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Understanding Layers: From Neuroscience to Human Responsibility

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Introduction

It was 48 years ago this month when my mentor Roger Sperry spoke here on the occasion of the Pontifical Academy of Sciences symposium, *Brain and Conscious Experience*. I remember the event well as Dr. Sperry was speaking about our research on the original "split-brain" patients – studies of patients who had undergone epilepsy surgery separating the two halves of the brain. In rereading that paper it is interesting to note that the participants commented only on those studies, not on his rather extensive arguments dealing with the problem of mind and free will. This is a shame because his thoughts on free will were quite clear and indeed set the stage for many discussions since that time.

Sperry segued from discussing the patients to the issue of free will by suggesting that the research had indicated that, with the slice of a surgeon's knife, one brain might become two, each with its own set of controls. This suggestion was immediately challenged by two fellow neuroscientists, Sir John Eccles and Donald MacKay. At that conference and in the years that followed, Eccles argued that the right hemisphere had a limited kind of self-consciousness, but not enough to bestow personhood, which resided in the left hemisphere. Donald Mackay was not satisfied with the idea either and commented in his Gifford lecture some ten years later, "But I would say that the idea that you can create two individuals merely by splitting the organizing system at the level of the corpus callosum which links the cerebral hemispheres is unwarranted by any of the evidence so far ... It is also in a very important sense implausible".

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These concerns were all about the meaning of split-brain research, not about the issue of determinism and free will. As I have reviewed elsewhere (Gazzaniga, 2011), many early interpretations of the meaning of split-brain work have been modified, leaving this aspect of the debate moot. On the larger question of determinism and free will, Sperry's original thoughts remain clear. It is worthwhile to remind ourselves of what he said.

> Unlike *mind, consciousness,* and *instinct, free will* has not made any notable comeback in behavioral science in recent years. Most behavioral scientists will refuse to recognize the presence of free will in brain function. Every advance in the science of behavior, whether it has come from the psychiatrist's couch, from microelectrode recording, from brain splitting, from the use of psychomimetic drugs, or from the running of cannibalistic flatworms, seems only to reinforce that old suspicion that free will is just an illusion like the rise and setting of the sun. The more we study and learn about the brain and behavior, the more deterministic, lawful and causal it appears.
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> In other words, behavioral science tells us that there is no reason to think that any of us here today had any real choice to be anywhere else, nor even to believe in principle that our presence here was not already in the cards, so to speak, five, ten or fifteen years ago. I do not like or feel comfortable about this kind of thinking any more than you do, but so far I have not found any satisfactory way around it. Alternatives to the rule of causal determinism in behavior that I have seen proposed so far, as for example, the inferred unlawfulness in the dance of subatomic particles, seem decidedly more to be deplored as a solution than desired.
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> This is not to say that in the practice of behavioral science we have to regard the brain as just a pawn of the physical and chemical forces that play in and around it. Far from it. Recall that a molecule in many respects is the master of its inner atoms and electrons. The latter are hauled and forced about in chemical interactions by the overall configurational properties of the whole molecule. At the same time, if our given molecule is itself part of a single-celled organism like paramecium, it in turn is obliged, with all its parts and its partners, to follow along a trail of events in time and space determined largely by the extrinsic overall dynamics of *Paramecium caudatum*. And similarly, when it comes to brains, remember always that the simpler electric, atomic, molecular, and cellular forces and laws, though still present and operating, have all been superseded in brain dynamics by the configurational forces of higher level mechanisms. At the top, in the

> human brain, these include the powers of perception, cognition, memory, reason, judgment, and the like, the operational, causal effects of forces of which are equally or more potent in brain dynamics than are the outclassed inner chemical forces.
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> You sense the underlying rationalization we are leading to here: "If you can't lick'em, join'em". If we cannot avoid determinism, accept and work with it. There may be worse "fates" than causal determinism. Maybe after all it is better to be properly imbedded in the causal flow of cosmic forces, as an integral part thereof, than to be on the loose and out of contact, free-floating, as it were, with behavioral possibilities that have no antecedent cause and hence no reason or any reliability for future plans or predictions.

