be connected heavily to the conclusion and is the most abstract idea of this paper. It is helpful to imagine these as two-dimensional transitions that can then extended into the third dimension with time as the axis; this type of representation is referred to as a world line (2020). World lines have been used in many theories of physics, most notably the theory of General Relativity, and will be used in this context to connect a line of human behavior, drawn by an avatar in a video game, to the behavioral movement of these fish or rats.

Now bringing the train of thought back to tangible evidence, the ability to react in milliseconds is a critical aspect of predator avoidance seen in most ~~of the~~ animal phyla; interestingly, some genetic variation correlates to differences in zebrafish movement. The two movements that measured in connection to the genetic basis of ASR are the Short Latency C-bend (SLC) and the Long Latency C-bend (LLC) (Burgess & Granato, 2007). The SLC movement pattern and its LLC counterpart are phenotypically different in that SLC is more rapid and is selected for more frequently as decibels of stimuli increase (Jain, et al., 2018). However, through the ablation of brain regions, it was discovered that the neural pathways are only slightly different, showing substantial overlap, and using this knowledge, the researchers isolated neurotransmitters that modulated the shift between SLC to LLC or the reverse. This same paper goes on to show how engineering eight different neuromodulatory mutant lines of larval zebrafish changes the phenotypical behavior of the ASR. By connecting this basic fixed action

pattern in zebrafish to physical lines of movement and to the chemical correlates of hormones and genetics, it is theoretically possible that the feeling generated by fish ASR is superimposable to humans.

Technological Triangulation

With the idea that information processing and neural correlates can describe the philosophical quale, along with ASR research that combines physical, ethological, and chemical analyses, a new direction of consciousness research can begin using a novel combination of experimental methods and analysis. However, before addressing the next step, a brief description of why a new avenue would be beneficial to this research is essential. Firstly the only animal at present which is considered conscious are humans, but the ethical concerns surrounding human research prevent the study of our species in a naturalistic setting, which ethologists note is a primary flaw in most animal research. Secondly, unlike animals, humans will change their behavior when they know they are being observed, making data unreliable. For the rest of this section, the argument will be made that a combination of BMI, biofeedback, and videogame play will be the new avenue that can circumvent these two problems of research.

Although BMI is in its infancy, this technology promises to deliver an even higher resolution look at the electrical information of the brain than any neuroimaging technique to date (Musk & Neurolink, 2019). The fifty-micrometer flexible wires have been able to collect in monkey subjects electrophysiological information, which through a series of steps, have been converted into commands for a mouse or keyboard. If this pseudo-mind control were to be turned on, the areas of conscious experience it may answer if the two previously mentioned information processing models exist electrically. However, this technology must find a way of ensuring safety as a piece of the skull is removed and wires are inserted directly into the cortex.

In addition to the layer of analysis that BMI technology could add to the study of the experience, biofeedback methods also have the potential to eliminate some of the ambiguity found in human consciousness research and are exceptionally safe. The most likely candidate in this category is eye-tracking methods. While at present, not much neurological research has utilized this methodology, but a closely related field human factors psychology provides a wealth of data suggesting that this real-time recordable measurement can provide insights into where a person is placing their visual attention (Kovesdi, Spielman, Leblanc, & Rice, 2018). As neurological and visual tracking hardware becomes less cumbersome, these two technologies will likely see more overlap in studies moving forward.

