Reason and Embodiment: Perceptual and Transcendental Structures of Scientific Phenomenology

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Abstract

I consider both the phenomenology of scientific reason and the prospects of science and phenomenology joining to provide a naturalistic account of consciousness, for a suitably liberal notion of "Naturalism". Acknowledging the "embodiment" and "situated" nature of human consciousness compels us to rethink our understanding of the nature of human thinkers insofar as we credit ourselves with scientific knowledge and understanding, and the capacity to acquire such. However, I will argue that this rethinking is a shift in perspective within the broad modern understanding of science, and not a radical paradigm shift or a philosophical break. I will argue that a similarly nuanced shift in perspective can yield a presentation of consciousness and subjective experience which honors its particular, personal character but still asserts its likely explainability within the terms of modern or future physics. In particular, I will argue that certain organizational principles are fundamental to the experience and the epistemic roles of conscious states, and that these organizational details can be structurally modelled by formal systems, which can provide formal theories of cognitive activity analogous to quantitative models of physical phenomena. No single formal system can capture all conscious experiential details, but certain formal systems can describe structures realized by cognitive operations involved in consciousness, perception, and judgment. In particular, I will mention Mereotopology and Conceptual Graph Semantics as providing accounts of perceptual and situational reasoning.

This paper is concerned with a Phenomenological Philosophy of Science, so it is appropriate to mention several different ways or traditions in which Phenomenology has concerned itself, and addressed, questions related to (the Philosophy of) science. Indeed, we can identify at least three distinct such traditions, and one of my overall claims is that these traditions are more closely integrated with each other than they may appear.

The first tradition I have in mind extends from Husserl through Heidegger and several generations of existential, post-Heideggerian and post-Phenomenological social and cultural thought, largely aligned with "Continental" philosophy, and particularly influential in the human or social sciences. To the degree that this tradition addresses "Natural" science, or the kinds of science most commonly associated with the self-identified "Philosophy of Science", this tradition approaches natural science with some skepticism or at least with a historically sensitive mindset, inclined to treat modern science as the product of specific historical and cultural circumstances, and to bracket and investigate — not necessarily to outright deny — science's claims to have (in principle) the final word on matters empirical. With Natural Science thus bracketed, the chief legacy of an "existential" Phenomenology — represented by philosophers like Heidegger, Sartre, and Levinas, and by scholars and theorists who followed then, such as Derrida, Lacan, Kristeva, Levi-Strauss, and Barthes, to name a few — within the purview of the Philosophy of Science, was to provide a complex framework for developing a philosophy of *human* science whose intellectual foundation was quite different from the assumptions and methods of natural science.

When comparing human and social sciences, it is important to distinguish between how we theorize the fundamental causative principles of human reality, from the practical sciences and ideas through which we approach human phenomena. Whether or not our basic-level cognitive and experiential processes are subject to natural explanation in terms of sciences like physics, chemistry, and neurology, how these basic phenomena translate to the realities of human life — our culture, politics, economics, society, emotions, and belief-systems — these higher-scale cognitive and experiential phenomena demand their own analytic methods and vocabularies, just as the models and terms of botany or cosmology are different from those of organic chemistry, or quantum mechanics. The *ideational* difference between human and natural science is self-evident, but it does not automatically follow that human and natural science are fundamentally or metaphysically incompatible. As such, although the more "existential" line of evolution within Phenomenology may suggest an underlying rupture with the tenets of natural science, there is a counter-tradition which emphasizes the mutual influence and relevance of Phenomenology and science. Husserl and Merleau-Ponty are arguably the two most influential thinkers for the phenomenological movement in itself — in contrast to Heidegger, for example, whose significant influence was felt as much outside as within Phenomenology — and both Husserl and Merleau-Ponty wrote extensively about (natural) science, and appeared to learn from and remain in touch with scientific developments throughout their careers. So there ia a different tradition which extends from Husserl and Merleau-Ponty to more recent "Analytic" phenomenology, which is receptive to the possiblity of a rapproachment between Phenomenology and Natural Science and seeks to "Naturalize" phenomenology, and also to "Phenomenologize" natural science; to develop phenomenology as a core foundation for scientific reasoning and foundations.

If we can associate the two traditions I just mentioned with Heidegger and Merleau-Ponty, respectively, then I think we can also articulate a third brance of evolution within “Phenomenological Philosophy of Science” which is more closely attuned to Husserl’s thought in particular. Husserl’s own relation to science is complex and “hedged”; Husserl as a philosopher is careful neither to critique science for casual or superficial reasons, but nor to uncritically accept science’s own account of its metaphysical and intellectual foundations. While even a brief sketch of this carefully-woven thought is well beyond the scope of this paper, I can offer at least my own understanding of how Husserl’s relation to science might be encapsulated in a few sentences. It seems to me that Husserl is respectful of the *achievements* of science, but finds philosophically problematic how science accounts for its own foundations and possibility. This is not so much a matter of science clarifying its own assumptions and methods, but of a philosophical interrogation of the very nature of scientific knowledge or understanding; that is, what it means for a person to have scientific knowledge, or for a mental state to qualify as a token of “scientific understanding”. Scientific laws, or at least many of them, are intended to apply across space and time — the theory of light and electricity, for example, is assumed to describe interactions between photons, electrons, and atomic nuclei, everywhere in the universe and at all times beyond a few fractions of a second after the Big Bang. But aside from this theoretic universality, there is a presumptive universality of the cognitive structures induced by learning and understanding the theory. The arrival at such a theory is a personal event — most scientific theories are not self-evident, built in to the operations of any intelligent system, like the basic principles of logic may be claimed to be. As a result, learning a complex scientific theory demands a systematic act of cognitive adjustment to the concepts, semantics, and structural organization of a theoretical system. This gradual, emerging clarity is an event within each person’s cognition, but it represents a collective representation of a trans-personal organizational structure, articulated within concepts and definitions, which is assumed and understood to transcend any single persons’ mentality; to embody an objective form, the objectivity of a structure formed from conceptual relations. This objectivity-of-structure is therefore corrolary to the preumed universality of many physical laws which, in turn, are then theorized by these conceptual structures.

When considering the transcendental structures of scientific reason, we have to distinguish between metaphysical assumptions made by science about empirical reality — in other words, about what sorts of laws or phenomena are or are not physically possible — with assumptions about human minds and individuals insofar as they are capable of scientific thought. A scientific worldview in the former sense is “transcendental” in that it makes broad assumptions about nature as a foundation for developing empirical theories, or theories backed by empirical evidence; these assumptions may not themselves be empirically demonstrable, although we can perhaps envision scenarios where they may be empirically *refutable*. We can imagine that the Euclidean stasis of three-dimensional space, for example, was presumed as a transcendental given before Einstein (inspired by Kant, for example), but then proven false by astronomic confirmation of Einstein's relativistic equations. Similarly, several quantum phenomena appear to challenge apparently "transcendental" assumptions about physical nature, assumtions which feel self-evident to us because they are implicit in our natural mental models of the world. For example, quantum entanglement suggests (counter to our intuitions) that spatially distant entities can instantaneously affect one another, and self-interference (of single photons in a double-slit experiment, for example) challenges our assumption that objects have single locations. The philosophical implications of these latter cases are less clear-cut than the Relativistic demonstration of space-time curvature, because the quantum phenomena are still not well understood. But in either case, the *falsifiability* of what seemed like a transcendental, self-evident assumption about nature as such — in other words, about what "naturality" actually is, what it means to be a *natural phenomenon* — this falsifiability is not the same as empirical *comfirmability* of transcendental assumptions. We form a basic picture of what naturalness *is* in accord with our perceptual intuitions, and then revise this picture as needed, given the departure of the Relativistic and quantum world from the everyday world where those intuitions evolved.

So science is driven by certain transcendental assumptions about naturalness which, we might say, are empirically falsifiable but not empirically confirmable. These are *metaphysical* assumptions of science because they are not themselves subject to scientific demonstration, but rather underlie the endeavor of scientific demonstration itself. But separate and apart from this set of transcendental assumptions, is a different suite of transcendental conceptualizations of science as a cognitive and epistemic phenomenon; of scientific knowledge as realized in and accessible to the minds of individual people. A well established and tested scientific theory does not exist on the paper where its equations or articles are written; it exists in the minds of scientists. It does not, however, exist in any one scientist's thought, but as a shared conceptual structure. In this sense a theory represents an ideality which extends, in a larger and more complex scale, the semantic ideality of words and sentences.

The intersubjective nature of scientific reasoning suggests both the ideality and the personal groundedness of scientific understanding. Scientific theories are *objective* because they represent conceptual structures which, *as structures*, exist outside individual minds; however, these structures become cognitively manifest by patterns within concept-tokens, which themselves do occur occur as cognitive phenomena within scientist's thoughts. So scientific understanding involves a negotiation between subjective and objective. A scientist needs a subjective affirmation of the clarity and coherence of theories in their minds; they need to know when they do indeed understand the theory, and have sufficient familiarity with its terms and concepts as to pass judgment on its empirical and formal adequacy. At the same time, a scientist needs to assume that the theory thus structurally presented is shared collectively by all who achieve similar understanding, and that the subjective phenomenon of theoretic clarity is a manifestation of intersubjective accord. We need to keep the dual roles of objective and subjective in mind, because I believe ignoring this dual synthesis can cause competing accounts of scientific reasoning — and its phenomenology — to be over-contrasted. In particular, while there are real philosophical differences between the traditions of Phenomenology Philosophy of Science which I have identified, we should not magnify their mutual incommensurability. Scientific reason can aspire to objective transcendence, and (when appropriate) universal validity, while still demanding a negotiation, of objective and subjective, whose psychological norms are historicized and culturally specific. So, in any case, while a Heidegerrian or (post-)Structural movement beyond phenomenology can provide a philosophy of (primarily) human sciences, and while a tradition headlined by Merleau-Ponty and by more recent "Naturalizing" phenomenology (Barry Smith, David Woodruff Smith, Jean Petitot, etc.) integrates phenomenology with cognitive and behavioral sciences, we also need to pursue a transcendental analysis of scientific understanding as a cognitive possibility, interweaving the subjective and objective, in the spirit of "Middle Period" Husserl.