Sperry captures many ideas in this his own summary of his views. Overall he articulates well that elements of all kinds become something else when configurational issues are accounted for. Some kind of other complexity arises out of interacting parts and that new layer can constrain the very elements that produced it.

Still, this formulation was not widely accepted at the time and other participants at the conference in their own contributions contested Sperry's view and for markedly different reasons. Again, Eccles and Mackay challenged his ideas. Eccles was a dualist and believed the mental inserted itself into the brain in the left supplementary motor area. Mackay, on the other hand, agreed that the brain "was as mechanical as clockwork". However, he believed there was what he called a "logical indeterminacy" that kept free will alive. This was the concept that in order for something to be true it had to be true for everybody at all times. Thus if a super brain scientist made a prediction about my future actions, all I would have to do to negate the prediction is not carry out the act at a prescribed time. If the super brain scientist wrote down the prediction and sealed it in an envelope and sure enough I did what he predicted, that prediction still wouldn't count since for something to be true and valid, it has to be known to all at all times. Once it is known to all, the person can choose not to carry out the prediction and so on.

While this debate raged on for years, it was somewhat local to neuroscience. The philosophers, by and large, were and still are coming at the problem from different angles, far too many to review here. What is relevant to the current effort is the strong belief among philosophers that it is difficult to separate the issue of free will from the issue of responsibility. This traditional position, which is well represented by Daniel Dennett, finds people viewing the determined brain as in fact an exemplar of a "free" system.

As Dennett has recently written:

> When, on the other hand, we have our wits about us, and are not massively misinformed or otherwise manipulated, then *there is no important sense* (emphasis in the original) in which the outcome of all the interactions in the many levels or layers of "machinery" is not a free choice. That's what a free choice *is!* It's the undistorted, unhindered outcome of a cognitive/conative/emotive process of exquisite subtlety, capable of canvassing the options with good judgment and then acting with fairly full knowledge of what is at stake and what is likely to transpire. (Dennett, 2013)

With this kind of definition of what it means to be "free" the yoking of free will and responsibility remains intact. While other philosophers don't see this need and indeed claim the two concepts are dissociable (Fischer and Ravissa, 1999), it is a key issue. In short, does a deterministic view of brain function make nonsense out of the idea of responsibility?

I join with those who believe one can hold a deterministic view and still maintain humans are personally responsible for their actions. In what follows I will make this argument by suggesting a layered view of human decision making that incorporates the social network within which we live, thereby making the idea not only plausible but inevitable and necessary. It is this perspective that advances the ideas of Sperry's contribution almost 50 years ago. While incorporating the mental realm in the causal flow is important as Sperry noted, it does not liberate one from the reality of determinism. After all, the mental layer, with its own abstract vocabulary and mechanisms, works in a deterministic way as well.

By recognizing the existence of yet another layer, the social layer, another level of abstraction and explanation is introduced which does impose a constraint on the individual. Being accountable and therefore responsible is the *sine qua non* of existing in a social world. In short, responsibility is established by participating in the social network; it is not found in the brain per se.

Towards Layered and Dynamical Views of Brain/Mind Function

Much of what follows, I have presented elsewhere (Gazzaniga, 2011, 2013; Bassett and Gazzaniga, 2011). In those efforts, I reviewed neuroscientific data which supports the modular view of brain organization, now widely established, along with a possible understanding of why our subjective life seems largely unified.

From today's vantage point: It's all about the brain – what it does and does not do. First, how is that thing built and connected, and how does it work? Is it a bowl of mush shaped by its environment, like a wheelbarrow full of wet concrete being poured into a form? Or does the brain arrive on the scene pre-formed, to some extent, and then await experience to place the final touches on its mature shape? More importantly, does it matter how it is built, for the purposes of this discussion?

It does. We are born with an intricate brain slowly developing under genetic control, with refinements being made under the influence of epigenetic factors and activity-dependent learning. It displays structured, not random, complexity, with automatic processing, with particular skill sets, with constraints, and with a capacity to generalize. All these evolved through natural selection and provide the foundation for a myriad of cognitive abilities that are separated and represented in different parts of the brain. These parts feature distinct but interrelated neural networks and systems. In short, the brain has distributed systems running simultaneously and in parallel. It has multiple control systems, not just one. Our personal narrative comes from this brain, and how it interprets the outside world within which it lives.

