Does Lateral Specialization in the Brain Arise from the Directionality of Processes and Time?

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Abstract:

It was well accepted before 1980 that there is lateral specialization of brain usage in humans, and it has more recently come to light that a lateral division of labor also takes place in the brains of other animals. However; there has been no universally successful general model of cognitive lateralization. Instead, we have a topical landscape where there is no clear consensus, various models are cited in support of different research results, and there have been few comparative reviews of the available models as the topic has become too broad. This paper suggests a unifying principle that accounts for many aspects of lateral specialization in the brain, and offers tools to help develop a better general model of lateralization.

Simply put; the two halves of the brain appear to address opposite phases of directional processes. While the left brain can take things apart and separate or distinguish the individual pieces, the right brain appears better at assembling those pieces, seeing how they fit together, and making them function as a congruent whole. But this same metaphor extends to a wide range of transformations which are directional and/or reversible. The key element, which makes this idea universal, is that many events in life are irreversibly directional, as they are tied to the ongoing flow of time. That is; time itself is a directional process which compels all creatures to move forward, in terms of our own evolution in time. This explains why even relatively primitive creatures develop brains that are laterally specialized.

Introduction:

If a human brain is examined outside the skull, the two hemispheres appear greatly similar, if not perfect mirror images. And yet, we have known for more than three decades that the two halves of the human brain handle things very differently, and end up with different tasks as a result. Considering the great diversity of strategies people employ in handling any task, it is no wonder that a great number of theories have emerged to explain this division of labor. However; the landmark research of Rogers, Vallortigara, and others, showing that more primitive animals also have lateralized brains, suggests a universality to lateral specialization which forces us to re-examine this matter and search for a unified description. The aim of this paper is not to explain all aspects of lateralization, but to offer tools which will help the experts create better general models of how and why the two brain halves are utilized.

When attempting to formulate a unified description, it is important to recognize that there are indeed absolute or universal factors which every creature must face. Although we tend to think in terms of the need to eat, drink, and breathe, or the need to deal with dangers like predators, perhaps the most primal of these universal factors is the ongoing flow of time. This author has held the view for several years now, that the two halves of the human brain are identically functional but in opposite directions, or operate as though they are doing basically the same thing in opposing directions of time. Another way to say this is that each hemisphere deals preferentially with different phases, or opposing directions, of a given directional process. If we take a watch apart, it ceases to be a functional watch, but we can examine each one of its many intricate pieces as a separate unit. Assembling the watch requires us to see how those pieces fit together, and to put each one in its proper relationship with the other pieces. Only then can it be made to function. And this is not an isolated example. It appears that this directional dichotomy is a feature of all processes and therefore may be the root cause of brain lateralization.

The process of assembling or disassembling a watch is the same transformation in opposite directions! The same thing is happening, either way, but the direction is reversed. And this process is not instantaneous, but unfolds or evolves over an interval of time, through the steps or stages in the process. Likewise; there are any number of processes having a specific directionality in time and a stepwise evolution toward a given outcome, but only a limited number of these processes are entirely reversible. This is due in large measure to the influence of the 2nd law of thermodynamics, which states that once the energy involved with moving a process forward is dissipated or dispersed, it is no longer available to reverse that process. If a clumsy watchmaker were to drop the watch before it was completed, the parts would scatter from the energy of the impact, and would not spontaneously re-assemble themselves. Instead, the watchmaker would have to expend more energy to recover all of the pieces, taking additional time to find any that were lost in the process of scattering. And of course; if it was an egg that got dropped, there would be no possibility of re-assembly.

There are plenty of examples of directional processes in everyday life, and many of these appear to go only one way, though some can be reversed with outside effort. This is true for all creatures, and not just humans. To broaden this a bit; natural processes outside living beings tend to dissipate energy, rather than concentrating it, but lifeforms have the capacity to concentrate energy or direct and utilize it where it is needed to preserve life. The important generalization here is that all creatures will encounter processes in their environment which are directional in time, in terms of their preferred or normal evolution, where living beings have the capacity to reverse the direction of some processes. So the real world requires us to deal with directional processes quite often. However; the abstract realm contains a plethora of additional examples of directional processes and transformations, going far beyond anything we can encounter in the world of the concrete, but frequently offering insights into the nature of concrete reality.

The fact that abstractions can aid a creature's understanding of reality, and therefore its survival, may be nature's incentive for evolving creatures with larger and more complex brains, such as human beings. The capacity for abstraction confers an advantage to those who have it, because it greatly enhances the possibilities for learning about one's environment. However, it also enhances the capacity for planning or the ability to take action in a more complex and strategic way. Noting that any process of abstraction involves differentiating or distinguishing the important details of an object, event, or environment (on the one hand), and integrating or assembling the details into a congruent whole picture of reality (on the other hand), it seems perfectly reasonable that nature should begin evolving lateralized brain structures early in the development of brains. And it is no surprise that this is exactly what we find. Experiments confirm that "a lateralized brain is a more efficient processor."