In particular, I want to consider the interplay of objective and subjective with reapect to scientific reason in contrast to the more "embodied" or "situational" reasoning which is more typical of daily affairs. Science can, and often does, concern itself with times, places, and scales of reality which are far removed from those around us and which we can directly perceive. Because science tries to theorize conditions of the cosmic and geologic past, or deep in outer space, it builds models of environments which of necessity are not those that we belong to, or could have any hope of occupying except in an imaginative, hypothetical way. With this imaginative projection of ourselves into these foreign environments, are we reducing ourselves to mere "disembodied" observers, who do not interact with phenomena in any way, simply assuming that they carry on as if we were not there? Or does this imaginative projection — this attempt to visualize the universe a few microseconds after the big bang, say, however inadequate our visual imagination may be — does the fact that we do try to *imagine* the world at extreme scales and distances constitute some fashion, however minimal, of "interacting" with the world in those places? Is there something corporeal, something of an imaginative projection of our bodies into unfamiliar times and places, so that scientific reasoning is not just disembodied abstractions, even when addressed to distant space or the distant past?

1 Observation and Reduction

My preceding comments about "embodiment", or alternatively a hypothetical "disembodied" scientific observer, where motivated by one perspective within a

Phenomenological Philosophy of Science, often associated with Merleau-Ponty but also resonating with English-language cognitive philosophers, like George Lakoff and Mark Johnson. We should recall that Merleau-Ponty was sympethetic to science, including but not limited to sciences of perception or psychology, but Merleau-Ponty's emphasis on the embodied nature of cognition — on "motor intentionality" and the role of body-schema in forming a mental and operational image of our surroundings — strikes some commentators as paradigmatically removed from the presumptions of most modern science. Merleau-Ponty scholarship, in particular, often emphasizes his interest in science but also highlights how his intuitions cut against its paradigmatic grain: "Nearly half a century has passed since Merleau-Ponty's death and — because physics has still not responded effectively to the critique of the 'absolute spectator' implicit in its own phenomena, its crisis has continued. In fact, it has gotten worse." (Steven M. Rosen, *Bridging the "Two Cultures". Merleau-Ponty and the Crisis in Modern Physics*, p. 5). In this section I want to consider this image of the "disembodied" observer, as an apparent foundational trope in scientific self-understanding, in the context of the integration of objective and subjective that I described earlier.

The metaphysical notion of observation as *detached*, at least in many cases — that the concept of observation implies an observer who is removed from and attempts not to affect the phenomena observed — this idea may be considered a "transcendental principle" which counts among the foundations of science, or at least of many scientific theories. This does not mean that such detachment is intrinsic to theoreticity as such; theories can be developed in which the observer *is* given affecting status, and must be included among the causal factors within the phenomena which it studies ("affecting" here meaning ability to effect changes within observed things, indeed in some case the *inability* to *fail* to cause such changes). Quantum mechanics provide some examples, but we can also mention Anthropology, say, where contact with researchers is understood to have some effect on the people whom they interact with. However, these cases where a theory has to include the theoretical observer among its terms and factors, are the exception rather than the rule: I doubt anyone seriously believes that measuring the position of astronomical objects affects them, or that studying the early universe by measuring Background Radiation can somehow time-reverse causality and affect the early universe. The critique of the "detached observer" seems more to address the idea that such detached observation is typical or paradigmatic of human knowledge. Instead of modern science being a supreme example of knowledge — able to peer into distant space and early time — this sheer scale perhaps makes it a very unusual and atypical kind of knowledge, one which is not well-suited for a philosophy of knowledge as a human capacity, part of our practical and interpersonal lives.

Another critique of science — or at least of the philosophical exaltation of science as a kind of supreme knowledge — addresses the scientific preference for reductive analysis, or, more confrontationally, "accuses" science of *reductionism.* In some ways this critique overlaps with a critique of the "detached observer". Reductive analysis tends to find the ultimate causal explanation of observed phenomena on scales which cannot themselves be observed, at least without the intervention of complex machinery whose construction itselved involves detailed theory, so they are not purely observative vehicles — machines like electron microscopes, or, as a paragon example, the Large Hadron Collidor. The scales of electrons or atomic nucleui are as remote from us as are distant times and galaxies, even if objects on those scales are all around (and inside) us: the distance in scale makes the subatomic realm as remote as distances in space and time. We do not "interact" with objects in this realm, at least except as all our interactions have some phyiscal manifestation at this scale, far below our awareness or the reach of our life-world concepts. So, insofar as our world-view embraces the subatomic scale as the ultimate source of all physical causality and mindfulness, and insofar as scientific theory attempts to build models of objects, events, and regularities on this scale, then there seems no role for the scientific obsever except as detached from this realm, metaphorically peering at it through a window. We quite literally cannot observe the subatomic realm as an active participant, in "real time", but instead in a contrived and after-the-fact manner, like analyzing images from bubble chambers. Here we do not observe what is happening, but what has happened, in a highly unique environment designed explicitly to make such observation possible. And observation does not mean just looking at the image, but subjecting it to detailed computational analysis, augmenting the capacity of "visual" observation. There is a very indirect sense, then, in which we can say for example that a Higgs Boson was in fact *observed*; but, nevertheless, I suspect almost all scientists believe that this "observation" was sufficient to perform the epistemic role which the observation was desired to fill, when the collidor was designed: to provide empirical confirmation of the Higgs theory in particular, and more broadly of large parts of the Standard Model of Particle Physics. And while we as observers did not affect the observation in the sense of physically intervening, in a broader sense the (act of) observation itself occurred only by virtue of an apparatus which "we" (more properly, the scientists at CERN) created.

So this "observation" of the Higgs particle provides a good case-study in the "detached" observer (as a metaphysically contested notion), since we, as observers of that Higgs "event", are indeed quite literally detached from the place where the event occurred, separated from it by both time and by a complex weave of computation and technology. We can then ask whether we are, relative to that one event, indeed "detached observers", and whether this casts doubt on the philosphical significance of the observation, or the metaphysical critique of "detachedness", both, or neither? Are we really *detached from* the event, even though the event only occurred because people constructed the possibility of its occurring? Indeed, the LHC may be considered a paradigmatic example of where we are *not* detached observers, since we endeavored to recreate, via technological apparatus, conditions which have not existed since the very early universe. On the other hand, once this machinery was built, it was designed to exclude us from causal interference with the events transpiring in its tunnels. With repsect to the *observation itself*, rather than to the physical surroundings which make the observed event possible, we are at least designed to be dispassionate, external observers. At the very least, the LHC is a case-study in scientific experimentation because it could potentially lend support to very different philosophical intuitions. Further questions may arise from how we philosophically interpret the apparent confirmation of the Higgs's existence. What exactly does the confirmation of this theory tell us, not only about the world on subatomic scales, but about the world as we know it personally and interactively?

The generally reductive world-view of modern science places particular emphasis on theories and explanations of phenomena at the smallest scales — molecular, atomic, subatomic, and even saller scales down to the Plack measures. On the other hand, this does not imply that causal explanations appropriate for these scales exhaust the demands of causal explanations of all phenomena, at all scales. After all, the confirmation of the Higgs Boson does not directly contribute to solving outstanding problems in other areas of science — for example, to reconstruct the earliest living (self-replicating) organisms on Earth. Scientific theories collectively represent a chain of causal explantions which span across scales, so that theoris on the smallest scales — such as the Higgs model — provide a causative *foundation* for higher-scale theories, but not an account of causal relations on those theories' own terms. Causation in the biological realm, for example, needs ultimately to be explained in terms of causation in the chemical realm, which in turn rests on atomic and subatomic theories. Ths causal reduction across scales is closed and completed by theories such as the Higgs mechanism, but the causal-explanatory *work*, the higher-scale explanations which have to be developed and tested, is not itself thereby closed or completed. The translation of causation mechanisms across scales "upward", against the grain of physical or compositional reduction, is as essential for thorough causal explations as are comprehensive theories at the smallest scales.

Reductive analysis, we can say, represents causal *dependence* of higher-scale phenomena and lawfullness on lower-scale mechanism, but not the causal-explanatory *completeness* of small-scale causation in the absence of explanatory and ontological relations established across scales. I think it is worth emphasizing the philosophical connections between causal explanation and theoretical (or inter-theory) reduction, because critiques of a "reductionist" scientific paradigm need to be clear on what role reduction actually plays in the scientific endeavor and world-view. We need to consider, then, the metaphysical motivation behind assumptions such as the "causal dependence of higher-scale phenomena" on the lower scale.

Perhaps the most important assumption underlying modern science is the idea that causal influences only operate through physical manifestations or carriers: two spatially distant objects, for example, can influence each other only insofar as one or the other "emits" some force or particle which can follow a trajectory toward proximity with the second. The causes which can influence the state of a given object, then, are those (and only those) whose physical bearers are or enter into its proximate space. We can refer to this metaphysical doctrine as the *localization of causative influence*, or the Principle of Causal Localization ("PCL"). This principle not only points toward how scientific theories need to identify physical influences which yield their theorized causal relations, but it also serves to distinguish properly scientific ideas from pseudo-science, and from mythical or pre-scientific notions of physical events. For example, a "theory" like Astrology is suspect because there is no clear acount of how astronomoical events or positions can exert a causally salient affect on a young person, based on the date of his or her birth. Similarly, the proposal that biological complexity is evidence for an "intelligent designer" is not widely cited as a properly *scientific* hypothesis, even if it is claimed just as a hypothesis and not a worked-out theory, because we have trouble envisioning how a "designer" could causally influence evolution as it occurs, or have an "intelligence" powerful enough to anticipate future evolution so precisely that the seeds for eventual biological complexity can be designed into the genes of the simplest organisms.