This overall neural architecture has been unearthed at many levels of examination. While developmental neurobiologists have revealed how the brain gets built, cognitive neuroscientists have studied the brain in healthy maturity and often when it is damaged. My colleagues and I used those insights to confirm that there are modularized, and frequently localized, processes in the functioning, fully developed brain. Classic studies on neurologic patients by Broca and others supported the idea that brain injury can lead to the loss of specific cognitive abilities. This notion has been the backbone of behavioral neurology. Split-brain research complemented this work. It showed what happened when one processing system was disconnected from others, even though it was still present and functioning. And what did happen? It just went on functioning, outside the realm of awareness of the other systems. The right brain was able to go about its business normally while the left brain didn't have the slightest idea what the right brain was doing – and vice-versa.

Still, this emerging knowledge of how our brain is organized was hard to square with ordinary experience. People – even split-brain patients – feel integrated, whole and purposeful, not modularized and multiple. How can our sense of being singular and responsible come from a neural architecture like ours?

The interpreter of experience

Years ago we unearthed a special capacity, a module in the left hemisphere that we called the "interpreter". Studies of split-brain patients demonstrated that each side of the brain could respond separately to queries about what it perceives by having the hand it controls point to answers in a multiple-choice task. So flash a picture of a chicken claw to the left brain, and the right hand could choose a picture of a chicken out of a group of pictures (each side of the brain controls the opposite side of the body). If the right brain was at the same time shown a picture of a snow scene, it could guide the left hand to select a picture of a snow shovel from a different set of pictures. It took us years to figure out the key question to ask after a split brain patient performed this task: "Why did you do that?"

We arranged for one patient's left hemisphere (which controls speech) to watch the left and right hand pointing to two different pictures while not allowing the left brain to see the snow scene. Of course, the left hemisphere knew why the hand it controlled had pointed to the chicken, but it had no access to information about why the patient's left hand, controlled by the right hemisphere, had pointed to the shovel. Nonetheless, immediately upon being asked our key question, "why did you do that?", the left hemisphere made up a story, an interpretation, of why the left hand, controlled by a separated brain module, did what it did. The patient answered, "Oh, the chicken claw goes with the chicken and you need a shovel to clean out the chicken shed".

Years of research have confirmed that there is a system that builds a narrative in each of us about why we do things we do, even though our behaviors are the product of a highly modularized and automatic brain working at several different layers of function (Gazzaniga, 2000). Our dispositions, quick emotional reactions, and past learned behavior are all fodder for the interpreter to observe. The interpreter finds causes and builds our story, our sense of self. It asks, for example, "Who is in charge?" and in the end concludes, "Well, it looks like I am".

Additionally, neuroscientists have continued to examine when the brain carries out its work that is associated with behavior or even conscious activity itself. Ever since the classic work of Benjamin Libet, it has been believed that the neural events associated with an action occur long before one is consciously aware of even wanting to will an act. Libet stimulated the brain of an awake patient during the course of a neurosurgical procedure and found that there was a time lapse between the stimulation of the cortical surface that represents the hand and when the patient was conscious of the sensation in the hand (Libet *et al.*, 1979). In later experiments, brain activity involved in the initiation of an action (pushing a button), occurred about five hundred milliseconds *before* the action. What was surprising was that there was increasing brain activity related to the action as many as three hundred milliseconds *before* the *conscious intention* to act according to subject reports. The buildup of electrical charge within the brain that preceded what were considered conscious decisions was called Bereitschafts potential or more simply, the readiness potential (Libet *et al.*, 1983). Using more sophisticated fMRI techniques, John-Dylan Haynes (Soon *et al.*, 2008) recently showed that the outcomes of an inclination can be encoded in brain activity up to ten seconds before it enters awareness! Furthermore, the brain scan can be used to make a prediction about what the person is going to do. The implications of this result appear definitive. They suggest completes its work independent of conscious input.