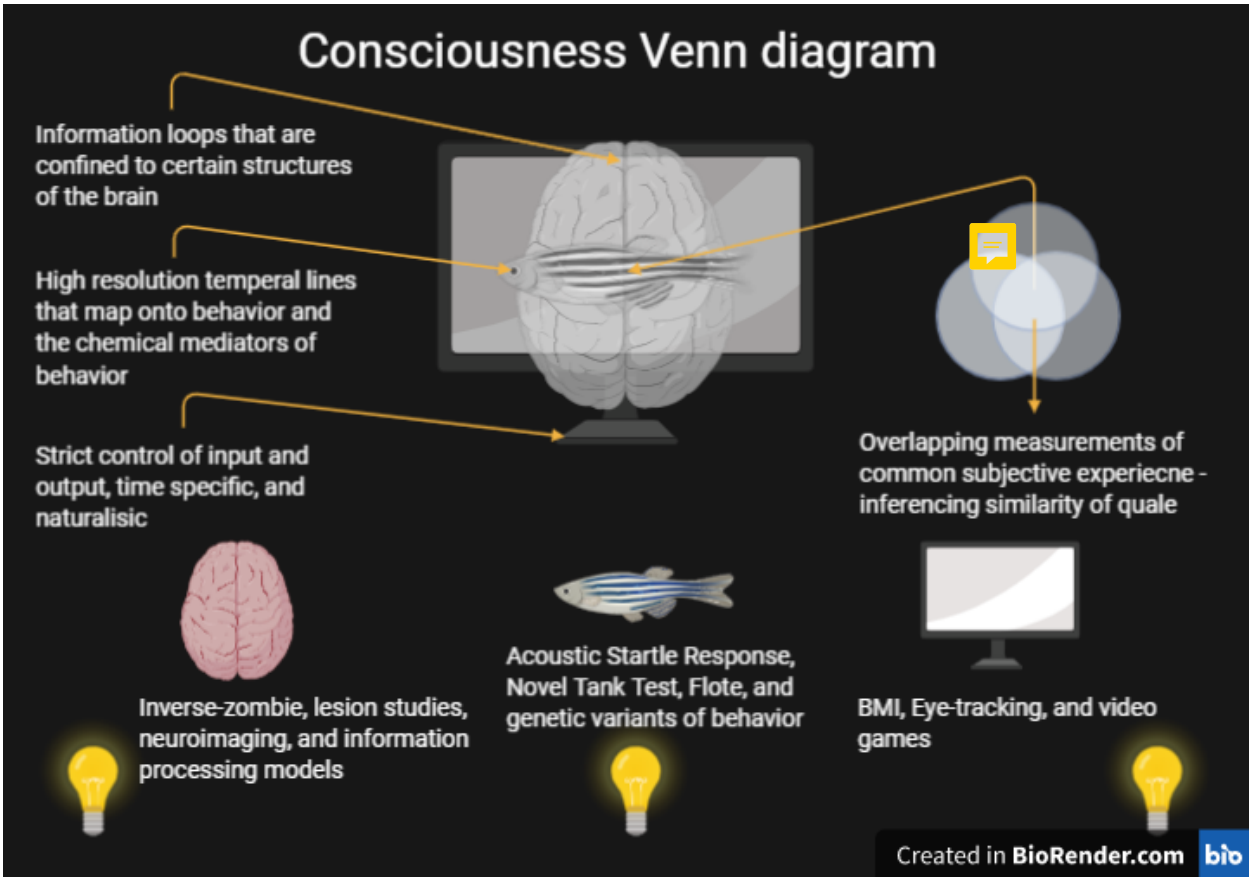
The third technology that this review proposes will assist future consciousness research is video games. A systematic review of ~~the~~ video game literature shows that only a little over one hundred papers have been published in connection to video games in ~~the~~ neuroscientific literature, and roughly half of those articles evaluate a negative role of this hobby on the humans who engage (Marc, Marron, Elena M., & Diego, 2017). The small sample size and bias displayed by this compilation shows how grossly the scientific community is underestimating the utility of video games. With the emergence of esports, we see that these games are as complex as traditional human sports, but like the NTT with a plethora of added benefits.

Nearly all sports require movement and a dynamic environment; this proposed medium constrains most of the body and standardizes the incoming environment. This trade up will decrease the area of the motor cortex that is active during experimentation and enable the possibility of recurring pattern discovery through standardization. In addition to controlling aspects of the experience by using a similar system to the FLOTE, which has already produced excellence with the zebrafish ASR study, the recording of an avatars world line would enable

irrefutable precise moment of behavior data, like a startled movement, effectively opening a naturalistic way to observe participants. Most importantly, the temporal resolution that this type of recording offers could be synced with timestamped biomeasurement technologies, like BMI, EEG, eye-tracking, finger-movement cameras, skin galvanization, and more to begin the explanation of the whole conscious experience; input - integration - output.

Conclusion

All the bulbs from different scientific disciplines cast their shadows creating a Venn diagram of experience. The hope is that there is enough overlap for the reader to believe that the hard problem can be reasonability circumvented. The first two bulbs are neuroimaging and information processing, both pointing to similar cross organism structure-function relationships and information pathways in the brain. The next two shadows cast are a chemical and genetic component of behavior that must be seen cross-species, ~~and~~ as well as a line of experience that has the potential to increase the accuracy of human experiments. Finally, the three lights of BMI, eye tracking, and video games are all dim at the moment, but with resource allocation in the future will be the microscopes of the mind. To my dismay, this solution aimed at the hard problem does not answer the philosophical question of if the experience of two subjective I's are the same, but it does point to an avenue of exploration that seems to be moving towards an understanding of this conundrum. As a last thought, the key to this combination of fields will be aligning all the measurements temporally, effectively showing how the levels interact.


Consciousness Venn diagram
Information loops that are confined to certain structures of the brain
High resolution temperal lines that map onto behavior and the chemical mediators of behavior
Strict control of input and output, time specific, and naturalisic
Overlapping measurements of common subjective experiecne - inferencing similarity of quale
Inverse-zombie, lesion studies, neuroimaging, and information processing models
Acoustic Startle Response, Novel Tank Test, Flote, and genetic variants of behavior
BMI, Eye-tracking, and video games
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