According to the PCL, we should not hypothesize or hope for causal intervention if we cannot provide a compelling account of how the causal dependencies thereby proposed will acquire or become manifest within physical carriers. We cannot, for example, pray for the ball which seems destined for our club's goal to veer off course. Passion for our team may be causally salient in some circumstances — the players can perhaps feed off of our energy when they stream into the attack — but there is no physical medium which could carry our hope for the ball to the sail harmlessly wide, to the ball's proximity. We can identify those forces that *are* potentially causally salient: the goalkeeper's hand, the ball's trajectory and spin, even perhaps the wind, may deflect the ball from its apparent course. But in each case we can select a spatial frame around the moving ball, and recognize that only those causal mechanisms which have physical bearers *inside that frame* have causal salience.

Someone who broadly accepts the PCL can be prepared to qualify it in special circumstances: for example, Quantum effects like entanglement *may* be a cases where PCL fails to hold. A physicist may even allow for paranormal phenomena, like telekinesis. Of course, an apparent violation of PCL in terms of physical influences *known as of now*, with their laws and limitations, may prove to be consistent with PCL in the event that new physical forces or mechanisms are discovered. For example, there may be some fundamental force other than gravity, electromagnetis, and the strong and weak nuclear forces; there may be forces whose carriers may travel faster than light; there may be undiscovered nuances in spatial geometry which shrink apparent distances, etc. So, even if it appears (as with entangled photons) that some causal influence is propagating in non-phyaical ways (e.g., instantaneously or with superluminous velocity), this is not *necessarily* an exception to PCL. But a scientist can believe that the PCL holds for *almost all* natural phenomena, and that those are precisely the phenomena which are subject to scientific explanation, without feeling compelled to presume the doctine that PCL is true everywhere or of necessity.

Insofar as PCL is presumed, at least for all scientifically explainable phenomena, then, I believe, it also diffuses the issue of the "disembodied" observer as an *a priori* metaphysical doctrine. Observation sometimes effects the observed, and sometimes not, depending on whether the apparatus and processes of observation are causally salient in the proximity of the observed. Thie is not a choice between metaphysical positions, but an empirical matter to be settled on a case-by-case basis. It may be that, in some circumstances, the degree to which observation *is* causally salient may itself be controversial. For example, someone may believe that the very fact of medical tests or treatment can have a psychological effect on the patient, which can engeder a causal influence on the patient's symptoms. One's intuitions about such cases may be shaped by a propensity either to anticipate, or to suspect, the effects of observation itself. One may believe, for example, that situations where observation *is* causally salient are more widespread than traditional science recognizes, and that an irrational faith in our general capacity for "value-neutral" observation predisposes scientists to assume observational neutrality, even in situaitons where this should be suspect. But these are matters of shades of degrees of emphasis, not a metaphysical disputation.

If we accept the PCL, then we assume that for each observed phenomenon there is an implicit "frame" which defines a proximity around the observed, through which we can isolate causally salient influences. If PCL is a principle of *localization*, then our choice of observation frames defines *localities* within which we can identify relevant causal factors. The scope and scale of these localities depends on the scale and the time-frame under consideration. A causal influence may not be acting on an observed entity in a given moment, but might be sufficiently proximate that it may have an effect a few moments later, making it relevant to an observation. In other cases, an observation may examine a locality over time, as causal influences enter and then leave its proximity. Some theories involve two different locales which are interrelated — for example, the analysis of solar flares which may affect telecommunications needs to consider both conditions on the sun's surface, which cause flares, and then conditions around machinery which may be affected. Such models however are compound pictures built from two separate models, each focussed on their own location. So, fundamentally, a scientific observation depends on the selection of an observed locale, which allows a theoretical isolation of causal factors inside the locale's frame. In many cases, the observers themselves are assumed to lie outside that frame, and therefore to have no causal bearing; they are neutral, detached, or "disembodied". The details actually observed, however, are nonetheless still dependent on the choice of a frame of observation: the observer does not (in many cases) *interfere* with the observed, but the observation is still to some measure constructed by this localizing choice. This does not necessarily diffuse the critique that science tends to "reify" a dispassionate, detached observer, but it does suggest that scientific observation can be considered against the philosophical backdrop of observation and localization in general, in which the observer does in many cases interact with the observed, because the locale of observation is also a locale or space where the observer acts, moves, and is situated. So before considering observer "neutrality" as a metaphysical issue, it is worth considering the varieties of observation in the context of the observed as well as the lived-in, occupied, situated, and embodied locale.

2 Observation and Embodied Locales

I will refer to a locale as "embodied" if we are actively, corporeally interacting with objects and phenomena also located in its proximity. I will use the term "Observation Locale" to suggest an observed locale, in which we observe from afar, from the future (as with Cosmic Background Radiation, for example), and so forth, so that we can see (or otherwise detect) but not causally influence the observed. Within an embodied locale, we see and observe things around us, but we also physically interact with them. Our disposition to these things therefore expresses a "motor" intentionality, an ability to plan, anticipate, and cognize motor interactions, as well as a visual and cognitive intentionality. As we interact with things, we may touch and move them, so that visual information is extended with tactile, kinaesthetic, and propriocentric perceptions. The combination of visual perception of external objects, tactile sensation of objects and of our own experienced body and limbs, experience of the motion and difficulties as we move things around (lifting heavy objects, for example), and of the positioning and location of our bodies, all synthesizes into a multilayered sensory and (by extension) cognitive image of our surroundings.

The integration of visual, tactile, motive, etc., experiences and intentionality marks a fundamental difference between observation in embodied situations, as opposed to cases where we observe things distant from our physical locations. If I am watching a football match from the stands, then I may have tactile sensations of the seat, the concrete beneath my feet, etc., but these objects have no bearing on the action I watch on the pitch. As I follow the action I do need to move my head and shoulders, so as to remain focussed near where the ball (or a significant player) is located. So even this distant observation depends on physical movement, so as to establish different visual frames according to the present action. But within each frame, my goal is to direct attention at the distant events, positioning my line of sight so that the objects I attend to most selectively (like the ball, or perhaps the striker I see running forward in anticipation of a pass) are also most centered in my visual field. Corporeal movements are involved in the transition between different frames, but they are not part of the sensory manifold relevant to visual interpretation of each individual frame. I am aware of other (e.g. tactile, propriocentric) impressions, but, recognizing that the objects (like the stadium seat) they disclose are not local to objects I attend to visually, I direct attention away from them, and allow them to recede to a dimly noticed experiential "hum".

This bifurcation of the visual and the non-visual, as a sensory expression of the distinction between the locale of my attentive regard and the locale of my corporeal location, is a canonical structure in (what I am calling) "Observation" locales. Contrast this account, then, with the phenomenology of "Embodied" locales, where I do not just push my nonvisual sensations to a semi-conscious background, but where they are actively mixed with visual and cognitive attention. As a visual observer, I position my line of sight so that the objects of most immediate interest are most centered in my visual field. Insofar as "motor intentionality" is also part of my immediate locale, however, this process is complicated by the fact that the most visually centered objects in my environment are also relatively less centered in the spatial area convenient for my grasping and touching objects. The things closest to the reach of my hands and arms lie roughly to my side, below my shoulders; the center of my visual field tends to lie in front of me, and above my shoulders. Of course both my arms and my head have some range of motion, so I can visually attend to objects in my hand, or reach forward to grasp an object I see in front of me. But it is relevant that neither position is the most comfortable for vision or motility. Both my visual and motor field (the range of space in any moemnt which is directly accessible to my contact or grasp) have an implicit measure of visual or motor acuity, respectively. We can theorize this measure as a scalar field distributed over the manifold of our perceptions, and the combination of visual and motor accesibility as a superposition of two different scalar fields.

Objects which lie most central to my visual field, not necessarily in easy reach of my hands, may still be perceived according to potential motor interaction. If I inted to reach out and grasp something, I usually glance at it first, sometimes pausing to visually assess it, forming a plan for my physical movement once this is initiated. Precisely because, when grasping and interacting with objects, often they are not ideally situated relative to my line of sight, is is therefore often necessary to gather visual information beforehand. Suppose I intend to spread a sheet out over a sofa. If the sheet lies covering it partly, and I need to pull the edges further so that they extend past the sofa's corners, then I pause for a few seconds looking at the sofa and the sheet and preparing for how far I should tug the sheet outward. For other motor tasks — like hanging a picture or lifting a sofa up a flight of stairs — I may spend a long time in visual appraisal.

In this case of a sheet and sofa, my pause may be only a few moments, but it is still noticeable. My visual reasoning about the sheet and sofa in relation is not yet mixed with any tactile or motor sensations, but I am nonetheless anticipating my physical movements, and this anticipation structures how the visual impressions are digested.

In particular, when visually attending to the sheet and the sofa I am attending to two surfaces (including the visible, two-dimensional surface of the sofa, which suggests the form of its three-dimensional depth) insofar as they are inter-related. Indeed, although there are occasional circumstances when we look directly through semi-transparent objects (like a glass paper weight, or objects underwater), almost all objects which we perceive are disclosed through their two-dimensional surface, rather than in full three-dimensional depth. Creating a useful schema of our visual surroundings is therefore, predominantly, a matter of identifying relations between distinct surfaces. These relations fall into different categories, such as the topological, geometric, and mereological. Relations such as the sheet covering the sofa, in part or entirely, are *topological* in the sense that they do not depend on their respective, specific three-dimensional geometry. They are also *mereological* because the relations involve parthood — the part of the sofa covered by the sheet, or not covered. These situations, where both mereological and topological relations may be identified, are natural targets for formal simulation in terms of Mereotopology.

