Second Order Science:
Putting the Metaphysics Back Into the Practice of Science
By Michael Lissack

Abstract
The traditional sciences have always had trouble with ambiguity. Through the imposition of "enabling constraints" -- making a set of assumptions and then declaring ceteris paribus -- science can bracket away ambiguity. These enabling constraints take the form of uncritically examined presuppositions or "uceps." Second order science examines variations in values assumed for these uceps and looks at the resulting impacts on related scientific claims. After rendering explicit the role of uceps in scientific claims, the scientific method is used to question rarely challenged assertions. This article lays out initial foundations for second order science, its ontology, methodology, and implications.

Keywords: model, ambiguity, metaphysics, dependence, science

Introduction
The traditional sciences have always had trouble with ambiguity – defined as the simultaneous existence of multiple meanings and/or multiple potential expressions. In the hard sciences, ambiguity is often replaced with a probability distribution – a contingent form of uncertainty which works well when the underlying ontology consists of indexical properties. In the social and special sciences, the underlying ontology is different – individual properties play a role in identity as do combinations of expressed and not yet expressed properties. Here the use of probability distributions to stand for ambiguity requires either omniscience or assertions of assumptions and claims of ceteris paribus. Emergence, volition, and reflexive anticipation – the very qualities which distinguish the subjects studied in the special sciences – are both context dependent in instantiation and fundierung dependent in observer attention.

Assertions of assumptions to bracket ambiguity thus function as what cybernetics calls "enabling constraints" – narrowing the degrees of freedom of the subject items to match or be below that of the suggested controller – the proclaimed "rule" or "law" or "heuristic" which supposedly allows the underlying ambiguity to be dealt with. Ashby's (1958) law of requisite variety suggests that the enabling constraints function to allow "science" to make predictions and to offer "explanations." But, predictions and explanations predicated on ceteris paribus demand interpretation, if they are to have meaning once the ceteris paribus constraint is relaxed. The use of these enabling constraints amounts to what Lakatos called a "protective belt," blocking inquiry into fundamental questions of how the constraints are chosen and what happens when they are altered. Second order science is the science which examines those very questions --questions which our current complex world can no longer ignore.

Science has an ambivalent relationship with ambiguity. While ambiguity is recognized to pervade the world in which we live, the role of science has evolved from seeking to illuminate and clarify that ambiguity to seemingly seeking to eliminate it. As this change has progressed, so too has the increasing distrust which the general public extends to the conclusions and findings of that same science (Lynas, 2015, Blake 2015). Ironically, when scientists perceived their role to be one of illumination, rather than elimination, trust was much greater.

Barack Obama told Americans in his 2015 State of the Union address that we live "in a world of constant change." Seventy years before F. Scott Fitzgerald (1945) wrote: "let me make a general observation -- the test of a first-rate intelligence is the ability to hold two opposed ideas in the mind at the same time, and still retain the ability to function. One should, for example, be able to see that things are hopeless and yet be determined to make them otherwise."

What links these two quotations is the concept of ambiguity – the very simultaneity of Fitzgerald's "opposed ideas" could be the product of dealing with Obama's "constant change." Ambiguity may be the foundation for many a work of literature, but is most often regarded as a "problem" when it comes to science. Falsifiability and its related demands, which Popper(1959) explicated regarding the scientific method, date from the same era as Fitzgerald's quote but hold to a very different standard. The aim of current-day "science" (at least of the "hard sciences") is *truth*, absent which, *certainty* and *reliable prediction* are a close second and a not-so-distant third. This aim is at odds with the notion that ambiguity can be built-in to scientific methods, and the trend is not in our favor. In 1910, Empson was well received in laying out *Seven Types of Ambiguity*. One hundred plus years later science journals instead publish articles focusing on ambiguity aversion and the role ambiguity plays in stress. (Arló-Costa & Helzner, 2010, and Millner, Dietz, & Heal, 2013)

The aversion to ambiguity has been mirrored by the success of *efficiency*. Efficiency and its pursuit may be seen as the idea which has marked the past century. Ambiguity is generally regarded as an enemy of efficiency –resolving ambiguity requires taking into account context, beliefs, history, or individuality, which demands energy and resources. Efficiency is about minimizing the outlay of each. "Nothing can stop an idea whose time has come." (Hugo, 2005) In our pursuit of material well-being, efficiency has created the modern world. But as an idea – an over-powering idea – it has had the effect of turning ambiguity from something which science aimed to clarify and describe into something which much modern science aims to obliterate. Western society has internalized both Frege's (1892, c.f. Dummett, 1981, Nye 1990) goal of the elimination of the ambiguities and vagaries of natural language and Planck's (1968) warnings about starting first from certainty all too well. Our predicament is well summarized by Morin (2008): "The distinctive quality of science up to the present was to eliminate imprecision, ambiguity, contradiction." But that elimination has only succeeded via a process of bracketing – shielding each separate question and domain in its own silo where the hidden enabling constraints listed below are frozen, ceteris paribus.

This dynamic – that of ignoring ambiguity in the interest of efficiency -- is captured in the seeming omnipresence in scientific practice (though not in declared philosophical outlook) of "model-dependent realism." This kind of realism has become the basis for applied science, in which each situation is afforded its own efficient, reliably predictive model:

> "The only meaningful thing is the usefulness of the model…. [Model-dependent realism] is based on the idea that our brains interpret the input from our sensory organs by making a model of the world. When such a model is successful at explaining events, we tend to attribute to it, and to the elements and concepts that constitute it, the quality of reality or absolute truth." (Hawking and Mlodinow, 2010)

In the name of efficiency, ambiguity and variation have been bracketed and silo-ed away from the foci of the scientific endeavor. Efficient science has dealt with the omnipresence of ambiguity through the imposition of assumptions and constraints. The "hard sciences" assume that what matters are indexical properties (not individual instantiations), observer independence, context independence, and belief (or more properly fundierung, c.f. Lissack and Graber 2014) independence. These assumptions match what would matter in an ideal Platonic world where the abstract essences are indexical and independent of context, fundierungs, and observers. They even match the ideal of what essences "are" (in an ontological sense) in Husserl's phenomenological world. The world of the laboratory, of the computer model, and of the "derived from big-data" allows for replication of these efficient conditions. And then…. there is the messy ambiguous rest of the world.

Hidden Un-Critically Examined Pre-Suppositions (uceps)

A classic tenet of cybernetics is that "the controller of a system needs to have at least as many degrees of freedom as the system it is intended to control." This is known as Ashby's Law of Requisite Variety (Ashby, 1958). It appears that modern science, in its efforts to act as a controller, has chosen to reverse this law such that the system being controlled must be reduced to the same number or less of degrees of freedom available to the model chosen to model (control) it. Modern science's method of control is *the model*. Ideally what applies in the "toy world" of the scientist's model is mirrored in the "real world" outside of the laboratory or simulation. While many efforts of philosophers have gone into probing, questioning, and doubting the fidelity of that ideal, the "reality" is that applied science as we presently practice it not only makes the "mirror" assumption -- but tends to ignore the very idea that this assertion is an assumption at all. The perceived ontology of the "real world" which is the concern of the scientist is presumed to match the ontology of the "mapped" model, where the only concession to the concept of ontological difference exists in the presentation of the map between model and world.

The effort to limit the ontology of the examined "real world" takes the form of what in cybernetics are referred to as "enabling constraints" – limitations which allow for desired behavior or effects by restricting (constraining) the degrees of freedom of the system so constrained. In first order science, these enabling constraints take the form of hidden (i.e. not explicitly discussed) *un-critically examined pre-suppositions* ("uceps") – assumptions upon which the models, predictions, and theories rest. The assertion herein is that, in general, when scientists do science ("first order science") much of their work begins with pre-given value choices for each if not all of these uceps (which is why they are *un-critically examined pre-suppositions*). Once the pre-given values are in place, the choice of those values is seldom explained and even more rarely are experiments done which are designed around variations from the initial. The lack of critical examination regarding such choices and the further lack of experimentation to discover what variations amongst those choices might mean is the ground for second-order science.

