Invitation

Introduction to Second-Order Science Research

To be held during the February 2017 meeting of the American Association for the Advancement of Science

Saturday, February 18, 2017

Sheraton Boston Hotel

Hampton Room 12:30 pm to 4:30 pm

We will be having a brainstorming and planning session on the materials attached. The goal will be to submit one or more projects for National Science Foundation funding.

Questions to Michael Lissack lissack@isce.edu **or 1-617-710-9565**

Note: Free to attend and no AAAS registration required

RSVP's requested but not mandatory

PLEASE SHARE THIS INVITATION WITH THOSE YOU THINK MIGHT BE INTERESTED

This session is being organized by the American Society for Cybernetics

Introduction to Second-Order Science Research

Background: Scientific research in the special and sentient sciences has faced an increasing number of challenges regarding robustness, reliability, and relevance. In September 2016, the SBE division of NSF issued a "Dear Colleague" letter seeking new approaches to deal with questions of robustness and reliability. At the beginning of 2016, Foundations of Science published two articles (Lissack, 2016a, 2016b) which proposed a research framework where the scientific method was used to examine critical assumptions and processes embodied in any given scientific research project. That framework is amplified and extended in the article attached. This "use science to take a critical look at the practice of science" was referred to as "second-order science." (Other authors have applied the same term somewhat differently see http://secondorderscience.org). This memo and the attached article serve an introduction to a proposed research project using second-order science.

Concept: Any scientific project in the special and sentient sciences makes a series of assumptions and presumptions concerning the world and both the context of and the content of the research. Some of these assumptions are well articulated; some are not. Some of the rationale behind the choices made in asserting these assumptions are well articulated; some are not. We can use peer reviewers to rate the perceived sensitivity of the research project's methods and results to potential changes in the underlying assumptions on a scale ranging from fragile to robust. (Fragile would indicate a high degree of potential sensitivity/dependence to potential assumption changes. Robust would indicate a belief that the results and methods should remain fairly constant regardless of any such change.) Assumptions would be rated along the ten categories outlined in Lissack 2017 with the results then provided to the original research team. The follow-up will then examine if possession of this input by the research team made any difference in research method, presentation of results, or presentation of project relevance.

Goal: To determine (on a preliminary basis) if examining projects for sensitivity/robustness to critical presuppositions is a means of operationalizing queries regarding robustness and reliability.

Projects to be examined: Ten to twelve ongoing research projects in or tangent to the SBE domain which are projected to be ongoing for at least another year and which publish interim results. (Interim results are necessary in order to have data for peer reviewers to assess. Ongoing projects are necessary so that there is time for the second order science data to be considered in the context of the underlying research projects themselves.)

Methodology:

1. For each selected research project, the project PI or team will be asked to identify 20-25 potential peer reviewers. (In this first round, it is critical that the peer reviewers be chosen by the underlying research team – this self-selection will maximize the likelihood that the survey results will be both considered by the underlying research team and taken seriously. Subsequent rounds of research may alter this protocol.)
2. The identified peer reviewers will be contacted and given background briefings on the goals of the second order science project as a whole and the concept of the UCPs in particular. They

will then be supplied with a set of interim publication/write-up data from the underlying project. Each peer reviewer will be asked three things:

- Rate the project's methods on the fragile/robustness scale for each of the UCP categories.
- Rate the project's interim results on the fragile/robustness scale for each of the UCP categories.
- Rate perceived tradeoffs amongst the UCP categories as they may apply to the underlying project.