Philosophical discussions about the perception of surfaces (assume for here that "surface" refers to two-dimensional surfaces of three-dimensional objects) often refer to concepts related to topology, manifolds, and so forth. Some inter-surface relations are indeed straightforwardly topological, because they do not depend on precise geometrc form: consider the relation of a surface envelloping a different surface (like the sheet over the sofa), or a surface which may be pulled back (the sheet can later be removed), or open up (like unzipping a purse). On the other hand, even as I attend to these *relations*, my actual visual impressions are disclosing and dependent on precise three-dimensional form, albeit perceived relative to the angle and limitation of my view position. Although I may perceive mereotopological *relations*, the fundamental structures of visual perception are three-dimensional surface *geometry*, geometric form which is, in computer simulation, captured by surface triangulations or point-clouds. However, I think the philosophical intuition that surface-perception, in terms of its potential mathematical representations, fundamentally involves *topology*, can be explained in part by the specific *kind* of geometry involved in the shape of surfaces extended in three-space. This is very different from planar geometry, and indeed from most familiar geometric relations. Occasionally real-world objects take on recognizable geometric forms (like spheres and cylinders, for example), and a wide class of objects exhibit some geometric symmetries, which help us to develop a mental image of their structure. Most objects, however, do not have any succinct geometric representation, or have shapes which can be summarized in geometric terms, involving angles, parallel or perpendicular lines or places, symmetries, and so forth. In developing a computer simulation of a sheet draped over a sofa, for example, it will be very hard to derive equations which can calculate the nuanced creases and form of the sheet. The most realistic depiction will almost certainly be built by trial-and-error, and be modelled not through any geometric structures, but simply by listing a very detailed mesh, so that the sheet's surface is subject to fine-grained triangulation.

So as visual perception attends to surface geometry, the actual perceived visual details are influenced by the precise three-dimensional form of objects' extension, and not just topological relations such as a surface covering or partially covering another, or topological transformations which might be caused as we act upon objects (for example, visually anticipating the changes in the sheet's form as we stretch or wave it). On the other hand, the relevant geometry does not typically involve the kind of geometric relations which we may visually identify, involving angles, congruent shapes, etc. Geometric analysis of surfaces can be developed in terms of vector fields defined across a surface manifold, such as "principle direction vectors" which provide a quantitative picture of surface shape. But these quantitative details simply restate the visual impressions which are already implicit in perception; they do not provide a straightforward geometric simplification or schematization of objects' shape. It is this inscrutibility of (typical) three-dimensional geometry to geometric simplification, which perhaps underlies the philosophical intuition that surface perception is fundamentally *topological*. But despite the lack of obvious "geometric" simplification, the fact that we may anticipate touching, moving, and otherwise interacting with objects and their surfaces provides an alternative vehicle for cognitively interpreting surface form. We perceive surfaces not just as visual data, but as loci potentially subject, as we can anticipate, to motor interaction and the expected tactile and kinaesthetic sensations which this will involve.

So when we see the visual shape of the sheet lying on the sofa, for example, we anticipate the act of pulling on its corners, and the expected change in its shape and spread as well as the sensations of its responding to our movements. These motor anticipations provide an alternative framework for making sense of the objects' form. To figure the contrast between visual perception on its own terms and this visual anticipation of motor involvement, consider the contrast between a three-dimensional graphic engines' rendering of the sheet, via a triangulation mesh, and how a robot might be programmed to perform the act of pulling the sheet over the sofa, the same act which we are (hypoethetically) contemplating. We can suppose that a robot has extensions like arms, fingers, and wrists, designed with a range of movement to simulate human motor capacities. Each angular position of the gears through which these appendages rotate, then, represents one point in the robot's configuration space. A coordinated action of extending an arm, turning a wrist, moving fingers, etc., is therefore a path in this configuration space. So the particular movements needed to grasp the sheet's corners and pull them outward, for example, represents one sequence of configurations. A different sequence may be involved in smoothing a robotic "hand" over the sheet's surface, both feeling and smoothing out the sheet's surface geometry. So while the sheet's surface shape can be modelled in terms of three-dimensional triangulation, the configuration path, through which the shape may be retraced by a robotic hand or finger, is an alternative "encoding" of the sheet's geometry. If a robot is to coordinate visual and tactile judgments, then both of these representations may be needed. By analogy, when we visually appraise the sheet's form in anticipation of grasping and smoothing it, we are implictly translating the three-dimensional coordinates of our visual manifold into a "tactile" coordinate space, defined by the range of movement in our arms, elbows, wrist, hand, and fingers, etc., defining different ways in which the sheet once grasped may be moved by us.

Because most of our interaction with objects involves both seeing and touching or handling them, the "coordinates" of perceptual space involve spatial locations, relative to our line of sight and the center of our visual field, and also the coordinates of our possible motor positions in anticipation of handling things, and of coordinated, extended activity in which things are moved in specific ways. Furthermore, the visual field alone, even in the absence of these "tactile" coordinates, is not a simple geometric grid, like a bitmap photograph. The clarity and discrimination of objects, as well as our sense of vihsual depth, is maximized at the center of our visual field and less precise around the edges. So even the spatial axes of our visual field alone are "convoluted" by dimensions representing varying degrees of attention and discrimination. If we then consider "motor intentionality" as well, this system of dimensions is still more complex. Our appraisal of space around us is not the direct three "axes" of geometric space, but a complex superposition of cognitive and sensory parameters which inbue each point in perceived space with different degrees of attention and salience, alongside whatever sensory contents are actually disclosed there.

Almost all of our visual and tactile experience of environing things is an experience of surfaces, and a perception of their specific extensional form or "spatiation" through their geometry in three-space. Our directly perceived image of spatial form is shaped by our position relative to objects, so the dimensional structure of perceptual coordinates reflects how both our visual and our tactile or kinaesthetic field have a center and a periphery. Insofar as we progress from direct sensory perceptions to a broader cognitive map of our environment, we tend to account for this perspectival specificity, not in perception as experienced, but in the further cognitive representations which we form as we plan, anticipate, and reason about our surroundings. When we walk toward and around a table to take a particular seat, our mental orientation toward the table, toward *the table* as the referent of the idea of "the table" insofar as we consciously intend to carry out these actions, this referent is not the specific *part* of the table disclosed in any momentary visual perception. Our motor intentions (both in the sense of *intentionality* and in the sense of intending-to-act) implicitly refer beyond the part of the table seen, to the part around the other side, which we *will* see as we move toward our chair. Already the table, then, exists in two different registers: as an immediate perceptual content and as a more complete, cognized entity, in which the entity seen is extended with anticipations and cognitive models of its whole form. The "unseen" parts have a cognitive presence in my thoughts and intentions, though this is less fine-grained, less precise then the explicit presentation of spatial form which is available to me among the parts which I do see directly. We can also consider reasoning where the intended object is not currently present at all in my current perception: if I am in another room, say, thinking about in a few minute's time walking into a dining room and taking my seat.

I have used the term "embodied locale" to express places where we directly, physically interact with objects immediately around us. Everyday reasoning and activity (in contrast to the atypical cognitive and percptual structures involved in science) is often engaged with our surroundings in this active, embodied way. But it is just as fundamental to real-life reasoning that we do not engage only with our immediately present locales, but with others which are related or nearby to them. We contemplate walking to another room, getting on a bus to visit someone, going for a walk outdoors. The objects in those other locales are not present for us with full geometric clarity, but they do exist as singular concepts in a mental structure of planning and intentions. Just as the parts of the table seen and also unseen can be extended and unified into a singular, conceptual whole, so we assign concepts to things that we do not perceive at all, in the moment, but which we will engage at some expected time later on. This kind of situational reasoning is just as real and concrete for us as the "emnodied" reason of motor intentionality. So our real-life, day-to-day phenomenology needs to attend both to the embodied structures of interacting with objects, where their surface and geometry is explicit for us in fine-grained visual and tactile detail, and equally with situational reasoning in which we anticipate operating within locales, even when they are not sensorially present. The mental image of locales involved in this latter, situational planning is more schematic and coarse-grained; we generally do not form detailed imaginary representations of surface geometry, but cognize objects through the prism of concepts and conceptual relations. We reason situationally about the table, not as this brown expanse before me, but as a referent of the concept "this table", as a token of the table-type, as a node in a network of connections, such as who is seated, who is seated next to exach other, etc.

Alongside the idea of "embodied locales", then, I would like to introduce a concept of Situational ot "Graphed" locales, which are not necessarily perceptually present, but which are reasoned through the structures of cognitive schema and conceptual relations. Objects in these locales tend to be thought not through fine-grained perceptual representations, but through concept tokens and relations, so that situations broadly conceived can be simulated in terms of formal systems which highlight conceptual relations, like Conceptual Graph Semantics. In many cases we form both Situational and Embodied representations of our immediately surrounding locales, but we may also have our minds on other, anticapated or imagined locales. Within our immediate surroundings, the structures of situational locales — highlighting conceptual relations and schema — and those of embodied perception and motor intentionality, whose immanent structures are fine-grained awareness of surface geometry and sensory presentation, are synthesized. With this distinction and further synthesis then introduced as theorized, I now want to consider how this account of "locales", involving both embodied and situational reasoning, can shed light on the cognitive foundations of science.