These sorts of findings, however, can be interpreted differently when the brain is viewed as a multi-layered system as is commonly seen in information systems (see Hillis, 1998; Bachman *et al.*, 2000; also see Doyle and Csete, 2011). Simply put, layered systems use layers to separate different units of functionality. Each layer preferentially communicates with the layer above and the layer below. Each layer *uses* the layer below to perform its function… "A **Layer** is a design construct. It is implemented by any number of classes or modules that behave like they are all in the same layer. That means that they only communicate with classes in layers immediately above or below their layer and with themselves" (Van Bergen, P.).

The framing of how the brain manages its tasks will undoubtedly be modified and extended in the years to come. Still, this suggested informational/functional assessment of how the brain does its work is liberating as it frees us from the linear assumptions of bottom-up causality. The traditional reductionist/constructionist approach with its claim of linearity on how the brain produces mental states leaves little apparent room for the role of mental life in human destiny. On the surface that seems absurd. This was Sperry's point 50 years ago and it is as valid today as it was then.

Clearly, we humans enjoy mental states that arise from our underlying neuronal, cell-to-cell interactions. Mental states do not exist without those interactions. However, as argued in the foregoing, mental states cannot be defined or understood by knowing only the cellular interactions. Mental states that emerge from our neural actions, do constrain the very brain activity that gave rise to them, just as Sperry noted that "a molecule in many respects is the master of its inner atoms and electrons". Mental states, such as beliefs, thoughts, and desires, represent a layer, and that layer arises from brain activity and in turn can and does influence our decisions to act one way or another. Ultimately, these interactions will be understood only with a new vocabulary that captures the fact that two different layers of stuff are interacting in such a way that existing alone animates neither.

Yet, this interpretation of the problem, where both upward and downward causation are discussed, comes with warning signs. As John Doyle puts the issue (See Gazzaniga, 2011):

> ... the standard problem is illustrated with hardware and software; software depends on hardware to work, but is also in some sense more 'fundamental' in that it is what delivers function. So what causes what? Nothing is mysterious here, but using the language of 'cause' seems to muddle it. We should probably come up with new and appropriate language rather than try to get into some Aristotelian categories.

Understanding this nexus and finding the right language to describe it represents, as Doyle says, "the hardest and most unique problem in science" (Personal Communication). The freedom represented in a choice not to eat the jelly donut comes from a mental-layer belief about health and weight, and it can trump the pull to eat the donut because a certain brain module likes its taste. The bottom-up pull sometimes loses out to a top-down belief in the battle to initiate an action. And yet the top layer does not function alone or without the participation of the bottom layer.

A unique vocabulary which has yet to be developed, is needed to capture the thing that happens when mental processes constrain the brain and vice versa. The action is at the interface between those layers. In one kind of vocabulary, it is where downward causation meets upward causation. In still another perspective, it is not only there but also in the space between brains that are interacting with each other. Overall, what happens at the interface of our layered hierarchical existence holds the answer to our quest for understanding mind/brain relationships. How are we to describe that? Recalling Libet and Haynes, we have to account for the role of time. I think we should say that mind/brain layers interacting has its own time course and that time course is current with the actions taking place. In short, it is the abstract interactions between the mind/brain layers that make us current in time, real and accountable to our past mental experiences. The whole business about the brain doing it before we are conscious of it becomes moot and inconsequential from the vantage point of a layered interacting system. Again and as I have discussed elsewhere:

> Once a mental state exists, is there downward causation? Can a thought constrain the very brain that produced it? Does the whole constrain its parts? This is the 64 thousand dollar question in this business. The classic puzzle is usually put this way: There is a physical state, P1, at time 1, which produces a mental state, M1. Then after a bit of time, now time 2, there is another physical state, P2, which produces another mental state, M2. How do we get from M1 to M2? This is the conundrum. We know that mental states are produced from processes in the brain so that M1 does not directly generate M2 with-