Evolution of the Theory:

This author has followed the subject of lateral brain research for some time, and has written and lectured on related topics, but has not been a serious researcher in this field. Therefore it was somewhat surprising that my insights on the topic were greeted with considerable excitement when I shared them with two authors of a recent Scientific American article. Their article shows that, despite the prevailing wisdom that humans are different; the lateralization we see in human brains is an outgrowth of evolutionary developments begun in more primitive species about 500 million years ago. This view seems entirely sensible, when seen in light of the idea that nature needed to develop the capacity for abstraction in an environment where all creatures are subject to the ongoing flow of time and the directional nature of processes. I have been working for a number of years to delineate the nature and stages (or levels) of abstraction (an important aspect of cognition), and I have more recently become involved with research into the Physics of time. When professors Rogers and Vallortigara informed me the insights arising from my research in these areas could be of value to their work, I became excited by this, and began to dig deeper.

One resource that was recommended is a paper by Joseph Dien which describes "The Janus model of lateralized cognition." This paper, which appeared in "Brain and Cognition," details the fragmented state of the field of laterality, reviews and compares the five primary theories of brain lateralization, and offers a model that bears considerable resemblance to the ideas I explore in this paper. The view he espouses is that the brain looks in both directions of time at once, to anticipate what is coming and to make sense of what has been. He states clearly that he makes no claim to explain all aspects of laterality, but he does show how the Janus model fares better than the frequency model at explaining some aspects of lateral specialization, especially in the area of motor control and semantic priming. These findings call into question the notion that the frequency model can be viewed as a general theory of laterality. And Dien is quick to point out that his theory addresses the need for generality raised by the findings of lateral specialization in nonhuman animals.

This differs sharply with the earlier paper on the evolution of foresight and "mental time travel" by Suddendorf and Corballis, which claims there is "no convincing evidence for mental time travel in nonhuman animals." The authors coined this term in 1997, to refer to "the faculty that allows humans to mentally project themselves backwards in time to re-live, or forwards to pre-live, events." Thus; they focus on our ability to learn from events in our past, and to foresee future events, which suggests a clear understanding that the two halves of the brain relate differently to process directionality. Unfortunately, they frame their model in a way that appears to exclude nonhumans by strict definition of terms. Several of the peer commentaries on this paper favor softening some of the distinctions made by the authors, however, to allow for their ideas to be less exclusive, or more general. A comment posted by Moshe Bar suggests that "foresight is a gradual continuum in that it is present in animals to the extent it is needed," and this seems appropriate to me also.

If we hope to have a general theory of lateralization in the brain, we must frame our questions and answers to be as inclusive as possible, and avoid restrictive definitions of terms which would prevent the generalities from being observed even if they are present. This means we must attempt to formulate models that explain the behavior and brain structure of animals as well as humans, and admit whatever shades of grey there may be in the evolution of faculties allowing abstractions which relate to the passage of time, or the directionality of processes. While it is difficult or impossible to determine whether primitive creatures have a sense of time, or a distinct concept of past and future, it is undeniable that all creatures including humans are subject to the flow of time, and are caught up in the ongoing evolution of events from moment to moment. We are also subject to the nature of procedural evolution, in terms of the fact that all processes involve steps or stages and the sense of a progression through some kind of evolution toward an outcome, and I reflect on this in an earlier QBS paper.

The idea that the ongoing flow of time forces the attention of all creatures to deal with the directional nature of processes can explain why lateralization came to be developed in early vertebrates, and how it has shaped the ongoing evolution of the brain to deal with time in more and more abstract ways. In human beings, the capacity for abstraction allows for a much more sophisticated way of relating to past and future, but it also opens the door to a great number of other abstractions whereby a more flexible definition of process and transformation is possible. However, the lateral division of labor present in the brains of nonhuman animals carries forward into the physiology of the human cerebrum, which we know handles abstraction. It would appear that the evolution of a lateralized cerebral cortex is an outgrowth of the need to deal with directional processes projected onto the increasing capacity for abstraction, resulting in greatly enhanced ability to make sense of complex processes and a measure of prediction and control impossible for more primitive creatures.

The idea of reversibility or symmetry is tremendously powerful, as a tool of abstraction, in that it allows us to view the similarity of opposites by seeing that they are the same thing in opposing directions. Mathematics is full of examples of transformations that are reversible, or have an inverse. One particularly relevant example is the notion of differentiation and integration found in calculus. Given a record of a car's location on a road at intervals of time, one can calculate its velocity (a derivative or differential), as this is the rate of change in position. Given a record of its velocity and direction at those same intervals, one can calculate (by integration) the car's position at a given time. Ergo; differentiation and integration are the same transformation in opposite directions, allowing us to convert one kind of information into another. Thus calculus offers us insights into real directional processes, and also into the mental process of abstraction, by allowing for abstractions or transformations that are themselves directional. This should help us to understand the reasons why the lateral division of labor in the brain aids abstract thinking.