3 Locale Phenomenology and Scientific Reason

Our embodied cognition, of embodied locales, includes awareness not only of how we can affect — move, cause changes in — things around us, but also the affective latencies which those things have upon us and upon each other. We recognize our immediate locales as traversed by actual or potential lines of force and movement. We have both sensory and conceptual familiarity with notions of force and energy, with the effect which moving things can have on other things, or the effort involved in causing movement. For example, we have all had experiences such as catching a ball, where we need to brace for its impact and coordinate the movement of our hands and arms, so that we can absorb the ball's impact while keeping hold of it. We have had experience of struggling to lift a heavy object. As we become familiar with scientific notions like force and energy, these experiences provide a repository of concrete impressions which help to clarify and focus the semantics of these scientific posits in our minds.

This embodied, concrete experience cannot be excluded from our account of scientific foundations. Science fundamentally recognizes, for example, the difference between two objects which happen to move in such a manner that the first contacts the second, comes to a stop, and the second one then moves, from situations where the former's momentum *causes* the latter's movement. But what is the *conceptual* evidence for this distinction of mechanical correlation from mechanical causation? We often cannot visually distinguish between mere coordinated movement (within some machinery, for example), and a physical transfer of momentum between objects, as an example of causal influence. We cannot *see* a physical influence spreading between two objects. This distinction is therefore not one which is conceptually grounded on visual evidence or the structure of visual perception alone. However, we have *felt* instances of transfer of force or momentum; experiential episodes like catching a ball, and noting the feel of its momentum with our hands and arms, provide a perceptual grounding *apart from the visual* which can animate our concepts of force or energy.

So, even in cases where we act as a "disembodied observer" far removed from the locale being observed, the *concepts* through which we interpret our observations are often informed by our embodied interaction with objects. If we observe a collision of two galaxies, for example, we may see merely a light show magnified by telescopes; but we conceptualize this event by analogy with collisions we see between objects around us, and indeed by our sense of the force of contact for which we have direct tactile and kinaesthetic impressions. Concepts like force or energy are not abstract constructs, imposed upon observed structures in phenomena like mathematical constants or regularities: we have *direct perceptual acquaintance* with certain tokens of force or energy, isolated, framed, and recognized as distinct impressions within the totality of our conscious experiences in the relevant moments. We have direct intuition, then, that notions like "force" are not abstract posits, but are rather empirically grounded, spatiotemporally located tokens of physical influence which have a givenness or "thereness" akin to physical objects. Similarly, we understand that tokens of physical influence are situated within locales along with (and potentially causing changes in) their objects.

Embodied experience not only provides us with conscious impressions of the causal efficacy of tokens of physical influence, but also of the causal *dependence* of physical changes on such influences. We have direct experience not only of the *presence* of causal influences affecting us, but also of their *absence*. We are aware that we can acquire knowledge, for example, only by situating ourselves so that the relevant information has some medium for communication to my vicinity. If I want to know what color are the Petronas Towers, I can fly to Kuala Lampur, or look at a photograph, or perhaps read the comments in an architectural magazine. But I cannot expect to close my eyes and simply have this information pop into my head, as if I had once known the relevant fact and simply needed to remember it. If I rely on an architectural critic or a photograph, then clearly *they* have seen the towers in person, so their direct acquaintance is proxy for my actually positioning myself before the towers (after flying to Malaysia). Fundamentally, then, the only way to acquire information about someting is to situate myself in its proximity, for a suitable definition of "proximate" given the object in question, or to defer to the testimony of someone else who has done so. In the case of a visible supernova in the night sky, "proximity" here may span across galaxies, but the point is that I must occupy a point of observation where physical influences bearing information about my intended object are accessible to my locale.

Even when we observe locales from afar, then, we interpret what we observe through concepts forged from our experience of locales which we directly occupy.

Our experience of embodied locales provides us with an innate sense of physical "normalcy" and we are attuned to explanations which conform to that sense, or seek explanations for cases which seem to violate it. When we observe a stationary object suddenly start to move, we naturally assume that some force has caused this movement. In some cases we can see a different object causing this force, or explain it in terms of something natural but unseen, like a gust of wind. Physical movements which seem hard to attribute to any causative force — like an object lifting straight up off a table, or something seemingly blown by a gust of wind but in an apparently sealed room — can sometimes be created or simulated with scientific experiments or optical illusions. Such situations strike us as unnatural and uncanny. In addition, similarly to how we interpret the play of forces within an observed locale, we also have an implicit understanding of the media through which information about that locale is communicated to ours. This transfer of information also has an implicit structure, which can seem unnatural or uncanny when it appears to be broken. Suppose, for example, that I have a dream about some unfamiliar travel destination just before I depart, and when arriving I find some things eerily similar to what I dreamt. Such foreshadowing — similar to the experience of "*déja vu*" — would probably strike me as uncanny, even disturbing.

Certain basic assumptions about the physical world, then, are systematized in scientific theories, but originate with instinctive assumptions we make about our everyday environments. These include, in particular, the principle that causal efficacy depends on a physical carrier, and the principle that information can be transferred between locales only through a physical medium. In particular, this perspective connects the general notions of *causal influence*, *information*, and *physical influence*, representing tokens of physical influence as bearers of both information and causation, and the latter two as existing only via their tokenized (spatiotemporally located and delimited) physical manifestations. This interconnected structure of concepts and assumptions lays the foundation for what qualifies as properly *scientific* theory and explanation, but it originates, I believe, in embodied interaction with the world.

The scientific emphasis on reductive explanation, also, I believe can be traced to this conceptual structuration of our physical intuitions. Insofar as causal influence depends on (spatiotemporally located and delimited) physical influence, the causal factors affecting any state of affairs need to be identified, if they are to be identified at all, by attending to the particular locales where their physical carriers are situated. A thorough scientific explanation depends not only on building a plausible causative account of why some phenomenon or observation appears as such, or even testing this account empirically. It depends on actually developing a space-time localized picture of the physical bearers of the causal factors being proposed. For example, Darwin's theory of evolution provided a plausible account of how biological diversity can emerge, in terms of causal factors related to Natural Selection and the possibility of traits being passed between species generations. This theory can indeed be tested — e.g., breeding rabbits or fruit flies in a controlled experiment — but Evolution did not mature into a modern scientific account until the empirical evidence was extended with the theory of genetics, mutations, and DNA. Clarifying the molecular structure of DNA, and DNA's role in passing traits between generations, allowed scientists to focus an explanatory lens on the actual physical locales where the causal structure of Evolurion as theory becomes manifest. In particular, we can identify the chemical bonds within the DNA molecule as sites where mutations can occur, and by extension where evolution and biodiversity can emerge.

Scientific explanation tends toward reductive analysis because effective *physically grounded* causal accounts tend to require focussing in on locales at a high scale of resolution. We have plenty of empirical evidence, for example, that the traits of parents are inherited by their offspring. However, just looking at parents and children does not give us a picture of what causal influences actually effectuate this relationship. Biologists did propose the existence of some physical medium transferred between parents and offsprint — anticipating the modern genetic theory — but it was only by identifying the DNA molecule inside each cell, modelling its splitting and recombination, and explaining at a molecular level how the traits of parents are combined and passed on during conception, that scientists began to have a convincing picture of the *physical carriers* of genetic causative structures. This account needed a theory scaled to the contents of the inside of cells, and, still more fine-grained, to the molecular structure of DNA and RNA molecules. It is only these scales that the observed higher-scale causal processes can be given an effective physically localized account.

Some accounts of causal influence can be relatively coarse-grained but still plausible as physically grounded explanations. For example, the basic mechanical principles of levers or billiard balls can be visualized in a rather coarse-grained way by considering, for example, a cue ball's kinetic energy as a singular force imparted to a target. We can, of course, look at this momentum at a finer scale, theorizing the molecular bonds which create a repulsive force between the two balls in contact. But an accurate equation can describe the balls' movement in which any inner structuration of the balls is excluded; and moreover this equation will provide a formal representation of our physical intuitions, based not only on our seeing of objects in motion but on our embodied experience of objects in our proximity. This is a specialized case, however, where our physical intuitions can carry over to scientific explanations on a high-level scale. In most cases of causal explanation (such as the inheritance of genetic traits), identifying the properly *physical* mechanisms demands analysis on a scale which is not characteristic of our everyday "lifeworld". Physical intuition is still relevant in an analogical, as-if fashion: we can imagine the structure of the DNA molecules, for example, as if its component pieces were billiard balls linked by chemical bond threads. But such analogies are cognitive tools to help us visualize unfamiliar scales and domains: we need be aware of their provisionality and limitations, and by therefore "bracketing" our visualizations we comport ourselves to these domains via a fundamentally different attitude than when we scientifically analyze larger-scale objects, like billiard balls or rockets. Because most analyzable causal influence is borne by carriers localized to spatial frames at a high resolution (relative to our everyday world), these locales are not directly perceivable or intuitive; as a result, reductive analysis, which honors the need for physical localization of causative factors, also creates a conceptual gap between our life-world and the conceptual world of most scientific theories.

Our physical intuitions are shaped by embodied experience in *our own* locales, but we tend to project them outward to the locales of other people and other phenomena, — across scales, as just suggested, and also across time and space. This involves projecting structures and limitations of information transfer as well as of causal influence. We believe, for example, that a person in one room cannot see or hear what transpires in a different room. We believe, that is, that information cannot spread between rooms without some window or some means of communication between them. Such anticipation of what other people will or will not know, based on our estimation of what information streams have trajectories toward their locale, is essential to our social world and to intersubjective cognition. We also anticipate physical influences in proximity of other people; we call to get peoples' attention when a baseball, for example, flies toward the stands. Just as we can project experiences and structures of information and of causal influence from our own locales to those of other people, we also project them to distant and unfamiliar times, places, and scales. Our familiar environing locales provide analogies and criteria of explanatory coherence which help us cognize objects, phenomena, and theories within and concerning locales far removed from the life-world.