out involving the brain. If we just go from P1 to P2 then to M2, then our mental life is doing no work and we are truly just along for the ride. No one really likes that notion. The tough question is, does M1, in some downward constraining process guide P2, thus affecting M2?
We may get a little help with this question from the geneticists. They used to think gene replication was a simple upwardly causal system: Genes were like beads on a string that make up a chromosome that replicates and produces identical copies of itself. Now, they know that genes are not that simple, there is a multiplicity of events going on. Our systems-control guy, Howard Pattee, finds that a good example of upward and downward causation is the genotype-phenotype mapping of description to construction. It "requires the gene to describe the sequence of parts forming enzymes, and that description, in turn, requires the enzymes to read the description… In its simplest logical form, the parts represented by symbols (codons) are, in part, controlling the construction of the whole (enzymes), but the whole is, in part, controlling the identification of the parts (translation) and the construction itself (protein synthesis)". And once again Pattee wags his finger at extreme positions that champion which is more important, upward or downward. As a teenager would sum it up, "Duh, they are like, complementary".
It is this sort of analysis that finds me realizing the reasoning trap we can all too easily fall into when we look to the Libet kind of fact, that the brain does something before we are consciously aware of it. With the arrow of time all moving in one direction, with the notion that everything is caused by something before it, we lose a grip on the concept of complementarities. What difference does it make if brain activity goes on before we are consciously aware of something? Consciousness is its own abstraction on its own time scale and that time scale is current with respect to it. Thus, the Libet thinking is wrong headed. That is not where the action is anymore than a transistor is where the software action is.
Setting a course of action is automatic, deterministic, modularized and driven not by one physical system at any one time but by hundreds, thousand and perhaps millions. The course of action taken appears to us as a matter of "choice" but the fact is, it is the result of a particular emergent mental state being selected by the complex interacting surrounding milieu. Action is made up of complementary components arising from within and without. That is how the machine (brain) works. Thus, the idea of downward causation might confuse our un-

> derstanding. As John Doyle says, "where is the cause?" What is going on is the match between ever present multiple mental states and the impinging contextual forces within which it functions. Our interpreter then claims we freely made a choice. (Gazzaniga, 2011)

It is also true that viewing the brain/mind interface from this perspective reveals a certain truth: the brain is a dynamical system. Instead of working in a simple linear way where one thing produces another, it works in a dynamic way where two layers interact to produce a function. Hardware and software interact to produce the PowerPoint image. Mental states interact with neuronal states to produce conscious states. Starting the clock on what happens when, when trying to analyze the flow of events during conscious activity, doesn't start with neurons firing off, as those events might reflect little more than the brain warming up for its participation in the dynamic events. The time line starts at the moment of the interaction between layers. At the level of human experience, that would mean we are all online when we are thinking about whatever we are thinking about. Thought is not on a delay after action. It also leads to the question of whether or not mental beliefs can be in the flow of events determining ultimate action (Posner and Rothbart, 2012). I think so.

Moving Forward: Emergence, Human Responsibility and Freedom

In one sense, the concept of multiple levels has a long-standing history in the study of the brain and mind. For literally thousands of years, philosophers have argued about whether the mind and body are one entity or two. The compelling idea that people are more than just a body, that there is an essence, a spirit or mind, has been around a long time. What has not been fully appreciated, however, is that viewing the mind/brain system as a layered system sets the stage for understanding how the system actually works. As reviewed in the foregoing pages, it also allows for understanding the role of how beliefs and mental states stay part of our determined system. With that understanding comes the insight that layers exist both below the mind/brain layers and above them as well. Indeed, there is a social layer and it is in the context of interactions with that layer that we can begin to understand concepts such as personal responsibility.

I believe that we neuroscientists are looking at the concept of responsibility at the wrong organizational level. Put simply, we are examining it at the level of the individual brain when perhaps responsibility is a property of social groups of many brains interacting. Mario Bunge makes the point that we neuroscientists should heed: "… we must place the thing of interest in its context instead of treating it as a solitary individual". By placing such concepts as personal responsibility in the social layer, it removes us from the quagmire of understanding how determined brain states negatively influence responsibility for our actions. Being personally responsible is a social rule of a group, not a mechanism of a single brain.