Nine such enabling constraints or uceps are readily observable from the work of practicing scientists:

1. ***Context Dependence***
   The extent to which observations/data/interpretations are dependent upon the context in which they occur. Attention (the notion that data points are attended to by actors/system/observers) may also be context dependent.
2. ***Fundierung Dependence***
   The extent to which observations/data/interpretations are dependent upon the belief set and habitus of the observer/interpreter. Attention may also be fundierung dependent. Differs from context dependence in that there is no dependency on material/ontological items external to the mind of the observer/interpreter and thus may not be cross checked by the addition of other observers/interpreters.
3. ***Quantitative Indexicality***
   The extent to which the items being examined/ represented/ modeled are available to be represented as indexicals rather than as individuals where the indexicality can further be represented quantitatively. The substitution of probability distributions for either context dependence or fundierung dependence is an example of an increase in quantitative indexicality as would be true of any substitution of such distributions for markers of individuality. This variable is not restricted to qualities which are explicitly examined/ represented/ modeled -- any of the other eight hidden uceps may be targets for the application of quantitative indexicality.
4. ***Holonification***
   The extent to which the items being examined/ represented/ modeled are discussed as both parts and wholes and the relative roles of each. A holon is an identified part/whole relation with regard to a specific item. Mereology is the study in general of such part/whole relationships. Synecdoche is the use of a quality (such as a name or a property) ascribed to a part to stand for the whole.
5. ***Graining***
   The size of the items being examined/ represented/ modeled as parts of the system being examined/ represented/ modeled. Graining questions are often discussed in the social sciences as the choice of “unit of analysis”. Graining questions are often obscured in data analysis by the application of “normalization” routines.
6. ***Clustering***
   The extent to which the units being examined/ represented/ modeled are assumed/ allowed/ ascribed/ afforded the status of being clustered together as sub-systems, where the resulting sub-system in then ascribed “item” status in terms of graining.

7. ***Communication/Attention***
   The extent to which the items in the system are assumed/ allowed/ afforded/ ascribed the ability to exchange information (both within and outside the system). This can be further modified by the extent to which that information exchanged is assumed/ allowed/ afforded/ ascribed the ability to be attended to (on a scale which might include being ignored).
8. ***Anticipation***
   The extent to which either individual items or the system as a whole is assumed/ allowed/ afforded/ ascribed the ability to anticipate what a not yet incurred interaction might do with regard to a stated variable or condition which is explicitly examined/ represented/ modeled or with regard to any of the other eight hidden uceps.
9. ***Memory***
   The extent to which a prior state of an item, the system, or a data point treated as information by either an item or the system is preserved for access and afforded some ontic status. In turn, that "memory" is allowed to be recalled/ labelled/ brought forth as a current input.

The blind acceptance of the assigned values for, and choices made with regard to, these hidden uceps serve to buffer the scientists' models from "uncontrollable" (i.e. un-modelable) extrinsic (or hidden intrinsic) influences. They can be recognized or hidden or given quantitative values. They can be stated in terms of one another or described as being contingently dependent upon one another. Meaning: the status afforded to these uceps affects the ontic status of both system and elements; the epistemic variations available to each due to interventions and/or processes operating in the system at question; and the notions of identity afforded to both system and elements.

Second order science – as proposed here – is the study of how variations in these hidden uceps might affect the practice of science, the conclusions reached from a given set of experiments or theories, and the interpretations offered by scientists as they map the results of modelling back to the "real world." Second order science is thus the application of the scientific method to the hidden uceps which constitute the enabling constraints – testing what happens when one or more such variables are altered.

Doing Second Order Science

This article is not the first to introduce the term "second-order science" (c.f. Riegler and Mueller, 2014, Umpleby 2014). For example, Mueller (2014) proposed that: "First-order science is the science of exploring the world. Second-order science is the science of reflecting on these explorations." Mueller's second order science is focused on a critical examination of the results of first order science. For purposes of argumentation, this article will bracket off Muellerian output focused second order science and focus solely on inputs. The second order science described herein takes a critical look at what happens if some of the inputs of first order science are varied. It is thus concerned with the enabling constraints of the models, representations, theories, and concepts which are used in doing first order science. Second order science is a Deweyian notion of science: "a formal inquiry into symbols, meanings, and their relations, yielding a unified understanding of the phenomena that are the subject of inquiry." (Buchanan, 2009)

Second order science differs from science studies in that it is not about the scientists (as is science studies) but is about their cognitive tool set. Second order science differs from philosophy of science in that it examines via the scientific method the effects of changes in metaphysical assumptions rather than discussing and categorizing the worldviews, ontologies, and epistemologies being employed in the practice of science or its artifactual output. Second order science by definition is "critical" in that it examines and questions the effects of base assumptions – those hidden un-critically examined pre-suppositions.

To do second order science is to vary relationships which are assumed between the scientific models used to represent the world and that world itself – and to make observations about what happens as a result of such variances. The relationships to be varied are the ones which rely on upon the hidden uceps above, and the variations to be introduced and examined are variations in the assumptions made regarding those uceps. This methodology conforms to the example set forth by Gooding and Addis (2008) regarding mediating models.

> If science is conducted by many communities of practitioners then we cannot expect a finite set of unambiguous rules to govern belief-revision and theory change. [This explains] the difficulty of reconciling a general, principled account of science with the variability and contextual nature of practice. To understand how any rule of inference would work in practice, it would have to be implemented in a way that reflects the contingent and socially situated character of scientific thinking. This is the context in which experiments function as models which mediate between the emerging language of description and explanation and the changing phenomenology of a domain.

The domain of practice of second order science is the set of first order science practices where the uceps noted above are made explicit. The method, contemplated herein, is to examine the effects of making changes regarding the assumed values for the uceps –such examination taking place via the scientific method. This examination is done within the context of the first order scientific practice being examined -- where the second-order goal is to make explicit the effects of potential changes in the values asserted for the uceps. This, in turn, is accomplished by examining alterations in the coding and de-coding regimes within the model being used by the first order science. The notion of coding and decoding regimes is part of the *modeling relation* first articulated by Robert Rosen three decades ago (1985).

The Modeling Relation (Figure 1) provides us with a methodology for studying one system (the "subject" or "natural system") in terms of another system (the "model" or "formal system").

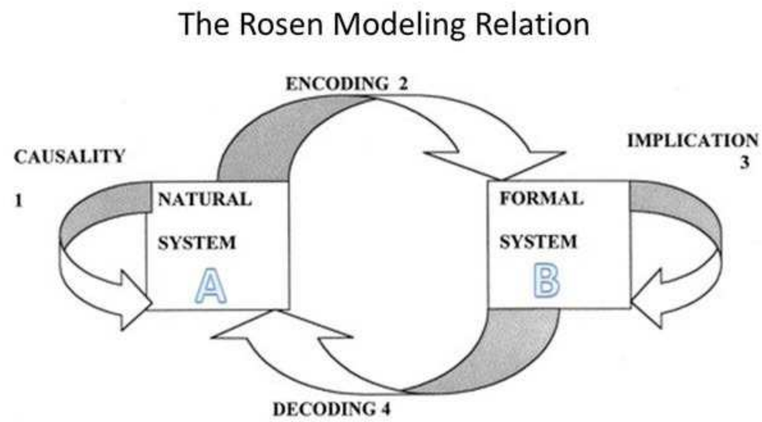

Figure 1

The two systems are related via the encoding and decoding arrows. Encoding is the process of measurement: it is the assignment of a formal label (such as a number) to a natural phenomenon. Decoding is prediction: it is the taking of what we generate via the inferential machinery of the formal system into representations of expected phenomena. Additionally, the arrows for inference and causality represent the entailment structures of their respective systems.

The modeling relation provides us with a way of ascertaining congruence between the natural system, N, and the formal system, or model, F. What determines successful congruence is that the diagram, as a whole, commutes. That is, such that the numbered arrows meet the condition: (1) = (2) + (3) + (4). This means that our measurements (2), when run through the inferential machinery (3) of our model, will generate predictions (4), which will agree (when verified) with the actual phenomena (1) occurring in N. It bears mentioning that any encoding from N to F is an abstraction and if the modeling relation holds, then F is a model of N. If all four conditions of the modeling relation do not hold, then F is merely a description of N under a specific condition.

For the purpose of argumentation herein, we can draw a distinction between “science” and “non-science” based upon the use (either explicit or implicit) of the modeling relation in the theories and practices of the subject domain. Science makes use of the full modeling relation. Non-science makes only partial use – thereby reducing any claim of a “model” to the status of representation or description. For example, evolution is Science while Creationism is non-science. The modeling relation provides a formal distinction between model (where manipulation may result in outcome) and representation (where manipulation only results in changes to that representation). If the ultimate goals of modern science are reliable prediction, better attunement to environment, and the potential exercise of “control”, only models can be facilitative. Representations and descriptions (the tools of non-science) fall flat.