If this is true, then, we can consider whether this embodied and life-world foundation of physical intuitions reinforces or counter-critiques the phiosophical claim that traditional science neglects "embodiment" or represents scientific understanding, at least in its idealized essence, as the cognition of a detached, disembodied observer. On the one hand, we can argue that "embodied reason" is latent in scientific understanding and plays a role in how science is taught and conceptualized, even if the origins of scientific intuitions are not themselves systematically developed in the course of scientific theorizing or model-building. On the other hand, we can also say that scientific observation in its essence draws intuitions from everyday situations but then passes beyond them, so the "embodied" source of scientific intuitions only becomes true scientific understanding insofar as these intuitions are formalized such that their embodied familiarity gives way to mathematical abstraction and conceptual formalization. The question is whether this balance between the roles of embodiment and abstraction — intuitions whose embodied sources provide an initial structure of concepts, but whose structure is then formalized and extended so that the structural organizaiton of scientific concepts, not their intuitive sources, are the crucial cognitive factors in understanding a scientific theory — the question of whether this means that some notion of embodiment has always been latent in scientific understanding and therefore critiques of "disembodied" science are misplaced, or whether, conversely, science has neglected to properly acknowledge its own intuitive foundations.

So this account of Embodied Locales, and their role in scientific intuitions, has elements which can support both a critique and a counter-critique of "traditional science". I will now consider in a little more detail how abstract scientific reason, in which intuitions drawn from embodied locales are extended and systematized but also somewhat "defamiliarized", translated into mathematical or technical forms, can be compared to a kind of engaged activity where embodiment and motor intentionality remains directly involved.

4 Embodiment and Scientific Reasoning

There is certainly a cognitive and phenomenological difference between a *scientific* or *theoretical* understanding of some domain, from a physically active, motor-intentional, practical know-how. These can coexist with respect to the same domain. The pianist who performs an arpeggio, the chef preparing a recipe, the gardner tending to a plant, and the veterinarian soothing a wounded animal, are each mobilizing a "motile" know-how which includes, but is not limited to, a "theoretic" conceptual presentation. The music critic who understand the arpeggio's place in a harmonic scheme, the chemist who can explain the recipe's flavor and nutrition, the botanist who identifies the plant's classification, and the expert in an animal's biology, are each engrossed in cognitive orientation toward the same phenomena as the practitioners just mentioned. But the crucial faculties of the more theoretic practitioners are to maintaing linguistic and attentional structures in which concepts are assigned specific sites in a theoretical order, and in which conceptual relations are marshalled to present causitive connections, correlations, mereological relations amongst theoretical entities, and so forth. The highlights of theoretical reasoning are specialized concepts which are defined and isolated in cognitive schema, and identified within theoretically meaningful relations. These conceptual structures play a role in more operational know-how as well, but our comportment to phenomena in a more practical vein centralizes less the cognitive isolation of concepts as abstract intentions which we know ourselves to be contemplating in the moment, but rather intentional relations (including motor intentions) to phenomena in which these conceptual structures play more of a regulative, rather than a cognitively isolated, role.

For example, the pianist about to play — or practicing — an e-minor arpeggio may have a theoretical understanding of its place in a compositions harmonic progression, but this understanding is important as a guide, a motivation toward a certain expressiveness and articulation of performance. The music theorist, by contrast, who analyzes the arpeggio's harmonic signifance, will have a more detailed structural picture of harmonic relations. Imagine the arpeggio as an extended modulation to a melodic theme in F-Major. The theorist will understand this structure as a conceptual relationship, once suited for example for a graph-type representation, with the arpeggio and the melody serving as concept-tokens, connected by a relationship type drawn from musical theory, such as how arpeggios can act as harmonic bridges to a melodic opening. The music theorist's mental attitudes when considering this structure will foreground the conceptual isolation of these elements — the arpeggio, the melody, and the harmonic bridge relation they exemplify. She may not necessarily entertain a *visual* picture of this structure, with the various concepts individuated as visually imagined "nodes"; nor would she necessarily rely on a graphical indication of the structure, such as a Shenkerian chart, which would be a kind of schematic summary of the musical form written on staves with a notation similar to musical notes. She may of course use such facilities, but what is important is that the concept-tokens have an attentional clarity *akin to* the clarity focussed through visual or graphical icons. The concepts must stand in her awareness with a kind of *attentional iconicity*, a kind of primordial awareness of thinking *of them specifically* as distinct conceptual entities, with an isolation and individuality comparable to that which accompanies concepts represented through visual or graphical icons.

All of this differs, furthermore, from the stance of this same conceptual musical structure as it is disclosed in the comportment of the pianist who actually performs the sequence. He may well understand the theoretical details, but the individuation of the musical elements *as concepts* is not foregrounded for him. There is not the same inner awareness of these conceptual tokens as occupying his thoughts. As he is about the perform the arpeggio, for example, he may for a very brief moment turn his thoughts to the conceptual representation of the arpeggio as an element in a musical structure, but he must very quickly pass his attention beyond this purely structural representation; he is not trying to hold these concepts in his abstract awareness as sites within a structural organization. Instead, his attention is more fine-grained; he comports himself to the arpeggio not as a structural site but as a sequence of fine motor operations to be performed; he passed over the arpeggio as a conceptual singularity and reorients himself toward it as internally structured, as an operational episode, one which provides a rule for the motor activity he will enact in the next few seconds. The conceptual form of the musical structure serves for him as a regulative principle, not as a relational form whose components parts are to be attentionally singled out and held for further reflection, even if understanding this relation theoretically can help him apply expressive nuance to the musical sequence which embodies the form.

The pianist and the theorist are experiencing the same phenomena — the same musical sequence and structure — but they bring to bear fundamentally different attentional attitudes. For that matter, the music critic evaluating both the pianist's and the composer's work, and the listener simply enjoying the music, are also comported to the same phenomena, but with still further variations in how their experiences are simultaneously lived through and interpreted. As an analogy to science, the pianist's motile and operational know-how, theoretically informed but not primarily constituted by cognitive self-presentation of theoretical-conceptual structures, is analogous to an active, engaged scientific knowledge, like the botanical knowledge of a gardner, or the astronomical knowledge of a navigator. The music theorist's conceptualization, more directd toward conceptual structures as objects of thought in their own right, is better analogous to the theoretical stance of most modern science. Since the same phenomena can be disclosed to people in these different modalities, we do not need to metaphysically prioritize one or the other; both contemplative and engaged science are phenomenologically grounded in how we experience the world.

Nonetheless, even if we accept as a philosphical doctrine the phenomenological equiprimordiality of "engaged" and "contemplative" science, there is still a possibility that a cultural or academic community *in practice* will value one above the other. The knowledge of the botanist or biologist may be considered more respect-worthy, and be more lucrative, then the knowledge of the gardner or veterinarian. The same academic institution whose philosophers argue against "disengaged" science could reject the application of a noncredentialed (even if in person highly articulate) gardner to teach botany. A college drop-out who founds his own theater may find it harder to get teaching positions than a recent graduate from a doctoral program, even if the former's theoretical competence, manifest not in published papers but in the considered staging of actual plays, equals or surpasses the latters'. This is not intended to critique academic emphasis on theoretical investigation for its own sake — practical knowledge of a community as a whole needs to be grounded in theory, and academic institutions play a role precisely of nurturing theoretical investigations during formative periods where their practical applications are still emerging. Nor do I ignore the occasional mathematician or computer scientist who ascends to an academic career via unlikely routes, like a Ramanujan, or a programmer whose catches the attention of an academic department with an impressive "app". Such cases, however, are the exception, rather than the rule.

But I do not want to focus on these trends in the prestige or economics of scientific knowledge, as sociological phenomena. The important *philosophical* question is how phenomena in different modes of presentation — more theoretical or more active and operational — are interrelated, both in terms of their contents, and, considering that given phenomena may be disclosed in different ways for different people and different contexts, how these modes or presentation relate to one another. I think we can argue that the more theoretic mode of presentation became more philsoophically important — as the kind of orientation to phenomena which is identified as on the path to legitimate scientific knowledge — as a cultural and historical trend coinciding with the rise of modern science. This does not necessarily mean that scientists believe that the theoretical mode of presentation gives them *truer* or *deeper* insight into reality, but it does mean that a certain inner awareness of entering a theoretic stance viz-a-viz observed locales is a self-affirmation of entering the cognitive modality of scientific reasoning. We can accept that the contents of scientific reason, as it produces well-substantiated and tested theories, are universal and transcend particular cultural and historical norms, while simultaneously considering that the psychological dispositions, from which the cloth of scientific reason are cut, have come to prominence in a historicized and culturally localized way.

When exploring the "embodied" foundations of scientific intuitions, it is important to emphasize that, at least in my opinion, the experiential stance this involves is best comparable neither (continuing my example) to the pianist, nor to the music theorist. If we integrate another example I have mentioned — catching a ball — then this latter episode does involve some motor skill (like the pianist performing), but my discussion emphasized the affective feel of the ball's energy. This is an embodied experience, but it is an experience centered on a bodily, somatic sense-datum, which has a spatial and temporal articulation comparable to the kind of individuation which visual percepts hold in a visual manifold, though within different dimensions. This is fundamentally distinct from the embodied, motor skill of the piantist executing the arpeggio; for her, haptic sensations like the touch of the piano keys are relevant, but the chief attentional structure concerns the performance as a carefully executed sequence of actions. For the pianist, the body is a locus of action and planning; for the thinker reflecting on the sensation of catching a ball, the body is considered in the guise of a locus of primordial qualia. On the other hand, givens like the experiential quality of the ball's force are not akin to the conceptual tokens which form the basis of the theorist's mental image of the music's form. The ball's force has a comparable individuation, but it is not the cognitive-attentional iconicity of a thematized site within a structural organization, even insofar as this site is associated with a sensorially presented impression; it is rather a more primordial, somatic iconicity of the world unfolding its affects upon me. If anything, the stance of the proto-scientist who feels in the ball's force an experiential indicator of a scientific notion like momentum, may be best comparable to that of the listener who simply enjoys the music — who enjoys the pleasant affects of rich harmonies and melodic embellishments as sensory things happening to her.

