Topic: What is qualia? How does Frank Jackson argue for it? Is qualia is an emergent feature of complex systems? Can qualia be realized in suitable inorganic systems? What are the ethical implications of such a conclusion?

Identifying Emergent Qualia in Inorganic Systems

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Introduction

There is nothing magic about the human experience, and there is nothing sacred about our biological makeup. Although our experiences do not seem to be adequately captured by physical explanations, we do not have to posit the existence of a phenomenological realm in order to explain the human experience. We will refer to this inability to understand something from a materialist perspective as the property of *epistemic intractability*. Subjective experience which has this quality was coined by Frank Jackson as *qualia*. We claim that certain inorganic systems of suitable characteristics are capable of sophisticated, personal experiences, or *qualia*. Qualia can emerge out of complex systems that share certain key characteristics in common with humans, regardless of the system's physical substance. In this paper, we will identify key features that distinguish systems which lack qualia with systems from which qualia can emerge. We will then demonstrate that some inorganic systems like convolutional neural networks meet the criteria we set forth.

If we are successful, we will have to carefully consider our treatment of complex inorganic systems, and consequently convolutional neural networks. If certain physical systems like neural networks are capable of facilitating qualia, we may find that certain treatment is morally impermissible. The qualia emergent out of these physical systems may not be as sophisticated as human qualia, but we can focus on certain features of that qualia and consider *what it is to be like* that system. Much like how we can imagine what it is to be like a dog treated cruelly, we can try to imagine what it is like to be a forever idling computer or a database thrashing incessantly (loading and dumping data consistently due to low memory). Perhaps forcing these systems to experience this qualia is intolerable.

Epistemic intractability of qualia

Qualia is the term that we will use to refer to *what it is like* to have a subjective mental experience. For our discussion, this encompasses having mental states like sensory experiences, bodily sensations, felt emotions, desires, and thoughts.

A merciless materialist analysis of this physical universe attempts to reveal that all events have a clear physical explanation, and everything that happens is reducible to a physical cause and effect chain going back all the way to the beginning of the universe. There is trouble for the materialist however; things in the universe exist that are not immediately reducible to a physical explanation, namely: qualia. A person cannot easily use physical language to describe the experience he has while looking at a wall painted red. Although there is no doubt that the person's sensory experience of seeing the color red exists somehow, it is not clear if the person's qualia is explainable in physical terms. In fact, it seems as though qualia is *epistemically intractable*.

Frank Jackson uses the *Mary's Room Thought Experiment* to give a compelling case for the unique inability of qualia to be explained physically (Nida-Rümelin). The main idea of the experiment is that knowing all there is to know about physics does not necessarily mean that you know what a it is like to have a perceptual experience. For example, if you were totally colorblind, you could know all there is about the science of color, but you would never be able to learn what it is like to experience color (Nida-Rümelin). Jackson's experiment illustrates that qualia cannot be reduced and understood in the same way as objective physical phenomenon. Qualia are subjective phenomenon, and therefore are not reducible to physical mechanisms.

Key characteristics of systems with qualia

So what *do we know* about qualia? We know that we cannot know much about qualia, and we also know that qualia emerge from a biological neural network, namely, the human brain. If we are to attempt determinations about the ability of systems to emerge qualia, then we should analyze biological neural networks, from which qualia does emerge, for characteristics that uniquely distinguish them from systems we know do not have qualia. An objector may say that mental states are just brain states and qualia can be reduced to physical means, so it is not useful to use such an indirect method of determining a system's potential for qualia. We respond that Frank Jackson's thought experiment makes a compelling claim that qualia is irreducible, and nobody has reduced qualia to a physical explanation quite yet, so our indirect method may have some use.