> "Why models? Because the inanimate world is filled with quasi-regularities that hint at deeper causes. We need models to explain what we see and to predict what will occur. We use models for envisioning the future and influencing it. … If one wants to 'model' a situation one needs to be sure of the definitions, identities and terms of use one is making use of. And if one wishes to assert that a representation holds true for a given situation, one must attempt to match the context of the representation to the situation actually at hand. …Theories and models are a kind of magic, and the builders of successful ones, are shamans bridging the visible and invisible worlds." (Derman, 2011)

The modeling relation is the formal explanation of how the "magic" of science gives rise to better understandings of the world. **"**Science might best be understood as a language with which or through which people try to understand the world. All languages have rules that determine what acceptable sentences are and how utterances are to be understood. Similarly, scientific rules tell us which experiments are acceptable and how one interprets the results." (Slife and Williams, 1995) The modeling relation is the process by which both the language and the rules of that language get determined.

The importance of the modeling relation for second order science is to highlight the role of the hidden uceps in the encoding and decoding regimes which go into making a model a true representation of the potential dynamics of its subject. Variation amongst the values asserted and the manner of their choice regarding the hidden uceps determines the very nature of these encoding and decoding regimes. For example, a claim of ceteris paribus regarding a value choice is an assertion that variance is either impossible, irrelevant, or identity threatening. A claim re the overriding importance of individual cases is an assertion that group level statistics are impossible, irrelevant, or identity threatening. Because much of scientific practice implicitly relies upon model-dependent realism, the very claim that a model is indeed a model (as defined by the modeling relation), and thus not mere static representation nor description, is critical.

An example of the model versus representation distinction can be found in what I shall label as "writers' causality." In writers' causality the encoding from the "natural system" is done based on observation, ascription, or assertion. A label is created to "name" the encoding and that label is reified into an "as-if" natural kind. All decoding then stems from the ascribed qualities of this reified label. The system response is to either ignore the label or to adopt whatever enabling constraints (e.g. values for uceps) necessary to allow the label to work. Taleb (2007) refers to this cycle as the reification of a "narrative fallacy" (which describes how humans are biologically inclined to turn complex realities into soothing but oversimplified stories).

American society's general understanding of the causal linkages between cholesterol and heart disease provides a good example of writer's causality at work. (Brown, 2014) The initial linkage was based on a multi-country study where the evidence from "Mediterranean Countries" was ignored (Keys, 1970, 1980) so as to suggest a strong correlation between dietary cholesterol and heart disease. This correlation was adopted by the media and the policy establishment as "causal." Americans were urged to change their diets (Ernstene, et al, 1961) and then to consume massive quantities of statins – with the goal of reducing blood cholesterol levels. For decades the counter evidence from Europe (diets high in cholesterol but low in coronary disease) was ignored, because it ran counter to the narrative fallacy/writer's causality which was the "established model." (Kromhout, et al, 1989) Only in the past few years (and billions of statin pills later) has the medical policy establishment proclaimed that *maybe this was wrong*. (Brown, 2014) Statins can help only those with certain genetic traits. (Lawrence, 2014) Dietary cholesterol may not matter. (Whoriskey, 2015) Yet how many lives were affected by the writer's causal claims regarding dietary cholesterol -- hundreds of millions.

Assertions in the popular media that "Science does …" or "Science requires …" in some claimed unanimous and supposedly ubiquitous voice are yet other examples of writer's causality being asserted and, should the policy makers so comport their response, resulting in the imposition of related enabling constraints. The science of the popular media is all too often a science where writer's causality reigns. Writer's causality is based upon static representations/descriptions and not on dynamic models (defined by the modeling relation).

Where first order science makes explicit assumptions about hidden uceps, second order asserts no pre-given assumptions and instead seeks to examine these same variables. The choices of values and the allowed method of variation then themselves become the foci of potential applications of the scientific method. It is the role of second order science to question the assumptions made which serve as enabling constraints for the first order science problem at hand. The first step in such questioning is the process of *revealing the role of the hidden uceps in the scientific argument, explicating their assumed values and thus opening up a process to allow the practicing scientist to explore other potential values for each of the constraints*.

This first step has an incredible consequence – claims of incommensurability in several spheres are vanquished.

Incommensurability

Incommensurability, or some form of it, is generally accepted as part of our multi-valued, many disciplined, cross cultural world. That incommensurability is often processed by layman and philosopher alike as if it were an irreconcilable opposition. As an opposition, the claim of incommensurability is then used to block or bracket discussion. But, what if incommensurability was only a fabled illusion, a cognitive processing limitation, imposed, not by nature, but by our own choices of frames? By providing a common ground, the explication of the uceps and how the values chosen for them are treated, second order science by definition renders its subjects commensurable. (See Tables 2-5 below.) They can be compared with regard to the uceps.

The usual treatment of the incommensurable has been to label it as dangerous. What the elucidation of the nine hidden uceps does is allow for the formerly incommensurable to be mapped to regions in a space defined by those same hidden variables. What may have been seen as incommensurable (or threatening) by each of two perspectives when viewed from within their own cognitive space, become comparable mapped regions in a by-definition commensurable third space. Treating incommensurability in this manner removes it from Lakatos's (1970) "protective belt" and creates new territory for philosophers of science to actively explore. This explorative territory seems better suited to the complexities of our current age than the oppositional incommensurabilities of Kuhn (1962) and Feyerabend (1962). By making the hidden uceps explicit we can examine the impact of changes in those variables, and, by definition, turn the incommensurable (when measured against each other's' native words/language) into the directly comparable. The formerly incommensurable are no longer so when they are compared through the lens of the hidden uceps.

Second order science is one method by which concepts and situations formerly "bracketed" due to claimed incommensurability can now be directly examined. The use of incommensurability as an enabling constraint to limit discussion is revealed to be a cultural ritual rather than an intellectual or cognitive limitation.

> "All cultures have ways of dealing with these anomalies and ambiguities. One way to deal with ambiguity is to classify a phenomenon into one category only and maintain it within the category, thus reducing the potential for uncertainty. Another method of dealing with anomaly is to physically control it, removing it. A third way is to avoid anomalous things by strengthening and affirming the classification system that renders them anomalous. Alternatively, anomalous events or things may be labelled dangerous." (Lupton, 2013)

Claims of incommensurability allow for the bracketing off of anomalies and ambiguities. By contrast, second-order science uses them to bring research questions front and center. This is a direct consequence of the second order science process of explicating values for the uceps and the methods allowed for variations in those values. Once the value choices for the uceps have been explicated, the formerly incommensurable are now directly comparable. When the scientist knows the values assigned to uceps and how ucep values can be varied as part of the encoding and decoding regime, new light can be shed on the formerly incommensurable.

The first four examples which follow are illustrative of this explication process:

- *The "Hard" Sciences and the "Anticipatory" Sciences*
- *Perspectives underlying first-order science: Scientific Realism vs. Pragmatic Constructivism*
- *Kind of Experiences*
- *Kinds of Causality from Direct to Anticipatory (or teleological)*

The tables shown for each example are meant to highlight the role of the hidden uceps in shaping the models used and thus the domain of practice for the attended to first order science. The contrasts shown in each table are illustrative of how explication of the values and choices relating to the uceps renders the oppositions in the example commensurable. The metaphysical questions exposed in each of the examples concern the nature of the values assumed for the uceps and the degree of variance those values are allowed. Why are these questions important? Some sample notions:

a) That which is made explicit has a different nature from that which is implicit, hidden, or overlooked.
b) The "individual case" has a different nature from group level statistics.
c) Isolated datum differ in essence from agents allowed to communicate.
d) That which is a focus of concern for one group of scientists but which is bracketed away by others, will have a different nature for each.

Winston Churchill (1943) famously said, "We shape our buildings, and afterwards our buildings shape us." The science equivalent is – we shape our assumptions and then our assumptions shape our science.

A fifth example – *A Look at the Human Effects on Climate Change Debate* – illustrates the kinds of observations a second order science approach can take and draws upon the material presented in each of the four earlier examples. The Climate Change Debate is frequently presented as "incommensurable" between believers and doubters. A second order science approach replaces such claims with observations about the role of value decisions and tradeoffs. Here the modified Churchillian quote above plays an obvious role: the assumptions the scientist or policy maker brings to the debate shapes his/her view of both the debate and the underlying science.

Example 1 -- The "Hard" Sciences and the "Anticipatory" Sciences

Our first example notes the contrast between the "hard" sciences and the "anticipatory" sciences. By making explicit the variation in models used by these sciences regarding anticipation, memory, context dependence and perhaps fundierung dependence, one can illustrate both differences and potential "boundary areas" where common assumptions might give interdisciplinary work the best chance to flourish.