Sperry did not introduce the idea of the social layer. He fully accepted and indeed implored us all to "join'em if you can't lick'em". He did feel better about determinism by conceptualizing it was the mind layer that intervenes and becomes a part of the causal chain that constrains the neural elements that built the mind. With the present view, adding the social layer to the human condition completely restores the idea of personal and therefore moral responsibility no matter how stringent a deterministic stance one adopts. Responsibility comes out of the agreement humans have with each other to live in the social world. The human social network is like any other kind of network. The participants have to be held accountable for their actions—their participation. Without that rule, nothing works.

Brains are automatic machines following hierarchical decision pathways and analyzing single brains in isolation cannot illuminate the capacity to be responsible. Again, responsibility is a dimension of life that comes from social exchange, and social exchange requires more than one brain. When more than one brain interacts, a new set of rules comes into play and new properties – such as personal responsibility – begin to emerge. The properties of responsibility are found in the space between brains, in the interactions between people.

Finally, neuroscience is happy to accept that human behavior is the product of a determined system, which is guided by experience. But does it matter how that experience is doing the guiding? If the brain is a decision-making device and gathers information to inform those decisions, then can a mental state that is the result of some experience or the result of some social interaction affect or constrain the brain and with it future mental states?

We humans are about becoming less dumb, about making better decisions to cope and adapt to the world we live in. That is what our brain is for and what it does. It makes decisions based on experience, innate biases, and much more. Our "freedom" is to be found in developing more options for our computing brains to choose between. As we move though time and space we are constantly generating new thoughts, ideas, and beliefs. All of these mental states provide a rich array of possible actions for us. The couch potato simply does not have the same array as the explorer. Just as Daniel Dennett suggests, even though we live in a determined world, new experience provides the window into more choices and that is what freedom truly means.

Personal responsibility is another matter. My argument is that it is real, the consequence of social strategies that people adopt when living together and that are the fabric of social life. Personal responsibility is not to be found in the brain, any more than traffic can be understood by knowing about everything inside a car. I am inclined to think there is something like a universal architectural principle common to all information processing systems. All networks, whether they are neural or artefactual like the Internet, can operate only if accountability – cause and effect, action and consequence – is built into their functioning. Human society is the same.

It could be argued that the addition of the social layer actually reduces rather than enhances personal responsibility – responsibility in the sense of an individual having a choice about their actions. If the system is deterministic and the social layer impinges from above along with the mental layer while the brain impinges from below it would seem that the individual (wherever he or she is located amongst the layers) doesn't have much choice about what to do. His or her actions are determined, but not by him or her alone, but by the interactions of these various networks. "The network made me do it!"

This line of reasoning slips into place the assumption there is a control center, indeed a homunculus, a thing that is calling the shots. What modern neuroscience perspectives argue for, however, is that the brain is an information processing system whose function it is make decisions for actions. In carrying out that function it gathers information from multiple layers with the impact of each layer being evaluated by the neural algorithms that manage choice for action. Framing the problem in this way removes the endlessly circular problem of defining the self with its seemingly appealing solution to providing an explanation for the mind's need to have an essential mechanism in charge. As I have summarized elsewhere:

> Understanding that the brain works automatically and follows the laws of the natural world is both heartening and revealing. Heartening because we can be confident the decision-making device, the brain, has a reliable structure in place to execute decisions for actions. It is also revealing, because it makes clear that the whole arcane issue about free will is a miscast concept, based on social and psychological beliefs held at particular times in human history that have not been borne out and/or are at odds with modern scientific knowledge about the nature of our universe. As (Caltech's) John Doyle has put it to me, "Somehow we got used to the idea that when a system appears to exhibit coherent, integrated function and behavior, there must be some 'essential' and, importantly, central or centralized controlling element that is responsible. We are deeply essentialist, and our left brain

will find it. And as you point out, we'll make up something if we can't find it. We call it a homunculus, mind, soul, gene, etc. … But it is rarely there in the usual reductionist sense … that doesn't mean there isn't in fact some 'essence' that is responsible, it's just distributed. It's in the protocols, the rules, the algorithms, the software. It's how cells, ant hills, Internets, armies, brains, really work. It's difficult for us because it doesn't reside in some box somewhere, indeed it would be a design flaw if it did because that box would be a single point of failure. It's, in fact, important that it not be in the modules but in the rules that they must obey".