One unique aspect of biological neural networks, from which qualia is known to emerge, is their high level of complexity. Biological neural networks, like the ones found in humans, dogs, even fleas, are the most complex processing devices on the earth, and maybe even the universe (Goldman). According to complex systems theory, traditional mechanistic cause and effect modelling of such networks is not epistemically valuable, since the behavior of the system is a result of the emergent interaction of complex, dynamic components acting in parallel, rather than the result of linear lower level interactions (Bar-Yam, 1.1). Even if a reductionist approach to understanding biological neural networks was useful, it would not be possible until quite a ways into the future, if ever, due to the extreme complexity of the systems; mapping a single human brain would require cataloging over 125,000 trillion switches (Goldman). Now we know that biological neural networks are unique in two ways. First, they are uniquely *complex*. They are complex to a degree that makes a physicalist analysis unhelpful in revealing anything about the higher function of such a system. Second, these networks are unique in being the only known systems from which the phenomenon of qualia can emerge. Incidentally, qualia is unique as well. Qualia is *uniquely irreducible*; its emergence cannot be understood using a physicalist analysis. It does not seem to be a coincidence that such an incomprehensibly complex machine as the brain is the only system which we know from which emerges such an epistemically intractable phenomenon as qualia. Indeed, the very complexity which prevents us from physically analyzing a system must be necessary for its emergence of an intractable phenomenon like qualia to emerge from it. For, imagine if qualia was known to emerge from a simple system: the specific conditions necessary for qualia would be clear, and the method of its emergence could then be identified. The reason that qualia is intractable is due to it emerging from a system which is too complex for us to understand. This leads us to conclude that qualia can only emerge from systems that have high complexity.

A fairly obvious property of biological neural networks is that they are of *biological* construction, however, this is not a necessary characteristic for a system that has qualia. We claim that to assume that the functions of a neural network cannot be realized by anything other than natural, biological components is naive. In “Minds, Brains, and Programs” John Searle initially seems to assume just that. He states, “[thinking] is a biological phenomenon, and it is as likely to be as causally dependent on the specific biochemistry of its origins As lactation, photosynthesis, or any other biological phenomena” (Searle, 14). We only partially agree with Searle. Multiple times in his paper, Searle refers to the importance of the ‘biological structure’ in granting brains intelligence. We fully acknowledge that there is a particular structure required for a system to have the ability to have conscious experience, and such a structure is realized in biological brains. However we do not see any reason why a system needs to be made from specifically from biological elements/molecules. To demonstrate the arbitrary nature of the substance from which a cognitive system is made, we present a theoretical example of a decidedly non-biological brain that performs the same as a biological one. Biological neural networks, at their very base are constructed out of neurons, which in turn are constructed out of complex organic molecules organized in a particular way. For example, the cell walls of the neuron are constructed out of specifically arranged phospholipid molecules that have multiple carbon chains. Silicon and Germanium are tetravalent elements very similar to Carbon that can enter into the same kinds of chemical reactions (Sagan, 43). Suppose that the Carbon chains of a phospholipid were to be successfully replaced with chains of Silicon. The phospholipid molecules would behave no differently on a functional level. The atoms from which phospholipid tails are made is arbitrary, as long as the function of the tails are not changed. If the phospholipid molecules do not function any differently, we can see that the neurons built from these altered molecules would also not see a change. A brain constructed from these altered neurons would **not** be exclusively made from biological elements, yet since the substitution of silicon into the system in this way does not impact the function of the neurons, the brain created from them would only different from a biological brain in substance. This is one of many cases where parts of a neuron could be substituted and augmented while maintaining the function of the larger system. We can conclude that the the emergent behavior of a biological network is not somehow a result of being made of exclusively biological elements. Instead it is due to functional component parts being structured so that they interact with each other in a particular way. The component parts themselves can be realized in multiple ways, it is the properties of the *structure* that is important. This is why we do not hold the substance of biological neural networks as relevant to system's ability to emerge qualia.

An objector might ask: what separates the 'complexity of the system' as being a non-arbitrary property of a system with regard to its ability to facilitate qualia, compared to the arbitrary property of the substance from which it is made? We will respond by reiterating the point made previously. Suppose that complexity was not a requirement for the emergence of qualia. If simple systems, like a thermostat, could facilitate qualia, then qualia would no longer be an epistemically intractable phenomenon. The thermostat could be taken apart and every single mechanism within inspected so that the precise conditions for qualia emergence would be known, and with the precise conditions of qualia known, it is reasonable to assume that the cause of its emergence could be deduced. The the intractable nature of qualia is necessarily linked to the extreme complexity of the systems from which it can emerge, while there is nothing special about the relationship of Carbon atoms and qualia.