In Lissack and Graber (2014) two kinds of science were distinguished:

> "Objectivity and a goal of reliable predictivity are the hallmarks of what we shall label Science 1. These are the hard sciences as traditionally taught and as used as references by philosophers of science. Physics is the exemplar of Science 1. In the Science 1 world we label and categorize via deduction, probabilistic inference, and induction. Science 1 excludes context dependence, thus when it is forced to deal with the possibility instead

> asserts ceteris paribus. Discovery and attunement to context are the hallmarks of what we shall refer to as Science 2. In the Science 2 world we instead seek to identify relationships, affordances, and potential actions. We ask questions rather than seek to label or categorize. Science 2 explicitly makes room for the context dependencies that Science 1 has excluded. These can be characterized as emergence, volition, reflexive anticipation, heterogeneity, and design, among others".

Thus the "hard" sciences are Science 1 and the "anticipatory" sciences are Science 2. Please do not let the names confuse you. Both are part of first order science. Both make use of hidden uceps. Neither undertakes a critical examination of the effects of variations in the values assumed for the uceps.

Where Science 1 and Science 2 differ is in objective and purpose. The hard sciences (Science 1) are marked by "Objectivity and a goal of reliable predictivity." In the hard sciences (and as Umpleby 2014 points out with respect to any non-sentient phenomenon) it makes sense to label and categorize via deduction, probabilistic inference, and induction. The world of Science 1 excludes context dependence. By contrast context dependence is the hallmark of Science 2. Here the objective and purpose are discovery and attunement to context. Where "models of" are the currency of Science 1, "models how" are the currency of Science 2. Here, the scientist seeks to identify relationships, affordances, and potential actions and asks questions rather than seek to label or categorize.

Key distinctions between the two perspectives are exemplified by their approach to anticipation and sentience (a concept which encompasses many aspects of the hidden uceps above). Sciences of the sentient will require different languages than are commonly used in the hard sciences of non-sentient beings. "One thing that seems not to be considered is that the context of everyday interaction might have other motivations than the search for laws, causal explanations, prediction, and control that we associate with the ideas of natural and biological science. " (Carr, 2008) But, "the concept of anticipation has been rejected out of hand [in Science 1]… because it appears to violate causality. We have always been taught that we must not allow present changes of state to depend on future states; the future cannot affect the present." (Louie, 2009)

Table 1 below highlights some of the features for which each such science is well suited.

Table 1: What each of the two sciences is good at.

What Science 1 is good at	**What Science 2 is good at**
• Dealing with "knowns"	• Dealing with "unknowns" & emergence
• Decomposition	• Network interaction
• Discovered, well formed, realistic modeling	• Exploring, continually emergent, cybernetic modeling
• Risk analysis	• Opportunity analysis

• Categorization, sensing & matching	• Learning, probing & sense making
• Operates as planned	• Redoing, re-planning
• Distribute "knowledge" to individual actors	• Highlight co-ordination across systems
• History	• Reflexive anticipation
• Actors differentiated by defined properties	• Volition
• Responds to planned contingencies	• Revising to unplanned contingencies
• Simplifying the complicated	• Narrating the complex

Table 2 outlines implications for Science 1 and Science 2 when assumptions are made for each of the hidden uceps. Tables 2-5 also have another purpose: by explicating differences and commonalities with regard to the common set of hidden uceps, such tables demonstrate where commensurability can be found amongst two communities of practice which often regard each other as incommensurable. As Noe (2012) might phrase it, the dialogue makes both perspectives available to one another and thus grants their respective adherents access to the other perspective.

Table 2: How Assumed Values for the Hidden uceps are Treated

Hidden ucep	**Science 1**	**Science 2**
Context Dependence	Ceteris Paribus	Explicitly Noted
Fundierung Dependence	Observer dependence issues	Observer dependence issues, actor awareness issues
Quantitative Indexicality	Prominent	Available at the large group/population level via a mapping to probability distributions
Holonification	Seldom made explicit	Seldom made explicit, actor awareness issues
Graining	Usually made explicit	Often discussed as a methodological issue
Clustering	Usually noted as either graining or as a process outcome	Often discussed as a methodological issue, one of the foci of “network science”
Communication/Attention	Usually bracketed away or ceteris paribus	Often discussed as a methodological issue, one of the foci of “network science”
Anticipation	Usually bracketed away or ceteris paribus	Often discussed as a methodological issue, a foci in behavioral sciences
Memory	Usually bracketed away or ceteris paribus except as preserved in the concept of fatigue in materials science	Often discussed as a methodological issue, a foci in behavioral sciences

A second order science approach might be triggered by a first order science query such as asking*, what is common amongst metal fatigue and memory?* Anticipation makes use of memory; might that have an implication for metal fatigue? Could there be a relation between myelin layers and metal fatigue at other than a mere metaphorical level? The second order science questions might take the form of:

a) What is the appropriate holonic status to be afforded to the myelin layers? When/how do the layers function as parts of a system or systems and when as a system unto themselves?
b) Does that holonic choice affect the myelin/metal fatigue relationship? Can the myelin stress to the point of fatigue leading to system failure?
c) Does the choice of graining matter when looking at myelin layers? If it does, then how should one grain? By cell count? By thickness? By brain area? By neuronal function? Or is there clustering and/or communication which is determinative of either graining level or holonic status?
d) Do the answers regarding holons, graining, clustering etc vary when looking at different brain/body functions such as memory, motor movement, or anticipation?
e) Are the physiological implications of the chosen values, and the ontic status afforded changes in those values, different from the cognitive implications?

Example 2 – Perspectives underlying first-order science: Scientific Realism vs. Pragmatic Constructivism
Just as one can distinguish the hard and anticipatory sciences, one can distinguish the philosophical stance or world views which the practicing scientist (and especially the philosopher of science) brings to scientific examinations. Two of the most prominent such stances are Scientific Realism and Pragmatic Constructivism.

Scientific Realism makes truth claims, judges those claims for coherence against a pre-given world, and affords the status of "real" to entities whose existence cannot be observed and can only be inferred. Scientific Realism is often modeled as taking Newtonian physics to be the paradigm instance of science. Other sciences are understood via assimilation to the Newtonian model. Within Scientific Realism, explanations are understood to be reductionist and law driven. While the Scientific Realism practiced by scientists and philosophers is much more nuanced, what it shares with the "common sense" version is an underlying belief in the independent existence of reality and of the fundamental importance of truth.

By contrast, Pragmatic Constructivism begins by asking what actions are being contemplated and how judgments regarding those actions can be arrived at; these practices are consistent with second order science. The key to these observations lies in the recognition of the ontological difference between natural entities and those which are the product of human construction - while the "natural" entities can be referred to as "pre-given" and thus "described" (functional explanation), human constructions are always changing and requisite explanations demand mechanism and explication of relationships. This form of Constructivism is less concerned with the idea that man "constructs" reality and more concerned with the notion that "what matters" is the representations of a supposed reality that we opt to deal with at a given time. Truth is thus irrelevant and "reality" is observer dependent.

Realists and constructivists differ on the role of representations and descriptions including those which may be derived from models and their use. The constructivist will assert that a representation/ description is a human construct and is thus one step removed from that which might be called "real." “Knowing in pragmatist constructivism, is individually, culturally, and socially framed. There is no fixed reality waiting to be discovered by diligent analysis. Experience is interpreted in various ways and different people experience the same events in wildly divergent, yet internally coherent ways.” (Brookfield, 2000) The realist, by contrast, is often comfortable with judging the reality of a representation by its predictive success.

The bulk of philosophical activity in Science 1 is often based in scientific realism. "Science 1 target[s] objectivity, truth, universal laws, invariance, and context-free descriptions by the use of models of representing" (Faye 2014). By contrast, in Science 2, the focus of scientific inquiry is on the context and contingencies that have provide an environment wherein the "to be explained" occurs despite regularities. It "works with meaning and contexts, with how context influences our thinking and bestows meaning to our actions.” The related philosophical activity is most often based on forms of pragmatic constructivism.

These two perspectives have differing “takes” with regard to each of the hidden uceps. Explication of those differences can be a means of better clarifying where there is room for an ambiguity which can be embraced by both. Further, as with the hard and anticipatory science example above, the mere ability to explicate commonalities and differences is a means of providing commensurability to two communities of practice who often claim incommensurability with each other. Shared ambiguities are a key to shared discourse. For while, as a realist, Ziman (1984) may claim that "scientific theories appear as ordering principles that explain general classes of observational and experimental facts, including the taxonomies, 'laws,' causal chains and other empirical regularities that are discovered about such facts," van Fraasen (2002), as a constructivist, notes "quite to the contrary, ambiguity and vagueness not only characterize also our most precise discourse at every stage of our history but are essential to the character of discourse."

Table 3 below outlines a commensurable comparison of the two perspectives.