Again, the idea here is that the whole concept of personal responsibility is a social concept, automatically assigned and pinned on the individual by the group de facto. It is a fact of the social world, the price of entry and participation. It is part of the architecture of human existence.

Responsibility is a needed consequence of more than one individual interacting with another. It is established by people. Researchers might study the mechanistic ways of the brain-mind interface forever, with each year yielding more insights. Yet *all* of their research can only add to the scientific case for the central value of human life. It is because we have a contract with our social milieu, we are responsible for our actions.

References

Anderson, P.A. (1972). More is different. *Science*, *177*(4047), 393-396.

Bachman, F., Bass, L., Clements, P., Garlan, D., Ivers, J., Little, R., Nord, R and Stafford, J. (2000) *Documenting Software Architecture: Documenting Interfaces. Technical note*. Carnegie Mellon, Software Engineering Institute.

Bassett DS, & Gazzaniga MS. Understanding complexity in the human brain, *Trends Cogn Sci*. 2011 May; 15(5):200-9. Epub 2011 Apr 14.

Bohr, M. (1937) Causality and Complementarity. *Philosophy of Science*, *4*(3), 289-298.

Dennett, D. (2013) Seduced by Tradition: Comment on Gazzaniga's paper. In: *Moral Psychology*, Volume 4: Free Will and Moral Responsibility, Ed. Walter Sinnott-Armstrong Cambridge, Mass.; MIT Press, 2013.

Doyle, John (2011) personal communication.

Doyle JC & Csete ME. Architecture, Constraints, and Behavior, *P Natl Acad Sci* USA, (2011) vol. 108, Sup 15624-15630.

Eccles, John C. (1980) *The Human Psyche* (Gifford Lectures) Springer-Verlag.

Fischer, John Martin, & Revissa, Mark (1999) *Responsibility and Control: A Theory of Moral Responsibility*. Cambridge University Press.

Gazzaniga, M.S. (2005) *The Ethical Brain*. New York: Harper Perennial.

Gazzaniga, M.S. *Human – The Science Behind What Makes Us Unique*. Ecco Books, Harper, New York 2008.

Gazzaniga, Michael S., Neuroscience and the Correct Level of Explanation For Understanding Mind 14, *Trends in Cognitive Sciences* 291 (2010)

Gazzaniga, Michael S. (2011) Who's in

Charge, Free Will and the Science of the Brain, Harper (Ecco) New York.

Gazzaniga, M.S. (2013) Mental Life And Responsibility In Real Time With A Determined Brain. In: *Moral Psychology*, Volume 4: Free Will and Moral Responsibility, Ed. Walter Sinnott-Armstrong Cambridge, Mass.; MIT Press, 2013.

Hillis, W. Daniel (1999) *The Pattern On The Stone: The Simple Ideas That Make Computers Work* (Science Masters) Basic Books, New York.

Libet, B., Gleason, C.A., Wright, E.W., & Pearl, D.K. (1983). Time of conscious intention to act in relation to onset of cerebral activity (readiness potential): The unconscious initiation of a freely voluntary act. *Brain*, 106 (3), 623-642.

Libet, B., Wright, E.W., Feinstein, B. & Pearl, D.K. (1979). Subjective referral of the timing for a conscious sensory experience: A functional role for the somatosensory specific projection system in man. *Brain*, 102(1), 193-224.

MacKay, D.M. (1991) *Behind the eye*. Oxford: Basil Blackwell.

Posner, Michael & Rothbart, M. (2012) (in Press) Willpower and Brain Networks, *Bulletin of the International Society for the Study of Behavioural Development* (ISSBD) Special issue on Neuroscience and Development.

Soon, C.S., Brass, M., Heinze, H.-J., Haynes, J.-D. (2008) Unconscious determinants of free decision in the human brain. *Nature Neuroscience*, 11(5), 543-545.

Sperry, R.W. (1966) Brain bisection and mechanisms of consciousness. In: J.C. Eccles (Ed.), Brain and Conscious Experience, pp. 298-313. Heidelberg: Springer-Verlag.

Van Bergen, P. online at www.dossier-andreas.net/software_architecture/index.html