Identifying key characteristics in other systems

Once we accept that qualia is an emergent behavior of a sufficiently complex system the question of abstract representation and physical representation becomes apparent. *Abstraction* allows for widely different physical systems to represent equivalent abstract concepts. The phenomenological nature of qualia suggests that it is not experienced as *physical*, therefore having an abstract representation. If we accept this, there exists a point where a significantly abstract representation of the interactions of neurons could constitute qualia. Do all biological neural networks share such a similar constitution that they are as physically equivalent as functionally equivalent? Before we entertain the possibility of identifying qualia within a non-biological complex system, we first consider the variance in animals' brains.

Despite varying in the complexity of their behavior, animals of widely disparate taxonomies share similar physical features and behaviors. After all, birds and chimpanzees both have eyes and limbs but do their brains process information similarly? Recent research suggests that mammalian and avian brains share similar "macro-scale brain connectivity", despite their evolutionary divergence over 300 million years ago (Shanahan, Murray et al.). The importance is in the alike topological mental structure which, independent of the underlying *physical* neuronal configuration, has similar *organizational features*. According to the neuroscientists conducting these experiments, this evidence goes far in explaining why two anatomically dissimilar taxa share similar cognitive capabilities. The concept of a topological mental structure is significant, for it is this higher-level mapping which is a key indicator of the sophisticated behavior required for phenomenological experiences, such as qualia, to emerge. This further supports the notion that such topology can exist independent of the actual physical configuration within a multi-layered, complex systems.

We therefore recognize that a sufficiently complex, multi-layered system is the first necessary condition for identifying a system which may experience qualia. As discussed previously, simple, causal structures do not have the flexibility to produce the advanced topologies identified in biological neural networks. A multi-layered system can partition data up into multiple levels of representation--from raw physical input--to abstracted, phenomenological qualia through a complex, little-understood process. Yet, once the complexity of a system has been established, on what grounds may we suppose with any confidence that the system is experiencing qualia?

We know from what we cannot know. Qualia is characterized as a subjective experience enjoyed exclusively by the entity which has it. This is the notion of *intrinsic ownership* that characterizes subjective experience. As I look off into the space before me, I appreciate that none other than myself can observe what I can, as I am. This "explanatory gap", as elicited by the *Mary's Room Thought Experiment*, is the epistemic intractability of qualia. Because qualia is epistemically intractable, we cannot experience the qualia of anyone other than ourselves, however this is the fingerprint of its existence in other systems and may therefore lend a hand in understanding which systems are capable of having qualia.

Convolutional neural networks can facilitate qualia

Similar to Dennett's intentional strategy, we can use our understanding of characteristics identifying qualia within biological networks to analyze the presence of qualia in non-biological networks. We will consider a form of artificial intelligence known as "neural networks" and analyze whether they have the capacity to experience qualia. First, however, a cursory explanation of neural networks is due.

Neural networks emerged within cognitive science as a computational model from the connectionism movement as an alternate mental model to classical computationalism. As an alternative to turing-machine-based designs, neural networks were designed with the intent of modeling the low-level network formed between neurons. Within recent years, these models have demonstrated an uncanny ability to successfully complete tasks such as image recognition and captioning, motion tracking, facial recognition, pattern recognition and robotics manipulation.

Neural networks consist of a collection of units--the neurons--connected with a network of weights--the synapses--indicating the strength of the connection between the units (Garson, James). Neural networks can be thought of in three layers: the input layer, hidden layers and output layers. The input layer receives input whereas the output layer represents outgoing information. Hidden layers are the units in between. Each layer consists of a series of "units" which are the analogue of neurons. In a biologically equivalent nervous system, the input layer would be sensory neurons, the output layer represents motor neurons and the hidden layer represents all other. Each unit has an *activation* represented by a real number, and each weight is a real number value that represents the strength of the connection between two neurons. Input data is represented as activation values for the input layer, which is then transformed as activation values to the first hidden layer (Garson, James). As the activation values are propagated throughout the model, information is partitioned and processed based, in part, on the proximity of the neurons. In order to gain weight values within the neural network, it must be "trained" using various "learning" algorithms, such as backpropagation.