Conclusions and Reflections:

There is a considerable amount of work to be done, before a definitive general model of lateralization can be formulated. However, the finding that even primitive vertebrates exhibit lateral specialization of brain function gives us reason to believe that there must be general principles at work which foster lateralization in all creatures and find a higher expression in the more developed brains of humans. This compels us to discover some of the generalities underlying the specific usage of various portions of our brain for different tasks. The hypothesis spelled out in the Scientific American article by MacNeilage, Rogers, and Vallortigara is that the left brain dealt mostly with familiar circumstances, early on, and that the right brain dealt with the unexpected, resulting in a situation where the left brain exerted top-down control (self-direction) and the right brain gave rise to bottom-up responses to external stimuli. They suggested that "more specialized behavior – language, toolmaking, spatial interrelation, facial recognition, and the like – evolved from those two basic controls."

This characterization resulted in a flood of associations for me, as the basic modality of top-down versus bottom-up creative and reasoning processes is quite familiar, having appeared in a great variety of different arenas over time. One example I encountered many years ago is the contrast between additive and formant synthesis in electronic waveform generation. Any waveform can be constructed either by adding together a collection of sine waves, or by starting with a more harmonic-rich waveform and filtering out the extra overtones. One could liken this to a sculptor who can either add bits of clay to achieve the shape he or she is looking for, or they can start with a larger piece of clay and carve away the parts they don't want. Of course; one could use both additive and formant techniques in creating the same sculpture. But the idea of top-down and bottom-up processes - working simultaneously to shape reality - has also been suggested as a factor in the evolution of the cosmos. And of course; creating a representation of reality through cognitive processes most definitely involves using both top-down and bottom-up modes of abstraction.

But the idea of reversing directionality implied by their characterization (top-down and bottom-up) is not the only one we can make. We can move things from the inside outward, or from the outside inward. We can move forward or back. We can take things apart or put them together. We can distinguish more and more details in what we observe, or we can see how all of the details comprise or pertain to one thing, and how that thing is part of something greater still. The left brain appears very good at seeing the differences or knowing when something is different, which makes it a sort of difference engine, while the right brain is well-equipped to perceive the ways in which the pieces fit together, or can be assembled into functional wholes, making it more of a congruence engine. The left brain is skilled at taking things apart, and so it is the champion of reductionism as a way to learn about the world. The right brain is geared toward a more holistic view of the world, and it tends to mistrust or reject reductionist logic arising from either-or thinking and the law of the excluded middle, in favor of an integrative both-and viewpoint. Ergo; the left brain's view is rather fragmented, where the right brain sees all of reality as unified.

If we take this to the limit, the left brain is seen to represent the particle-like aspect of things most accurately, while the right brain is better at seeing the wave-like nature of things. Where the one sees objects, the other sees fields. Where one sees features, the other sees how the individual features comprise one entity, or one system. While one sees the pieces that make up an entity, the other sees how that one entity is the source or generator of those pieces. While one perceives items and events, the other cognizes the relationships between them. Thus, the two halves of the brain have complementary roles, where both sets of functions (and both phases of the process) are necessary for a complete cycle of cognition. Understanding requires both attention to details, and knowledge of how they relate. The capacity for complementary views of directional processes is therefore a distinct advantage conferred by a lateralized brain, which would not be a possibility if there was no lateral specialization.

So where do we begin, if our goal is to develop or foster better general models of lateralized cognition and we believe that studying directional processes will help? Dien's paper on the Janus model points out that the fragmented state of the field "is largely a reflection of dissatisfaction with efforts to forge broad dichotomies to account for hemispheric asymmetries." As an outsider to the community of cognitive research, it is apparent to me that this is mainly because the early work on the subject was undertaken with no knowledge that lateral specialization is already at work in nonhuman animals. Given the tremendous diversity of human individuals, and the divergent influences of culture in various parts of the world, it is a wonder that scientists were able to discover any general principles of brain usage whatsoever. It is well established that two people may do the same things, but have a very different motivation, while two others might do different things, yet have almost the same reasons for choosing a given course of action. So this makes drawing conclusions from similarities in human beliefs or behavior both questionable and complicated.

If we take the view that laterality is something more fundamental, and adopt the hypothesis of MacNeilage, Rogers, and Vallortigara that hemispheric specialization began when vertebrates emerged about 500 million years ago, we are forced to assume that there are general principles at work which foster lateralization. That is; the discovery that nonhuman animals have laterally specialized brains shows that factors present in nature drive the development of lateralization by giving a survival advantage to creatures having bilateral brains who can then utilize complementary modes of cognition afforded thereby. Dien's Janus model is "based on evolutionary considerations of complementary hemispheric roles." It proposes that the left brain has a role of choosing between possible future scenarios, while the right is involved with "integrating ongoing information into a unitary view of the past," which gives the ability to "respond to novel and unexpected events." This fits nicely with the notion that the unavoidable directionality of processes determines which half of the brain handles various tasks. And while this leaves researchers with many challenges for creating a unified view of laterality, it is a definite step toward formulating a general model of lateral specialization in the brain.

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