Table 3: How Assumed Values for the Hidden uceps are Treated

Hidden ucep	**Scientific Realism**	**Pragmatic Constructivism**
Context Dependence	Ceteris Paribus	Foci
Fundierung Dependence	Ceteris Paribus	Foci
Quantitative Indexicality	Afforded the status of “real	Ascribed status of transitive label
Holonification	Usually compartmentalized by role	Most often ignored though ascribed the transitive status of ‘as-if real’
Graining	Essential to compartmentalization	Essential to compartmentalization

Clustering	Ceteris Paribus	Usually noted and ascribed the transitive status of 'as-if real'
Communication/Attention	Amongst objects noted and amongst subjects bracketed	Foci
Anticipation	Ceteris Paribus, except for goal setting and Bayesian statistics	Treated as an affordance
Memory	Ceteris Paribus, except for evaluation procedures and Bayesian statistics	Treated as an affordance

The values in Table 3 shed new light on what can be referred to as the reification cycle of neologisms (Ison, Collins & Wallis, 2014). Once a pattern is detected, should it be given a name (the neologism), and should that name "stick" such that it becomes common usage (either amongst scientists, the public, or both), there is a tendency to afford the ontic status of "real" to the category so defined by that name and then to attribute qualities and powers to that newly reified "thing." To the scientific realist, if that now declared real thing works as either the subject or object of reliable prediction, then the ascription of "reality" to the "thing" makes sense. There appears to be neither context nor fundierung dependence and the values asserted for the other uceps are "justified" by the success of reliable prediction. Ceteris paribus is frequently asserted. By contrast, the pragmatic constructivist, having a native skepticism regarding reification and neologisms, will continue to examine the context in which the name arose, the circumstances and beliefs of those who did the naming, and compare both to the continued use of the name as a "thing." Reliable prediction will not create justification for an ascription of reality and the named "thing" will have its transitive "as-if" status prominently re-asserted in most discussions. Ceteris paribus will be rejected. Memes are a prominent example of such a reified neologism, and, should this article be well regarded, so too will uceps be.

Using memes as the example, the second order scientist might ask what would happen should the scientific realist waive some of the ceteris paribus assertions noted in the table. Do clustered and then re-grained memes acquire some new reference or status? Clearly social media gives the impression that such clustering and re-graining occurs. What status does one afford that impression? Here the roles of the pragmatic constructivist and the realist might be reversed – where constructivism discounts the "reality" of the regrouped memes and the realist is examining their predictive and explanatory power. It falls to the second order scientist to examine how such role reversals occur and their potential impact on that part of science upon which the particular perspective is taking a stance.

Example 3 – Kind of Experiences

Much effort in both the "human" sciences and in the "arts" is devoted to understanding "experience." Experiences range from the fleeting moment barely perceived as it occurs and disregarded afterwards to the identity changing – those "recognizant transformative experiences" which involve introspection, re-cognization, and re-affirmation. The fleeting kind of experience and its close kin are seldom treated in first order science as anything other than the subjects of quantitative indexicality – the individual experience (if it even gets recognized or afforded ontic status as such) is rarely of interest. The exception to this is when the studied experiences are perceived to be anomalies – such as shock or pain.

By contrast, transformative experiences tend to be focused upon individually. Transformative experiences mark segments of that flow such that experiencers attach significance to the marks whenever re-encountered or recalled. We tell our self-identity stories to both self and others. Jerome Bruner (1990) calls this our "narratives of identity: A story is a way of explaining a series of experiences that happen in a certain flow in someone's life." A change in narrative can evoke a change in identity which would then be transformative. This occurs both while the experiencer is attempting to make that encounter coherent with both his or her perceived context, fundierungs, and self-identity and his/her actions post the experience itself.

How we go about classifying and studying the various kinds of experiences will vary depending upon how we address each of the nine hidden uceps. Are such experiences indexical? Context dependent? Available to a group? The result of communication? Affected by memory? For the scientist of experience, such questions about uceps may evoke a different kind of study.

Table 4 below outlines a commensurable comparison of the two defined kinds of experiences.

Table 4: How Assumed Values for the Hidden uceps are Treated

Hidden ucep	**"Fleeting" Experiences**	**Recognizant Transformative Experiences**
Context Dependence	Equal to "content" in defining the "experience"	Seen as a potential source of cognitive dissonance which then acts as an affordance
Fundierung Dependence	Usually overlooked except as having an interpretive effect on recall and retelling	Seen as a potential source of cognitive dissonance which then acts as an affordance
Quantitative Indexicality	Only has value at the population statistics level, focus here is on individual	Only has value at the population statistics level, focus here is on individual
Holonification	Usually overlooked except as having an interpretive effect on recall and retelling	Seen as a potential source of cognitive dissonance which then acts as an affordance
Graining	Defined at the individual level	Defined at the individual level
Clustering	Usually overlooked except as having an interpretive effect on recall and retelling	Explored when there is group phenomena reported, an affordance otherwise
Communication/Attention	Usually overlooked except as having an interpretive effect on recall and retelling	Explored when there is group phenomena reported, an affordance otherwise

Anticipation	Usually overlooked except as having an interpretive effect on recall and retelling	Seen as a potential source of cognitive dissonance which then acts as an affordance
Memory	Usually overlooked except as having an interpretive effect on recall and retelling	Seen as a potential source of cognitive dissonance which then acts as an affordance

How the uceps above are treated (manipulated, described, communicated) clearly can have a role in how experiences of all kinds are described and dealt with. Second order science's role is to examine the impact of variations in the uceps. For example, a comparison of the two kinds of experiences highlighted in Table 4 sheds added light on the role of cognitive dissonance. The comparison between the two suggests that the key to "causing" a recognizant transformative experience lies in recognizing an event of cognitive dissonance and then focusing on interpretations which can remove the "dissonant" quality. In psychology, this process goes by the name "talk therapy." The second order scientist may ask what happens when a group or team is the unit of graining instead of the individual. Such graining would change the potential import of holonification, clustering and communication and thus lead to such questions as: What is the role of cognitive dissonance and how is it accomplished at the group level? Where group therapy is seen an affordance for recognizant experiences at the individual level, what is its effect at the team level? Can groups be placed in a context where a collective 'aha' moment is possible?

Example 4 – Kinds of Causality from Direct to Anticipatory (or teleological)

Exploring causality, its inference, attribution, and ascription are some of the major tasks of the modern scientific endeavor. The reliance on statistics and probability distributions has given rise to rigorous standards and tests so as to distinguish the ascription of cause from either random occurrence or mere correlation. This domain in science tends to cause much puzzlement for the lay public, as an outcome that seems highly probably and discussed as a truth in public discourse, may well turn out to be completely false as more data becomes available. A "habitable" planet (Gliese 581 g) is "observed" and then its existence is denied (Robertson, 2014). The inflation hypothesis of the "big bang" is confirmed to a "non-trivial standard" and then is dismissed as being nothing but evidence of dust (BICEP2/Keck 2015)**.** The underlying assumptions regarding randomness (independence and identical distributions) which pervade the statistical models are seldom made explicit and even less frequently challenged. The obverse condition (items with a single cause are by definition correlated) is even less seldom addressed.

What is the role of context and fundierung in describing cause? If an action is dependent upon its environment having an appropriate affordance (indirect causality), how is that causal relation described once it is noted that unattended-to affordances do not exist to the relevant actor? Lissack and Roos (1999) noted, "Interpretations can be considered as "having made sense" out of a situation. Having made sense out of it means that ambiguities have been removed, and so action is possible. By contrast, when there is a lack of sense making, when multiple interpretations are flourishing, ambiguity prevails and action avoidance is the normal result." The implications of this observation for causation are again dependent upon the ontological status, and epistemic treatment, and identity assigned to combinations of the nine hidden uceps.

The existence of indirect causality is often questioned in many of the sciences. Yet, indirect causality can be looked at as the existence or creation of an environment where the conditions (including embodiment of the assumed values for the hidden uceps) afford/allow direct causality. Causality is also not just a “truth” statement, but also an acceptance of belief by the relevant community of practice. Lack of theory at one level of graining or of clustering or communication had much to do with the decades long gap between the observation that Helicobacter pylori “caused” ulcers and the acceptance of that observation as an explanatory theory. Bracketing of the hidden uceps led to the now infamous Einstein (1950) claim: “There are no non-psychical elements in the causal system of the processes of nature. In this sense, there is no room for ‘free will’ within the framework of scientific thought.” [Of course, it is an act of “free will” to define the “relevant” values for the hidden uceps, but let us not digress.]