My brief analysis of "Locale Phenomenology" suggested that our observing and interacting with embodied locales lays the foundation for "physical intuitions", which are then mobilized and formalized into scientific reasoning. These intuitions construct, in particular, the conceptual relations between causation, information, and physical influences; these three notions unified into a triad where physical influences carry both causal agency and information content. This triad then provides an explanatory matrix through which locales large and small, and near and far, are observed. The structural interconnection of this "CIPI" (causation-information-physical influence) triad originates, as an intuition about how physical reality is structured, from our embodied interaction with our surroundings. Insofar as science gathers these intuitions into a world-view, into an account of legitimate world-explanation, science nevertheless removes them from their everyday familiarity and reintroduces them as a formal system. Accepting the scientific criteria of explanatory warrant therefore demands that people both accept CIPI as a legitimate restriction on what kinds of physical phenomena and causations can (perhaps with some exotic exceptions) exist; and also be able to reflect on their own experiences, their own CIPI intuitions, and mine their everyday experience for concepts to be hardened into fundamental scientific maxims. This is not only a question of self-reflection, of a willingness to generalize from familiar, everyday observations to distant locales of space, time, and scale. It is a particular *kind* of self-reflection, a particular *kind* of attending to the contents of one's experience so as to extract generalized, relational schema. I will now explore this process in greater detail.

5 Affectivity and Self-Reflection

Consider the kinds of experiential episodes which provide intuitive insights into the semantics of concepts like momentum and kinetic energy — experiences such as my catching a hard-hit baseball. These experiences become generalized to scientific notions not only by remembering the *correlation* between the contact of the ball and the subsequent sensation in my arms and hands, and not only even by the self-conscious awareness of the ball as seeming to cause the resulting sensation. The most important experiential detail for subsequent generalization is that the inventory of sensory and perceptual contents includes not only the ball as a perceived object, but the *force* of the ball as ontologically *distinct from* the ball. The ball can be seen; it has a visual and also a tactile form, because I can feel its shape as I hold it after catching. But in the moment (or the very brief episode) of my catching the ball, I am distinctly aware of a sensation of force communicated from the ball to my hands and onward, which is different from the tactile feel (or indeed the visual presentation) of the ball before and after. This force, this physical influence as a discrete entity with its particular trajectory and temporal rise and fall, this token of physical influence is disclosed as a worldly thing different from the ball, even if it is carried by the ball and through the ball's kinetic energy. The experience of this influence is very immediate and vivid; it resides in my experience, in the moment as it is experienced, as a raw affective presence, one involved with a mesh of conceptual relations — I experience this content in the course, and because, of catching the ball — but this affect does not have a ready conceptual identification of its own.

I cannot name its concept-type with an idea like "baseball", and it does not have a visual form. There are not the familiar vehicles of language, categorization, shape, etc., which can conceptually summarize or iconify the distinct affective content which is the ball's momentum as felt in my hand. This raw affective presence seems to cut through the conceptual descriptivity of the world and to peer down into its deeper causative structures, and into physical reality, the nature of physical being itself.

This affective influence — highly *subjective* precisely because it does not have the kind of compact conceptual expression that could communicate it between subjects — is nevertheless, as if paradoxically, highly *objective* because it seems to disclose objectivity itself, the raw presence which tags *objectivity* as such as the foundational character of the objective. This interplay of the objective and the subjective — the two woven together, like dialectical threads — this fusion lays the foundation for scientific reason, I believe, because it prepares consciousness to frame in its own experience not only the observed regularities of the world but also a notion of its underlying causal mechanisms. But the historical context which allowed people's self-awareness to be marshalled in this paradigm-forming manner, preparing the scaffold of comportment to the world as science sees it, this context is manifest not only in science, but also elsewhere in the arts and culture. We can see this in the literary and musical exploration of the psychological, in the Romantic period, for example. We can also see this in the visual arts, such as landscape painting, in which the emphasis shifts from realistically depicting nature to recreating the affective feel of the scene within the canvas, as it would have been felt, through the different senses, to someone situated right there at the moment which the painting depicts. Coloration, brushwork, large-scale canvas structure, etc., seem designed to impart not only the visual content but the embodied feel of the scene; if a painting depicts a dark, damp evening, then through the manner of depicting the low-level foreground ground or foliage we can almost feel the cold wetness of the leaves we brush against, or the biting wind. The landscape depicts not only visual form, but, indirectly and allusively, the primordial affective presences of cold and wind, or in other contexts — paintings of a furnace-blower, for example — the heat and fire. The representation of the world suggested by this style is not the world as a collection of states of affairs, but the world as an aggregate of locales each permeated by a primordial *presence*, this presence disclosing itself to consciousness through the raw affective form of heat and cold, pressure and the distinct sense of objects' movement against us, embodiment and the vulnerability of our bodies to outside forces. The distinct cultural form, which seemed to have arisen in 19th-century Europe with specific clarity and weight, was the recognition of our capacity to reflect *on* this affectivity, to iconify tokens of affective presence through the medium of aesthetic expression, but also to thematize the vehicles of affective influences as presentations of primordial physical reality, as a cognitive window onto world at that level of reality where we can focus on underlying causative structures, not just the conceptual categories and states of affiars which those causative mechanisms have engendered.

To refine this account of the *experiential* origins of scientific reasoning, then, it is useful to distinguish the *epistemic* states of a conscious self from our *affective* states. If we walk through a cold, windy, moonlit night, we entertain several propositions — that the white crescent in the sky is the moon, that the temperature is cold, that a gust of wind just blew. We also have various affective experiences in which external conditions — or at least what phenomenally appears to us as external conditions — cause affective contents tokenized in our consciousness: the chill, the wind force, the sensation of white against black. The presentation of the affects and the rise of my belief-dispositions occur in the same conscious events, but they are not the same conscious contents: my experience of wind force, isolated as a mentally referenceable (rememberable, subject to reflection like comparing the feel of wind gusts of different force at different times, etc.) element of consciousness, is not the same as my experience of believing that it is windy. Affective and epistemic states are interrelated, but a state of consciousness includes (a set of) affective states and, apart from that, (a set of) epistemic states. This distinction between affective and epistemic states is not always made in theories of consciousness and cognition. One could argue that Western culture and philosophy was not prepared to make this distinction in full clarity before, perhaps, the 19th century, and only then could it be marshalled for a thought not only of human subjectivity but of the ontological possibility of science as well. This is not to say that scientific *theories* are historicized, but that the cultural context in which people who believe themselves to accept the scientific world-view make the ideational association between their affective consciousness — their self-understanding as beings whose inner notion of self is foundationally associated with having and being aware of having affective experiences — and, on the other hand, their self-understanding as having scientific (or scientificially motivated and warranted) beliefs: the interweaving of these two aspects of self-understanding is historically contextualized. I also believe that this dimension or "structure" of self-understanding is an important part of how science, in the modern world, is understood both to present an account of how the world is and as a cognitive realm and paradigm.

The interconnection of affective and epistemic states suggests that there are "higher-order" states in which these are layered: epistemic states of believing oneself to be or to have been in such-and-such an affective state; the affective state of believing oneself to know something, as a distinct qualitative mode of consciousness; the epistemic state of believing that the red-affect of an apple discloses predicative information that the apple is red, etc. I do not intend to minimize the ontological and conceptual hurdles involved in clarifying the sorts of entities and related ontological infrastructure needed to give a philosophically well-defensible account of this collection of types of states; but I pass over this here only because it lies beyond the scope of this paper. I *will* suggest that a comprehensive treatment of the ontological foundations involved here may benefit from Semantic Web style Ontological Modelling as well as conventional philosophical-ontological analysis. Leaving this for future work, however, let me here focus on the claim I am emphasizing in this context: that the ontological structure of *affective* states, including its structural contrast to that of epistemic states, has — in the modern world — a paradigmatic role in defining the boundaries of proper scientific explanation.

In particular, affective and epistemic states have different temporal structures. If an epistemic state is believing that the moon is visible, then the temporal boundaries of my entering into and leaving this state are less crisp than the affective state of seeing the white moon. The onset of these states may coincide, because epistemic and affective states can interleave — so when I affectively experience the white moon I also believe that the moon is visible tonight, and moreover that I am having the experience of seeing the moon (and not dreaming, etc.). Affective states, with crisp temporal boundaries, may therefore engender similarly crisp-bounded epistemic states, but in other cases epistemic-state time boundaries may be fuzzier. When do I pass into the state of no longer believing that the moon is visible — when I wake up the next morning? What about the state of remembering how the moon looked last night? The contrast in temporal structure between affective and epistemic states higlights how the former are the base-layer means of my acquiring information about the world, and the latter are a superordinate layer in which information is processed and retained. The temporal boundedness — and also spatial directionality, since for example I see colors in specific places, or feel and hear a gust of wind from a specific direction — is consistent with the assumption that affective states are manifestations of physical influences affecting me, since phyiscal influences (according to the CIPI paradigm) are information-bearers and are spatiotemporally localized. This structural impossibility is not expressed by the temporal form of epistemic states, but it *is* implicit the form of affective states which are assumed to provide all epistemic states that concern empirical content.