3. The data will be aggregated. Both the aggregate data and individual reviewer comments will be presented back to the underlying project team.
4. The underlying project team will be surveyed for their reaction to the data so presented, and their responses will be presented in an aggregate form across the set of underlying projects.
5. The aggregate second order science data will be presented to all underlying project teams and all the peer reviewers. The collected set of peer reviewers will be surveyed as to their reaction to the data.
6. Six months will be allowed to pass.
7. Each underlying project team will be surveyed regarding changes which may have resulted from the knowledge of the second order science data by the research team.
8. Another six months will be allowed to pass.
9. Each underlying project team will again be surveyed regarding changes which may have resulted from the knowledge of the second order science data by the research team.
10. To the extent that new write-ups/publications are available which originated in this second six-month period, these will be sent out to the originally identified peer reviewers. They will be asked to comment on whether they perceived any change regarding:
    - The project's methods' sensitivity on the fragile/robustness scale for each of the UCP categories.
    - The project's interim results' sensitivity on the fragile/robustness scale for each of the UCP categories.
    - The perceived tradeoffs amongst the UCP categories as they may apply to the underlying project.

    This peer review data will be aggregated and presented along with the project team data.

Challenges:

1. Identification of underlying research projects to be examined
2. Education of the identified peer reviewers regarding this second-order science project and UCPs
3. Getting the languaging (vocabulary, jargon, context) right regarding the UCP concepts

Expected Outcome: Demonstration of whether the explicit consideration and articulation of choices made regarding UCPs can enhance the perceived robustness and reliability of SBE research.

Attachments: September 2016 Dear Colleague Letter (SBE Division of NSF)
Article: *Testing for Unexamined Critical Presuppositions (UCP's) in the Social, Behavioral, and Economic Sciences* (submitted to Foundations of Science, http://bit.ly/2i5KEIN

NSF 16-137

Dear Colleague Letter: Robust and Reliable Research in the Social, Behavioral, and Economic Sciences

September 20, 2016

Dear Colleague:

With this Dear Colleague Letter, the Directorate for Social, Behavioral, and Economic Sciences (SBE) announces its interest in stimulating research and other activities to enhance the robustness and reliability of research in the social, behavioral, and economic sciences. As defined in the SBE Advisory Committee 2015 report, *Social, Behavioral, and Economic Sciences Perspectives on Robust and Reliable Science* <http://www.nsf.gov/sbe/AC_Materials/SBE_Robust_and_Reliable_Research_Report.pdf> , "robust and reliable" science refers to research that is reproducible, replicable, and generalizable. Reproducibility refers to the ability of a researcher to duplicate the results of a prior study using the same materials and procedures used by the original investigator. Replicability refers to the ability of a researcher to duplicate the results of a prior study if the same procedures are followed but new data are collected. Generalizability refers to whether the results of a study apply in other contexts or populations that differ from the originals. Robust and reliable research is the foundation of all scientific development and progress, which depends critically on the ability of investigators to build on prior work.

To enhance the robustness and reliability of fundamental research in the social, behavioral, and economic sciences, SBE invites the submission of proposals for the following types of projects to its standing programs:

- Research to determine the extent of, causes of, or remedies for research in the social, behavioral, and economic sciences that is neither replicable, reproducible, nor generalizable;
- Methodological development to improve the robustness/reliability of research in the social, behavioral, and economic sciences (e.g., improvements in study design, data-sharing techniques, analytic techniques);
- Outreach/training/workshops designed to enhance the robustness and reliability of research in the social, behavioral, and economic sciences, including increasing acceptability of explicit research in this area; and

- Reproductions, replications, or generalizations of seminal or pivotal studies that have served a demonstrably critical role in conceptual or empirical progress in the social, behavioral, and economic sciences, including generalizations that demonstrate validity in atypical or nontraditional populations and samples. Reproduction, replication, or generalization projects require clear justification of the fundamental role of the seminal or pivotal studies in the scientific advance of social, behavioral, or economic sciences.

Investigators interested in this opportunity should submit proposals to the most relevant SBE program and designate the proposal as being related to robust and reliable science by including "RR:" at the beginning of the proposal title. SBE's programs are described on the following websites:

- Division of Behavioral and Cognitive Sciences: http://www.nsf.gov/funding/programs.jsp?org=BCS <http://www.nsf.gov/funding/programs.jsp?org=BCS> ;
- Division of Social and Economic Sciences: http://www.nsf.gov/funding/programs.jsp?org=SES <http://www.nsf.gov/funding/programs.jsp?org=SES> ; and
- SBE Office of Multidisciplinary Activities: http://www.nsf.gov/funding/programs.jsp?org=SMA <http://www.nsf.gov/funding/programs.jsp?org=SMA> .