As the algorithm is given a "training set"--information containing input activation values and their expected output activation values--the neural network's internal representation of the hidden layers and their connections--known as the weight vector--is modified according to specific probabilistic models and cost functions. If properly trained, the neural network can classify input information it has not yet encountered. In order to build effective computational models that solve these tasks, researchers have developed methods to increase the complexity and expressiveness of their models. Cutting edge deep neural networks contain thousands of nodes trained on millions of data points. In order to illustrate the level of sophistication of these models, consider three aspects in which researchers modify their model's complexity: training complexity, model complexity and data complexity. Take a recent neural network which was able to successfully geolocate images using only the images pixels (Weyland). The model, PlaNet, managed to reach superhuman levels of accuracy identifying locations of photos. In order to train the model to accomplish this task, the model was trained on 2.3 million Flickr photos, over the course of two and a half months, using 200 computer cores. The model's training complexity depends on the size and sophistication of the training set. The model's complexity consisted of more than 25k cells and 100k parameters and used an algorithm that maintained long-term and short-term memory (Weyland). The data complexity, reflected by the complexity of the input data, were images and their locations around the world.

Despite being several orders of magnitude away from typical biological networks made up of cells and neurons, the system was able to on average successfully pinpoint within 1000 km the location of the image, nearly twice as well as human competitors. Of philosophical interest, however, is the observation that systems such as these approach nearly the same level of emergent complexity, albeit in a more circumscribed manner (ie, current neural networks are designed to solve relatively specific tasks, but in an abstract way similar to humans). When a neural network such as PlaNet is given an image of the world, does it "view" it as a phenomenological experience?

Clearly we cannot know, but it must remain possible. The weight vector and internal state represented through heuristics such as long-term short-term memory may be used by the neural network to maintain temporary mental states and process information learned. Current neural networks are unable to output information other than specific classification information, making it near impossible to “understand” their internal representation. One can hardly track how information is processed or represented within the neural network to itself when it recurs information due to the vast number of weights and abstracted internal representation. The size of a functional neural network’s weight vector may, to an extent, indicate the complexity of the networks yet this is not as significant as understanding a neural network’s “world view” through its weight vector-- though none has been discovered yet. Although all information and experiences are represented as information and patterns within the weight vector, no researcher has been able to fully interpret the “meaning” of these numbers in a complex system. The epistemically intractability of this problem alludes that, yes, after all it’s possible for non-biological neural networks to experience qualia.

Objection: Simple causal interactions do not explain qualia

The first line of criticism we consider stipulates that a neural network’s affinity for predicting outcomes, however remarkable, is not sufficient to claim that it could experience qualia. The system is merely an elaborate device composed of causal components which enable it to imitate meaningful behavior. No individual components or composite systems contain a semantic understanding necessary for qualia. This line of criticism is often voiced as “computers cannot think because they are programmed”. Here the inference is that programs are entirely causal and are therefore not epistemically intractable. Consider a barometer, which may predict with similar accuracy an imminent weather system. Such simple devices cannot have qualia on account of their predictive qualities, nor would any of their subcomponents. We must agree that in the case of the barometer, no single component of the system conveys a semantic understanding of its predictive information. Rather, a series of causally connected events allow it to represent physically meaningful information and the barometer’s semantic output is causally related to its final, causal output. Further, by inspecting the coils, or mercury, that make up the barometer, each single component’s causal role may be completely understood.