The affective epistemic distinction, and its associated time-structure contrast, is not self-evident; it appears that reasonable argumentation, such as that of Daniel Dennett, can dispute it. Dennett presents a self-consistent account, in particular, where affective states do not have this contrast in temporal structure with epistemic states that I have suggested. Dennett's arguments, adapted to the terminology and claims I am presenting here, seems summarizable as saying that affective states are interwoven with epistemic states such as believing oneself to be in an affective state, and remembering having been in that state — *and moreover that it is Ontologically problemmatic* to assert that the original affective state exists *apart from* these epistemic-state "wrappers". In other words, we do not have (temporally crisp) affective states as distint ontological entities, but merely their packaging into epistemic states which, as such, have imprecise temporal boundaries. As a result, we do not have a good metaphysical basis for distinguishing knowledge acquired by affective tokens and knowledge provided us by (some equivalent of) divine fiat. On this argument, the structure of affective states cannot provide a basis for scientific or CIPI-paradigms laying the boundaries of scientific explanations, or demarcating the set of scientifically possible worlds, in contrast to brain-in-a-vat or divine-intervention scenarios. I do not deny that such counter-arguments are metaphysically defensible; my point is simply that modern notions of the metaphysical foundations of science actually depend on certain assumptions regarding our cognitive ability to ascertain proto-scientific paradigms from the structures of consciousness and of affective states in particular, and this depends on an account of primordial self-knowledge which hews toward Husserl's trascendental cogito, rather than toward Dennet's "hetero-phenomenology". Premodern science, less clearly partitioned from practical know-how like medicine or navigation, may have inspired in its practitioners a self-understanding rooted in the body as a locus of practical action; but, insofar as embodiment plays a role in demarcating modern scientific paradigms, the body more often, I claim, plays the role as a locus of isolated affective contents.

Our embodied experience, through affective presence, provides us with a conceptual entry into the originary causative structure of physical reality — but only insofar as we can accentuate our ability to frame affective presence in our consciousness, to isolate affectivity from the totality of our thoughts and experience into an order of discrete, tokenized carriers of affective content — content which *affects us*. This is not just content which we observe, or things which we believe to be true, but things which *happen to us*, and the precise, tokenized sensations which *affect us as* things happen to us. It is our phenomenological entrance into the causative structure of the world, not as something observed or hypothesized, but as directly felt. The concepts which are then extracted, as maxims for physical explanation generally — the CIPI triad, for example — these intuitions seem to apply to the world because they emerge from the midst of the world, from the world as it affects us most directly and primordially, even more fundamentally than in things we merely observe, or merely perceive visually. Our sense of physical influence seems both especially vivid and especially applicable to natural reality because it is not a conceptual scheme which we impose on the world, not a cognitive structure with which we observe things, but a record of the primordial affectivity implicated in how *things happen to us*, in how *things of the world* affect us, entirely beyond our control or volition.

If embodied locales sharpen our intuitions because of this non-volitional, primordially affective mode of presentation, then they seem to disclose truths about physical reality because they arise in the midst of this reality affecting us, anterior to and experientially deeper than our conceptualizations. But this same vulnerability of our embodied being to external affect, which grants us an intuitive sense of reality in its fundamental causative order, also seems to disclose our bodies and consciousness as *belonging to* this order, as acquiring intuitions about physical reality because they (or we, our bodies and minds) are affected by this reality, affected such that the trace of this affectivity lingers in consciousness, such that in turn its token presences can become vehicles for later scientific intuition. The belief in our intuitive view of physical nature — which, I believe, is at a deep, preliminary level, also the scientific world-view — this belief seems also simultaneously to be a belief that our intuitions carry weight because they are subject to the same causal principles which are subsequently conceptualized. In other words, the belief in these intuitions simultaneously is apparently belief in the ultimately physical nature of both body and mind, insofar as the things which transpire in both body and mind bear the affective trace and causative structure of physical reality, because they are, ontologically, just *part of* and *within* this reality. On this account, the phenomenological foundations of scientific reason are profoundly anti-dualistic.

6 Final Comment

We should be wary of *a priori* attempts to resolve philosophical contentions by fiat (or, more picturesquely, by waving a magic analytic wand), but I think we can notice that dualistic, and generally anti-physicalistic, approaches to the mind-body problem have a sometimes overlooked hurdle to climb. If science is to provide a meaningful account of the world according to some criteria of proper scientific explanation and theorizing, then science must be *meaningful*; it must communicate a world-picture by a set of meanings which are understood by human thinkers. Science is not a kind of purely formal mathematics, where proofs can be checked by algorithms; nor is it merely a formal test of different mathematical equations against empirical data. Science cannot be understood by computers, because it is not just an abstract set of relations between ontological posits, mathematical formulae, and observed data. Science relies on human intuition to provide meaning to the kind of very broad and basic concepts which are so fundamental as to be hard or impossible to define in terms of other concepts — concepts like force, matter, energy, space, time, causality, physicality, and physical influence. Science also relies on human intuition to relate phenomena as scientifically modelled to pheneomena at the macro-scale, everyday world: to understand that an optic theory of transparency, for example, is explaining at the molecular level the phenomena which, on a macroscopic level, is manifest in the transparency of a pane of glass. As a theory *of* transparency, human intuition is needed to relate the mathematics and ontology of the low-scale theory to the high-scale worldly phenomenon. Finally, human intuition is needed to understand the parameters of scientific explanation — the physicality of causal influence and of information transfer; the unscientific character of "magic" and of the paranormal — to intuit these parameters not as arbitrary partitions on a more general space of possible theories, but as motivated by how the world appears to be based on how it affects us.

So science, to *be* science and not just applied mathematics, or abstract models of possible worlds, needs human intuition to provide its foundations and also its large-scale, life-world semantics. But the believability of our intuitions as having scientific merit — in the broad sense of understanding the parameters of scientific reason, even if we are prepared to suspend our intuitions about specific phenomena where improved scientific measurement or analysis can correct misleading sense-impressions or thought habits — this warrant for our intuitions about how the natural world is, seems believable only insofar as our minds are subject to the same forces and principles of natural phenomena which are felt and observed, and from which these intuitions are forged. As a result, disputing that mind is truly "physical" or explainable in, fundamentally, physical terms, calls into question the possibility of scientific understanding in the first place.

Because, as I have argued, the most primordial affective structures, those least amenable to conceptual summarization or intersubjective communication, also can express the primordial structure of the human mind and body as affected by external influences — of hot and cold, physical force and momentum — the nature of physicality as such is disclosed to us most precisely, most cleanly, when we can reflect on our own affective sensations in their causative relation to something or other in the world around (and within) us. The most purely affective and subjective is also therefore the mode of experiential content where the objective is disclosed to us in the most unadulturated form of its primordial objectivity. If this seems true — even merely relying on evidence of this very seeming — it also certainly seems then that the affective *is* the physical, that the physical-as-such is disclosed in tokens of affective influence insofar as they form tokenized contents in consciousness, precisely because these contents *are physical phenomena*: so that consciousness is a synthesis of physical phenomena, events in consciousness are physical events, and the ontology of consciousness belongs within (perhaps as an emergent system or specialized domain) the ontology of physical nature.

A complete theory of consciousness, then, will need to explain tokens of affectivity as physical things, to develop a language of explanation in which both the objective and physical, and the subjective and experiential, are linked via semantic and causative connections. The macro-scale of conscious experience and the micro-scale of physical events within brains or neurons need to be thematically, terminologically, and explanatorily linked, by analogy to how the theory of transparency links a language and conceptual structure involving photons and molecular structure with a language involving what transparency means in the everyday world — such as the fact that we can see things on the other side of a pane of glass. This semantic-explanatory interweaving of physics and phenomenology, where the set of conceptual relations forming theories within each of these domains is extended by sets of relations *between* them domains — this physical explanation of affectivity as such is the ultimate quest of a scientific theory of mind and of consciousness.

But, before this explanation of conscious *experience* can be achieved, perhaps we need to set the stage with scientific accounts of cognitive *processes* which conscious experience engenders. A scientific account of cognitive process need not, necessarily, fully explicate its physical realization in neuronal or organic matter; a purely formal, algorithmic theory of cognition in some domain, can be a nontrivial and scientifically well-formed contribution to the scientific picture of cognition, and therefore ultimately of consciousness. This is why any theory which provides a believable account of some domain of mental operations, even one rarely realized simply or in isolation in real-world cognitive episodes — theories like first-order and modal logic, theories of categories and concept-formation, etc. — these theories, even if a little simplified and idealized relative to actual cognition, still shed structural light on cognitive proceses.

I believe that a physical theory of consciousness, one which integrates phenomenologically identified conscious states as experienced with their physical realizations in bodily and neuronal structures, is the only fully complete scientific account of consciousness and of the mind body relation. Such an account will provide an underlying causative theory which grounds the higher-order theories of cognitive functioning (including not only cognitive science but human sciences like political philosophy, cultural theory, and economics) — by analogy to how chemistry or quantum mechanics grounds higher-scale physical theories like biology or geology. However, scientific investigation of consciousness does not need to grind to a halt while such a causative cascade of theories is still under development. Scientific, mathematical, and structural analyses of organizational patterns may not provide a complete causative account of phenomena, but such analyses are an important step toward such an account, a representation and conceptual articultion of those phenomena which a causative account will subsequently cover via conceptual mappings between higher-scale concepts and observations, and lower-scale components and causations. Structural identification of formal patterns, identified in cognitive and perceptual structures and processes, aspiring to be an analysis of organizational principles rather than of physical realizations, is still a properly scientific paradigm for studying consciousness. This is not a functionalist argument that conscious states are to be ontologically *identified* to their cognitive roles, but rather a practical maxim that functional and structural analysis of cognitive states and their conscious components, is a precondition for an eventual scientific analysis where conscious states are ontologically treated as, foundationally, physical phenomena.

Moreover, and in conclusion, I would suggest that *mereotopology* is a valuable formalization of certain cognitive structures, one which may be especially useful to an eventual theory of consciousness, because among the most primordial affective conscious processes — among those which disclose physicality-as-such most purely — is the tactile, visual, and motor reconstruction and estimation of three-dimensional geometry from the seen and felt two-dimensional surface.