Successful research proposals will have scientifically sound research plans that are explicitly rooted in relevant theory and literature. Proposals will be evaluated using the standard National Science Board approved merit review criteria of intellectual merit and broader impacts, as well as their potential contribution to enhancing robust and reliable science. Specific questions about an SBE program should be directed to the program director of the program. This is not a special competition or new program; proposals in response to this Dear Colleague Letter must meet the requirements and deadlines of the program to which they are submitted.

Sincerely,
Dr. Fay Lomax Cook
Assistant Director
Directorate for Social, Behavioral & Economic Sciences

Testing for Unexamined Critical Presuppositions (UCP's) in the Social, Behavioral, and Economic Sciences

By Michael Lissack

President, American Society for Cybernetics

Executive Director, Institute for the Study of Coherence and Emergence

14 Stratford Rd

Marblehead, MA 01945

lissack@isce.edu

617-710-9565

305-513-5658 (Fax)

Michael Lissack is the Executive Director of the Institute for the Study of Coherence and Emergence, President of the American Society for Cybernetics, ISCE Professor of Meaning in Organizations, Professor of Design and Innovation at Tongji University, Visiting Fellow at Hull University Business School, and an Affiliate Member of the Center for Philosophy & History of Science at Boston University. His books on the philosophy of science are published by Palgrave MacMillan and his articles have appeared in *Foundations of Science*, *Kybernetes*, *Constructivist Foundations*, *Cybernetics and Human Knowing, and She Ji: The Journal of Design, Economics, and Innovation.*

Testing for Unexamined Critical Presuppositions (UCP's) in the Social, Behavioral, and Economic Sciences

By Michael Lissack, President, American Society for Cybernetics

Abstract*:* *The Social, Behavioral and Economic sciences (SBE) are facing pressure from government agencies and scholars from other disciplines regarding the robustness, reliability, and relevance of the research being performed. This article describes how to operationalize one methodology for improving such robustness, reliability, and relevance – Second-Order Science. Second-Order Science applies the scientific method to generate and question potential variations in any given SBE research program by seeking to make explicit the presuppositions which underlay its models. These presuppositions answer three questions which go to the essence of how the humanness of the actors being studied is transformed into the representational rigor of a scientific model. What is being observed? How do the observed actors interact (with each other and with their surroundings)? How is meaning ascribed to observations (both by the actors being studied and by the scientists doing the observing)? Far too often, the values assumed in these presuppositions are not disclosed nor is there any discussion of alternate value choices and their potential consequences. Decision-makers who act in reliance on these models are thus being deprived of information which may well affect their decision making. By asking about the effect of variations in these assumed values (doing science on the science), Second-Order Science can reveal fragility and robustness and thereby contribute to reliability and relevance. Second-Order Science is in need of supporting experimentation to assess its validity. The article describes how such experimentation might be carried out.*

Keywords: Model, Ambiguity, Dependence, Science, Decision-Making, Assumptions

"When my information changes, I alter my conclusions. What do you do, sir?" (Keynes, 1987)

Science involves an interplay amongst evidence, theory, and prediction which has as its goals the improvement of understanding and perhaps the explication of "truth." When theory and evidence combine to allow for successful prediction, we find confirmation in the soundness of the scientific method and the general concept of the "progress" of scientific understanding. But, predictions are not always successful, and emergence all too often rears as an unexpected variable. Scientists have many tools at their disposal for limiting the occurrence of such failures – chief amongst these is the assertion of a set of assumptions which serve to bracket away ambiguity and its likely sources – including multiple meanings, the role of the observer or interpreter, emergence and more. These assumptions get made and then are hidden. This paper argues that the unarticulated deployment of these ambiguity-reducing tools limits the value of any scientific inquiry – especially those in the Social, Behavioral, and Economic Sciences ("SBE"). Instead, it is critical that these tools be rendered explicit, and that consideration be given to what happens when the values employed in the tools as deployed are altered.