By failing to make the assumptions which go with the hidden uceps explicit, first order science in practice leaves itself open to errors in attributing cause. Here second order science has the potential role of revealing a hidden dependency on one of the uceps themselves. Similarly the lack of explicitness amongst the uceps can lead to scientific biases such as the errors described by Kahneman (2011): "We are ruined by our own biases. When making decisions, we see what we want, ignore probabilities, and minimize risks that uproot our hopes." By making assumptions (and in so doing restricting ourselves to a set of labels and a model) we predetermine what might be learned, which will limit the options that appear to be open to us. "We often fail to allow for the possibility that evidence that should be critical to our judgment is missing. What we see is all there is." By Gould (2010) : "We therefore fail to note important items in plain sight, while we misread other facts by forcing them into preset mental channels, even when we retain a buried memory of actual events." And by Piattelli-Palmarini (1996): "we take up only those actions and solutions that have an immediate effect on the situation, and always as they have been framed for us."

Attributions of causality play a major role in first order science. When they are wrong, they have potential to play a major negative role in Western society. It is here where the practice of second order science might find its earliest accomplishments.

Table 5 below outlines a commensurable comparison of the two defined kinds of causality.

Table 5: How Assumed Values for the Hidden uceps are Treated

Hidden Variable	Direct Causality	Indirect Causality
Context Dependence	If categorizable then sometimes recognized otherwise ceteris paribus	An enabling affordance
Fundierung Dependence	Usually bracketed ceteris paribus (with the caveat that what is	An enabling affordance

	recognized as a problem/situation about which causal information is desired is often explicitly recognized before the bracketing)	
Quantitative Indexicality	Considered the hallmark of reliability in the domain of science and distrusted in the domain of individuals	Considered the hallmark of reliability in the domain of science and distrusted in the domain of individuals
Holonification	If categorizable then sometimes recognized otherwise treated with ceteris paribus	If categorizable then sometimes recognized otherwise treated with ceteris paribus
Graining	If categorizable then sometimes recognized otherwise treated with ceteris paribus	If categorizable then sometimes recognized otherwise treated with ceteris paribus
Clustering	If categorizable then sometimes recognized otherwise treated with ceteris paribus	If categorizable then sometimes recognized otherwise treated with ceteris paribus
Communication/Attention	Ceteris paribus	An enabling affordance
Anticipation	Bracketed and ceteris paribus except when treated as an information input	An enabling affordance
Memory	Bracketed and ceteris paribus except when treated as an information input	An enabling affordance

The second order scientist would examine how the assumed values for the uceps affect the claims made regarding causality. For example, it is common to assert that "addiction" is the product of direct causality – a craving for some brain chemical which is "relieved" by the supply of the addicted to substance. Yet, nicotine patches work less than 20% of the time and most medical patients given addictive narcotics do not end up as addicts. Recent research has suggested that addiction has multifactor causality where the conditions in the environment (indirect causality) play a far greater role than brain chemical cravings. (c.f. Hari, 2015) Second order science would approach this issue by carefully explicating the ucep assumptions and then attempting variations. While assertions of causality are difficult to overcome with a study of subtleties, it is the role of second order science to examine those very subtleties.

Example 5 -- A Look at the Human Effects on Climate Change Debate

What used to be called "Global Warming" and is now most often referred to as "Climate Change" has attracted much public debate between a well proclaimed "majority" of scientists labeled as "believers," and an equally well denounced "minority" of scientists labeled as "skeptics." (The groups usually labeled as "advocates" and "deniers" tend to be political or social activists and seldom engage in science. As such they will be ignored herein.) These very terms have acquired the status of reified neologisms to which writer's causality is often attributed. Climate change is thus regarded (at least by believers) as a truth with causal powers which are properly the subject of science to be modeled and forecasted. Skeptics are seen as denying the "truth" status of the phenomenon but as accepting of the idea that science can be used to model and test forecasts made of the believer's claims. The fact that observed temperatures have failed to rise for most of the past two decades led to the abandonment of the "global warming" neologism in favor of "climate change." Of course, as neologisms, the words themselves fail to capture the subtleties of the claimed phenomenon – the climate changes all the time, what is at question is mankind's role in those changes.

In formal terms, climate change science is open about its dependence upon the processes and meanings assigned to the elements of the modeling relation. The values chosen for the uceps and the degree of freedom afforded for changes in those values all have direct effects on the outcomes of models. And, in this arena, the projected outcomes of models are the inputs of public policy debates and choices. Second order science can make a contribution here – by explicating the dependence of the models (and thus the forecasts) on ucep value choices and helping to recast the discussion from reified constructed absolutes to implicit hidden trade-offs. (For an initial example, see Aufenvenne, Egner & von Elverfeldt, 2014)

The second order science approach to the climate change debate begins by making explicit the ucep value choices inherent in each proposed model, and interpretation. The purpose of doing so would be to expose the starting positions of the scientist's queries in a manner which allows those queries to be compared to one another**.** Such an examination of the nine uceps might begin with the following observations:

1. ***Context Dependence***
   Where data is taken, how often, and what the local effects are, can have significant implications for the models being constructed to forecast climate change. So too can the vantage point of those conducting the forecasts. Warming could, for example, create a new fertile food belt in Siberia (or it could result in major methane releases as permafrost melts). Such a food belt might be viewed as a favorable outcome in Siberia and a threatening outcome in Southern Europe. Interpretations of models (the decoding regime) is thus context dependent.
2. ***Fundierung Dependence***
   The extent to which the scientist conducting any given forecast, or building any given model, is already cast as a believer or skeptic is often deemed to be an important factor in how that research, model or forecast is evaluated. Claims of "fundierung dependence" are usually made as an assault upon model, interpretation, or scientist. To combat the importance ascribed to this labeling the scientist will often stress his or her professional and methodological background and record. In doing so, the scientist reveals yet another fundierung dependence – the "academic" idea that "qualifications" afford acceptance to assertions of "objectivity" -- an idea seldom accepted even in academia.
3. ***Quantitative Indexicality***
   The extent to which any model's data (both inputs and outputs) are indeed quantitatively indexical has proven to be a critical element in both the science and the policy debate attached

to it. What is the implication of a one degree temperature rise to the planet as a whole? What are its local (non-indexical) contexts? How is one to judge claimed effects from models which calculated claimed indexicals? While much debate goes into the numbers which emerge form models and their interpretations, such questions are seldom addressed with respect to their claims of indexicality, yet it is the claim of indexicality which affords importance to the model.

4. ***Holonification***

   The extent to which inputs to models are explicitly discussed as parts and wholes has also proven critical. What is the role of the Arctic ice versus the Antarctic ice (the former seemingly shrinking the latter seemingly growing)? What is the role of deep ocean currents? Of wind patterns? Do these items merit study on their own or only as part of the Gaia system?

5. ***Graining***

   The area for which data is taken as representative and the timing intervals associated with such data are the topic of many a scientific debate concerning the relevancy and accuracy of climate models. Graining questions are another source of indexicality claims and are seldom explicitly addressed. Choices in graining affect both models and their interpretation.

6. ***Clustering***

   To the extent that the "global" model is comprised of many sub-models how those sub-models are clustered and their ability to affect one another is a constant focus of the scientific effort in this arena, yet the assumptions made regarding these interactions are seldom clearly explicated in a manner which is understandable to the policy maker. Clustering and graining may go hand in hand or may work against one another. Political-economic conditions have direct impacts on clustering at the policy level, yet the related clustering at the modeling level is all too often treated as a "black box." The second order science task is to make the workings of such boxes explicit.

7. ***Communication/Attention***

   Where the scientific effort goes into the clustering question, the criticism of such efforts tends to be directed at the communication assumed amongst sub-models and the ability of the global model to attend to or ignore local conclusions reached by sub-models. Here the role of the second order scientist is to: explicate the communication/attention parameters of a model; map those parameters against both natural phenomenon and political economic policy realities; and to then attempt to indicate what might happen should either the parameters or the mapping change.

8. ***Anticipation***

   Because climate change science is directed at forecasting, the models must explicitly (or implicitly) include anticipated behavior of both man and nature. What those anticipations are can be crucial to the outcome of the models themselves.

9. ***Memory***

   Similarly, because climate science is model driven, models are tested against known prior data. What that data set consists of is then the memory consulted by the model. Choices of prior data (of attended to memories) can and do affect the operations of the models themselves.

The scientists who do climate change research tend to regard their work as “normal experience,” but there are some powerful stories of recognizant transformative experiences where skeptics became believers (Muller, 2012) and vice versa (Bojanowski, 2014). Climate science is a Science 1 activity which involves forecasting with roots in both Science 1 and Science 2. This gives rise to conflicting beliefs and claims re each of the uceps above. The same can be said regarding the philosophical perspectives of the scientists conducting the climate change science activities.