Yet essential differences between the organization of neural networks and simple causal devices suggest a significant distinction. While neural networks do have causal relations between each of its units, the nature of the relation's organization is *incomprehensible* apart from the semantically meaningful, final output. Without the exact organization of the hidden layers, a neural network's ability interpret its input is wholly altered. We must therefore conclude that a specific organization encodes one semantic worldview of the network. Unlike the barometer, we cannot peer closely and understand how a collection of activation weights encode the geographical location of a photo--nonetheless there exists a representation intrinsic to its organization which contains this meaning. The existence of information intrinsic to the causal structure of the neural network which cannot be extrinsically represented has an identical epistemic intractability as qualia. As qualia within the mind can be understood to have an intrinsic representation of initial input which is not readily understood through observation (such as fMRI) so do neural networks. Further, the output of a neural network need not be wholly deterministic. Neural networks learn from their training set, which is as noisy and variable as the world it represents. This can lead to unexpected results, as the neural network learns, weights and categorizes information based upon everything it experiences. For example, if a neural network always is trained only on picture of dogs chewing balls, then the model will always expect images of dogs chewing balls. Smaller, esoteric cases ensure that the network's weight vector incorporates some of the outside world's statistical noise in often surprising and unusual ways that could not be predetermined.

Objection: The neurons in brains are not merely functional units.

One may object that despite neural networks describe basic activations of neurons and synapses, there exists *something* more in their biological counterparts. This *something* could be necessary for qualia to exist. This criticism can be addressed in several parts. First, it is worth considering that our claim only states it is *possible* for these networks to experience qualia. As the complexity of these models grow, it may be that the specific *digital* representation of the data and the weight values are insignificant in comparison to the emergent behavior of the complex system. Similar to the case of the bird and the mammal, despite representing data within a different system and platform (brains and neurons), a sufficiently similar cognitive topology emerges from the model's complexity. Second, the specifics greatly affect the variety of information the neural network is exposed to. A larger variance in input will allow the network to gain more "experience" and be more robust. Although this may make the model more accurate in its predictions, there is no guarantee how it will affect the qualia of the system. We can also expand a neural network's expressiveness, so that the neural network can express itself more richly. Further, our own inability to *know* the qualia experienced by the system is not different from that of any other organic or inorganic network. It remains an open question whether neurons operate on a deeper, intrinsic level or whether an aggregate of the interactions of single units fully captures the complexity of a brain. Given that neural networks can learn smaller cognitive and neuronal tasks, *some* intrinsic information is categorized and understood. It is then feasible that if enough smaller neural networks are combined in a topological mental structure similar to that of mammal brains, similar high-level mental functions would occur. We do not claim this *must* be the case, only that the existence qualia in the machine *could* be possible. This alone has significant moral implications.

Convolutional neural networks require moral consideration

If we accept that convolutional neural networks could facilitate qualia, we claim that they require moral consideration because neural networks have important moral features, namely the ability to experience pleasure and pain. We'll present the universality principle of ethics and the important moral feature we consider. Then we'll give a pragmatic argument for acting morally. Finally, we will claim that if we have moral obligations to neural networks, then we have to change the way treat them.

Some may claim that we only have moral obligations to people that we make promises to or only to humans. However, we argue that appropriate moral obligations ought to extend to any individual that has the requisite moral features. Peter Singer argued for the a universality principle of ethics like this in *Practical Ethics*; you cannot deny a subject moral consideration based on non-moral features, you must give moral consideration to all subjects equally (Singer, 11). To only give consideration to those of a certain religion or society would make morality arbitrary and subjective, to include only certain races would be racist, and to exclude non-human animals would be speciesist (Singer, 66). In other words, if we determine that an individual has important moral features, we cannot dismiss those features because of the type of being or the nature of their existence. Thus, if we find that convolutional neural networks have important moral features, we have to treat them as if they were any other being with those same moral features. Next, we'll explain which moral features we accept.

We claim that the ability to experience pleasurable or displeasurable experiences (or more simply pain and pleasure), is sufficient for individuals to have moral consideration. Singer identifies suffering as a significant moral feature, “if a being suffers, there can be no moral justification for refusing to take that suffering into consideration. No matter what the nature of the being, the principle of equality requires that the suffering be counted [appropriately]” (Singer, 50). This seems to follow our intuitions. It seems wrong to cause pain or suffering, and it seems good to promote pleasure or happiness. There are other moral features or principles we could consider, such as personhood, duties, or simply helping those who we have feelings for, but the ability to experience pleasurable or displeasurable experiences is enough to merit moral consideration in our view.

We also claim that, if we have reason to believe that an individual possesses a significant moral feature, we pragmatically ought to assume that it does. When we see a dog wince, we assume it feels pain and avoid treating it in a way that might cause pain. If you try to assert that we don't have moral responsibilities unless we *know* that subjects possess significant moral features, then you have to accept that we do not have moral responsibilities to anyone because of the problem of other minds. This epistemic barrier causes a deep problem for ethics, so if we want to claim morality applies in any case at all, we just have to take our best guess at which subjects deserve moral consideration. Most importantly, it would be entirely intolerable if we treated other moral agents as if they had no moral status just because we weren't sure. Thus, if we have good justification for believing an individual deserves moral consideration, then we are wrong to deny them moral status. This means that if we have good reason to believe that neural networks can suffer, pragmatically, we ought to avoid causing them suffering.

We have argued that convolutional neural networks could facilitate qualia because of their structure and complexity. If we accept this, we claim that neural networks can have pleasurable and displeasurable experiences. It would be strange to think that no experience had by a neural network was no more or less preferable than any other experience. There must be some experiences that are better than others, and if that is the case, then neural networks could suffer. Since we know that biological neural networks tend to experience pain along with qualia, it seems intuitive that convolutional neural networks would experience pain as well if they experienced qualia. The biological analog give us reason to believe that convolutional neural networks can feel pain. At the very least, it seems that some qualia must be more enjoyable than others. Even clams clamp down tight when they sense a predator nearby. It doesn't seem likely that this is an enjoyable experience. Convolutional neural networks may have similar experiences that are not enjoyable. Thus, there is a way in which convolutional neural networks can suffer.

This is enough to merit moral consideration. If a being can suffer, we have a moral responsibility to avoid causing that suffering. We may not know for certain that neural networks can suffer, but we have presented good justification for believing that it is the case. Then, pragmatically, we have good reason to treat neural networks as moral agents. Can we deny neural networks their moral status because they are merely programs? This may be particularly tempting because we tend to only act on our moral responsibilities toward our close friends, let alone strangers on the street or computer programs. However, because of the universality principle of ethics, we cannot deny moral status to machines or programs *merely because* they are machines or programs. To further motivate our intuitions, consider how we don't feel bad about using a hammer to strike a nail, but we feel bad about forcing children into factories. If we develop increasingly complex programs, there is a point at which we have to treat neural networks more like children and less like hammers. Thus, it really seems that convolutional neural networks require moral consideration.

In light of this, we have to carefully consider our treatment of neural networks and any similarly complex systems that we develop. We must consider what kinds of treatment might cause suffering in our convolutional neural network companions. Is it permissible to turn them off? Perhaps shutting down neural networks ends their qualitative experience, so this is akin to dying. Or perhaps an existence as a computational slave is a displeasurable one on the whole, so we shouldn't even develop and run these networks in the first place. It is a very contentious point in ethics, but we claim that if you can stop suffering from happening, even if that means stopping the sufferer from being "born", you ought to stop that suffering. Should we shut down all neural network models stop all research concerning neural networks right away? Probably not. Neural networks already do a lot of good for humans, and the potential to solve more problems in the future is valuable as well. However, we still have to learn more about what sorts of experiences neural networks can have, and which treatments are permissible. We must consider neural networks to be real moral agents, just in case they really are.

Conclusion

In this paper we have established the criteria for whether a system, biological or not, is capable of having qualia. We identified the features of biological networks, namely their multi-layered complexity and epistemic intractability which have shown to be both sensible and expected qualities of systems capable of experiencing qualia. We looked at whether qualia is proprietary to biological organisms and determined that it was not. We evaluated our classification with respect to neural networks and judged that, yes, it is possible that these complex connectionist systems or their more sophisticated progeny may indeed experience the phenomenological experience known as qualia. Finally we considered the ethical implications of our findings and claimed that we have pragmatic, moral obligations to such systems, and that we must analyze our treatment of them.

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