The extent to which the “model-dependent” realists amongst them attribute causal powers to the labels (neologisms) arising from their models becomes the active field of concern for the pragmatic constructivists who will insist on the neologism being recognized and treated as a construction. It is this portion of the scientific debate which seems to have taken hold amongst policy makers, who then ask how much causal power to attribute to the labels and narratives being told (Dinan, 2015, and Blake, 2015). The constructivism portion of the debate then carries over into the allocations of cause. The very topic “climate change” is asserted as a study of direct cause (man’s effects on nature) by some and as indirect cause (man’s effects change the environment in which nature does her thing) by others. Between these perspective’s, the degree of “reality” the scientist is willing to ascribe to a given model will itself be a major determinant of a given forecast. (Millner, 2013) This means in effect that not only do policy makers and advocates express “writer’s causality” in the climate change arena, implicitly so do the scientists on whose work the meanings of the asserted neologisms are based.

It is in deciphering and explicating this vicious circle where second order science can make a meaningful contribution to the science of climate change.

Implications – Putting Metaphysics back into Science

The above discussion illustrates the import of metaphysics questions in the definition and consideration of the coding and decoding regimes in the modeling relation. The choices made for the uceps and the treatment of the values so chosen are metaphysical in that by serving as enabling constraints they act to *delimit the nature of being* in the limited world of the particular first order science practice. While the normal first order science practice is to first set forth a static definition for these regimes and then to assert ceteris paribus with regard to potential deviations, the second order science practice is to first determine the basis upon which each such regime was first so defined, then to examine the results of changes which may potentially be made to the regimes, and then to articulate the hidden metaphysical questions which any particular definition of the regimes embodies along with the implications for change. As Habermas (1996) notes, "There is no one Science which itself is neutral; scientific activity is anything but monolithic - it fragments into a number of competing viewpoints that are shot through with values." First order science sublimates these value questions into the algorithmic implementation of the coding and decoding regimes. Second order science, by focusing on the very makeup of those regimes allows values questions to resume a prominent role in scientific debate.

This can be clearly seen by exploring relations amongst the elements in Rosen's modelling relation. In the beginning (say pre Galileo or Newton), the bulk of "scientific" work took the form of improved observations in the realm of the Natural world (the A in figure 1 above) and the encoding and decoding regimes took the form of metaphors to Platonic ideal forms. In the next stage of science, metaphysics came to play a large role in better defining the encoding and decoding regimes by imposing truth and justification criteria with regard to any assertions about the relation between formal system B and Natural world A. Our modern age has taken its focus on improving the reliable predictability of that formal system and in so doing has opted to freeze any particular assertion of the encoding and decoding regimes, ceteris paribus. The argument herein is that the time has come to embark on a fourth stage where the focus shifts back to better understanding these encoding and decoding regimes and their potential variabilities.

This kind of second order science is not an examination of the behaviors, beliefs, habitus, and fundierungs of the scientists but rather is an application of the scientific method to the variabilities which underlie the metaphysics of these encoding and decoding regimes. By making these values and their choices explicit, both the modeling and the science improve.

Gooding and Addis (2008) note:

> Scientists cannot always apply ready-made terms, concepts or procedures to interpret new or surprising features of the world. Traditional views of science have emphasized the established, accepted, finished product, [an] approach [which] hides the extent to which scientists invent and negotiate ways of representing aspects of the world they are investigating the meaning of a term is not given by a finite, fixed set of necessary and sufficient conditions for its application (as analytical philosophy assumes), nor by stipulating an exact set of referents. Rather, meaning is given by sets of objects and associations that are invoked when a term is used. Membership of these sets can change. In science—as in everyday life—words and phrases often emerge from concrete situations in which participants jointly work out ways of describing what is going on. New terms, symbols or images are situated—they acquire meaning through collective use in real situations.

What second order science can do is accelerate the discovery and dissemination of "new meanings" which are themselves discovered through an examination of variations in the assumptions held regarding the hidden uceps. If these new meanings are themselves part of science, then second order science helps scientists do science. And therein lies the linkage between science and metaphysics. Vaihinger (1924) noted: "the object of the world of ideas as a whole is not the portrayal of reality - this would be an utterly impossible task - but rather to provide us with an instrument for finding our way about more easily in this world."

The caution here is to not adopt the Freidman (1953) standard to not judge a model based on the realism of its assumptions but only on the accuracy of its predictions (Pfleider, 2014). In the short term accurate predictions can help us find our way, but there is no reliable way to ensure that any given model will produce accurate long-term predictions. Only by seeking better instruments –whose use we understand – can we hope to have long term way-finding. Second order science is a methodology for finding better instruments and better tuning the ones we have.

Yet, the Einstein-lnfeld (1938) caution remains: "In our endeavor to understand reality we are somewhat like a man trying to understand the mechanism of a closed watch. He will never be able to compare his picture with the real mechanism and he cannot even imagine the possibility of the meaning of such a comparison."

Conclusion and Next Steps

> Every scientist is aware of the constant change and ambiguity in every field, but no critic of science would like to board an untested airplane or do without electricity and computers. The scientific concepts are not just true but they are not just invented. We cannot get further if we stay within concepts. But we can shift from the concepts to consider how they are generated. Instead of being trapped in the picture of nature which science presents, we can think about the process by which concepts are constantly formed and reformed in a wider context. (Gendlin, 2009)

Rosen (1985) argued that complexity was revealed by items, events, situations which could not be represented *except* by more than one model. To simplify such complex items was to ignore many of their traits. Yet, the ignored traits may be the very ones which matter in the context at hand. Former Supreme Court Justice David Souter made a similar point in a 2010 speech at Harvard:

> The explicit terms of the Constitution, in other words, can create a conflict of approved values, and the explicit terms of the Constitution do not resolve that conflict when it arises. A choice may have to be made, not because language is vague but because the Constitution embodies the desire of the American people, like most people, to have things both ways. We want order and security, and we want liberty. And we want not only liberty but equality as well. These paired desires of ours can clash, and when they do a court is forced to choose between them, between one constitutional good and another one. The court has to decide which of our approved desires has the better claim, right here, right now, and a court has to do more than read fairly when it makes this kind of choice.

Instead of a single objective account we must learn to become comfortable with multiple, partial, subjective and even conflicting accounts. First order science is uncomfortable with such an ecosystem of accounts.

To misquote (Norreklit et al, 2010), "[Second order science] implies that a continuous major task is to extract, from the phenomena [first order scientists] wish to represent, the facts which have to be considered during the process of their accounting for it. Facts will include not only objects but also actions and events [and the choices re the hidden uceps] which the accountant deems relevant." As Dewey (1934) put it, "No matter how ardently the artist might desire it, he cannot divest himself, in his new perception, of meanings funded from his past intercourse with his surroundings, nor can he free himself from the influence they exert upon the substance and manner of his present being. If he could and did there would be nothing left in the way of an object for him to see."

Second order science allows us a new manner of dealing with ambiguity and a new manner of understanding how it is that we arrive at what we ascribe as "certainty":

> "Ambiguity is not the same as uncertainty. Ambiguity can be looked at as "having not quite made sense yet." The "not quite" and the "yet" are important, since they indicate a hoped-for future state when the ambiguity will be abolished and sense will have been made. Common sense will yet prevail. By contrast, uncertainty is the lack of willingness to act. Ambiguity can lead to uncertainty, but you always have the choice of acting. When you act, you act as if you were certain. This "as if you were certain" posture underlies all purposeful action and affects potential actions. " (Lissack and Roos, 1999)

Yet, "certainty blinds the certain to the possibilities inherent in any situation... immutable certainty masks ambiguous reality." (Wilkinson, 2006). Modern science has dedicated itself to finding certainty and in so doing has opted to bracket away {in Husserl's terms] the ambiguous reality which fails to confirm to that immutable blind vision. Only by being explicit about the hidden uceps and metaphysical choices inherent in the encoding and decoding regimes of modern science can we find the tools with which to lift the limitations of our self-imposed blinders. The result is the very Deweyian notion of science we set out to achieve.

By doing science on the very modeling which constitutes science, we can gain insights to which we are otherwise blind. These insights might change our understanding of science or of the world. Such is the goal of second order science.

References

Arló-Costa,H. & Helzner, J. (2010) “Ambiguity Aversion: The Explanatory Power of Indeterminate Probabilities”, *Synthese,* Vol. 172, No. 1, pp. 37-55

Ashby, W. R. (1958). “Requisite variety and its implications for the control of complex systems.” *Cybernetica*, 1(2): 83-99.

Aufenvenne, P., Egner, H. & von Elverfeldt, K. (2014) “On Climate Change Research, the Crisis of Science and Second-Order Science”, *Constructivist Foundations*, 10, 1, 120-129

BICEP2/Keck, Planck Collaborations (2015) “A Joint Analysis of BICEP2/Keck Array and Planck Data”, as submitted to *Physical Review Letters* arXiv:1502.00612

Brookfield, S. D. (2000). “The concept of critically reflective practice.” In Arthur L. Wilson & Elisabeth R. Hayes (Eds.), *Handbook of Adult and Continuing Education* (33-49). Jossey-Bass.

Blake, A. (2015) “Americans’ increasing distrust of science — and not just on climate change”, *Washington Pos*t, January 30

Bojanowski, A. (2014) “Climate Change Debate: A Famous Scientist Becomes a Skeptic,” *der Spiegel*, May 12

Brown, N. (2014) “Cholesterol Guidelines: Myth vs. Truth -- What You Need to Know”, *Huffington Post*, February 1

Bruner, J. (1990). *Acts of meaning*. Harvard University Press.

Buchanan, R. (2009). “Thinking About Design: An Historical Perspective” in *Philosophy of Technology and Engineering Sciences* (Handbook of the Philosophy of Science, Book 9) Meijers, A et al eds North Holland pp 409-454

Carr D. , 2008, “Narrative Explanation and Its Malcontents” , *History and Theory*, Vol. 47, No. 1, pp. 19-30

Chicago Social Brain Network , 2011, *Invisible Forces and Powerful Beliefs Gravity, Gods, and Minds*, FT Press

Churchill, W. (1943) Speech to the House of Commons, 28 October.

Derman, E. (2011). *Models. Behaving. Badly: Why Confusing Illusion with Reality Can Lead to Disaster, on Wall Street and in Life*, Free Press

Dewey, J. , 1934, *Art as Experience,* Minton, Balch & Company

Dinan, S. (2015) "Climate change is real and caused by humans, majority of senators believe," *Washington Times*, January 25

Dummett, M. (1981) *The Interpretation of Frege's Philosophy*. Harvard University Press.

Einstein, A. (1950/2005) "Physics, Philosophy, and Scientific Progress." *Physics Today* 58, no. 6, 46-48.

Einstein, A. and Infield, L. (1938) *The Evolution of Physics: From Early Concepts to Relativity and Quanta*, Cambridge University Press

Empson, W. (1910/1966). *Seven Types of Ambiguity*, New Directions

Ernstene, et al (1961) "Dietary Fat and Its Relation to Heart Attacks and Strokes", Report by the Central Committee for Medical and Community Program of the American Heart Association, *Circulation*, 23, January

Faye, J. (2014). "Explanation Revisited" in Lissack and Graber, *Modes of Explanation: Affordances for Action and Prediction*, Palgrave Macmillan

Feyerabend, P. (1962). "Explanation, Reduction and Empiricism", in H. Feigl and G. Maxwell (ed.), *Scientific Explanation, Space, and Time*, (Minnesota Studies in the Philosophy of Science, Volume III), University of Minneapolis Press, pp. 28–97.

Fitzgerald, F. S. (1945). *The Crack-Up*, New Directions

Frege, G., 1948 [1892]. "Sense and Reference," *The Philosophical Review*, 53: 209–230.

Friedman, M. (1953). "The Methodology of Positive Economics." In *The Methodology of Positive Economics*, University of Chicago Press, 3-43.

Gadamer, H.G., 1960. *Warheit und Methode [Truth and Method*]. Tubingen.

Gendlin, E. (2009). "We can think with the implicit, as well as with fully formed concepts". In Karl Leidlmair (Ed.), *After cognitivism: A reassessment of cognitive science and philosophy*. Springer. pp. 147-161.

Gooding, D and Addis, T. (2008). “Modelling Experiments as Mediating Models”, *Foundations of Science* 13:17–35

Gould, S (2010). *Triumph and Tragedy in Mudville: A Lifelong Passion for Baseball*, WW Norton

Habermas, J. (1996) *Between Facts and Norms: Contributions to a Discourse Theory of Law and Democracy*, tr. William Rehg. MIT Press.

Hari, J. (2015) *Chasing the Scream: The First and Last Days of the War on Drugs,* Bloomsbury USA

Hawking, S. and Mlodinow, L (2010). *The Grand Design*, Bantam Books

Hugo,V. (2005). *The History of a Crime*, Mondial

Ison, R., Collins, K., and Wallis, P. (2014). “Institutionalizing social learning: Towards systemic and adaptive governance, Environmental Science & Policy” (in press)

Kahneman, D. (2011) *Thinking Fast and Slow*, Allen Lane

Keys, A. (1970) “Coronary heart disease in seven countries”. *Circulation*, 41 (suppl 1):1--211.

Keys, A. (1980) *Seven countries: a multivariate analysis of death and coronary heart disease.* Harvard University Press

Kromhout, et al, (1989) “Food consumption patterns in the 1960s in seven countries”, *American Journal of Clinical Nutrition*, 49, 889-94

Kuhn, T. (1962). *The structure of scientific revolutions*. Chicago University Press.

Lakatos, I (1970),"Falsification and the Methodology of Scientific Research Programmes" in *Criticism and the Growth of Knowledge*, Lakatos, I and Musgrave, A, Eds.,Cambridge University Press.

Lawrence, J. (2014) “Genes influence response to statins, research finds”, *The Pharmaceutical Journal,* November 3

Lissack, M. and Graber, A. (2014) *Modes of Explanation: Affordances for Action and Prediction*, Palgrave Macmillan

Lissack, M., and Roos, J. (1999), *The Next Common Sense: Mastering Corporate Complexity through Coherence,* Nicholas Brealey Publishing

Louie, A. (2009). *More Than Life Itself: A Synthetic Continuation in Relational Biology*, Walter de Gruyte

Lupton, D. (2013). *Risk:*, Routledge

Lynas, M. (2015) "Even in 2015, the public doesn't trust scientists," *The Washington Post,* January 30

Millner, A., Dietz, S., & Heal, G. (2013). "Scientific ambiguity and climate policy". *Environmental and Resource Economics*, 55(1), 21-46.

Morin, E. (2008). *On Complexity* (Advances in Systems Theory, Complexity, and the Human Sciences) Hampton Press

Mueller, K. (2014) "Towards a General Methodology for Second-Order Science," *Systemics, Cybernetics And Informatics*, 12, 5, 33-42

Muller, R. (2012) "The Conversion of a Climate-Change Skeptic," *New York Times*, July 28

Noe, A. (2012) *Varieties of Presence*. Harvard University Press

Nørreklit, H., Nørreklit, L. and Mitchell, F. (2010), "Towards a paradigmatic foundation for accounting practice", *Accounting, Auditing & Accountability Journal*, Vol. 23 No. 6, pp. 733-58.

Nye, A. (1990) *Words of Power: A Feminist Reading of the History of Logic*, Routledge

Piattelli-Palmarini, M. (1996). *Inevitable Illusions: How Mistakes of Reason Rule Our Minds,* Wiley

Planck, M. (1968) *Scientific Autobiography and Other Papers*. Greenwood

Pleiderer, P. (2014). "Chameleons: The Misuse of Theoretical Models in Finance and Economics", on-line at http://stnfd.biz/v9YKB #finance

Popper, K. (1959/1974). *The logic of scientific discovery.* Hutchinson.

Riegler, A. and Mueller, K. (2014) "Special Issue of on Second-Order Science", *Constructivist Foundations* Vol. 10, No. 1.

Robertson, P. (2014). "Stellar activity masquerading as planets in the habitable zone of the M dwarf Gliese 581", *Science*, Vol. 345 no. 6195 pp. 440-444

Rosen, R. (1985). *Anticipatory Systems*. Pergamon.

Slife, B. & Williams, R. (1995). *What's behind the research: Discovering hidden assumptions in the behavioral sciences*. Sage.

Souter, D. (2010) Speech at Harvard University

Taleb, N. (2007) *The Black Swan*, Penguin

Umpleby, S. (2014) “Second-Order Science: Logic, Strategies, Methods” *Constructivist Foundations*, Vol. 10, 1, 15-23

Vaihinger, H. (1924/1911). *The philosophy of 'as if': A system of the theoretical, practical, and religious fictions of mankind* (C.K. Ogden, Trans.). Routledge & Kegan Paul.

van Fraasen, B. (2002). *The Empirical Stance*, Yale University Press

Whoriskey, P (2015) “The U.S. government is poised to withdraw longstanding warnings about cholesterol,” *Washington Post,* February 10

Wilkinson, D. (2006). *The Ambiguity Advantage: What Great Leaders are Great At*, Palgrave Macmillan

Ziman, J. (1984). *An Introduction to Science Studies: The Philosophical and Social Aspects of Science and Technology*. Cambridge University Press.