Assertions of assumptions to bracket ambiguity 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. (c.f. Hayles, 2001, Juarrero, 1999, Lissack and Graber, 2014) The use of these enabling constraints amounts to what Lakatos (1970) called a protective belt, blocking inquiry into fundamental questions of how the constraints are chosen and what happens when they are altered. This dynamic - that of ignoring potential ambiguity in the interests of efficiency and greater predictive reliability -- is captured in the seeming omnipresence in both scientific practice and the managerial/decision-making communities 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 real world, models as reality become the basis for decision making. But, it is critical to remember that the models work due to the imposition of a set of assumptions made upfront – assumptions which are then not explicitly communicated to those viewing, using, and relying on the model. Instead, the models used have an implicit dependency on assertions of ceteris paribus – to the extent that one enquires about the effect of a potential change in the value of a critical upfront assumption, the response is to state: the model works "all other things being equal," and you are asking about something being not equal. The model does not test for that.

Ceteris paribus assertions may be useful for scientific inquiry, but they raise serious concerns re real-world implementation. Predictions and explanations predicated on ceteris paribus demand interpretation if they are to have meaning once the ceteris paribus constraint is relaxed. Often the real world's implementation of declared inputs and variables differs from the narrow ceteris paribus conditions assumed by the scientists' rigorous models. As such, the protections (if any) offered by Lakatos' suggestive belt become counterproductive.

The scientist's rigorous models may indeed result in successful predictions – but only within the narrow sphere or domain in which the ceteris paribus constraints hold. The scientist may then assert that the results of the model so derived describe the "essence" of the issue at hand, such that ambiguities do not matter. (c.f. Vaihinger, 1924) But, the very situations which decision-makers face are explicitly concerned with such ambiguities and their resolution. Their focus is specifics not essences.

SBE is one of the foundations upon which the managerial community and other decision-makers turn raw observations into coherent narratives, situational analyses, and predictions. That foundation has a crack, and the crack is widening. SBE is about humans – their interactions, communications, and activity. Humans are not homogeneous, rational, nor indexical. Far too many SBE studies assume they are. Such bad assumptions allow the powers of computers, statistics, and mathematical modeling to be deployed in the pursuit of "science."

Physics and the other hard sciences succeed by focusing on objectivity. SBE tries to recreate that objectivity through math. But, subjectivity, emotion, context, and habitus cannot be captured through Bayesian statistics. To the extent that decision-makers process observations through an SBE lens which fails to account for the "humanness" of humans, faulty interpretations are likely. This paper argues that managers and decision-makers need a different kind of SBE. In the complexity and cybernetics communities, we call this Science 2. (c.f. Lissack and Graber, 2014). We can distinguish between the Sciences of Objects (Science 1) and the Sciences of the Sentient (Science 2).

The Sciences of the Sentient

"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". Lissack and Graber (2014)

The sciences of the sentient will require different languages than are commonly used in the Science 1 hard sciences of non-sentient beings. "The main function of self-consciousness is to provide integrated internal representations of the outer world and of our organism based on actual experiences, perceptions and memories providing reflected responses to the needs of our environment for the purpose of our orientation in the world.” (Newen and Vogeley, 2003) "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)

Science 1 and Science 2 further differ 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 many of the dependencies which categorize our human centered world. "Science 1 target(s) objectivity, truth, universal laws, invariance, and context-free descriptions by the use of models of representing" (Faye 2014).

By contrast, context dependence and its ilk are the hallmarks of Science 2. Science 2’s objective and purpose are discovery and attunement to context. In Science 2, the focus of scientific inquiry is on the context and contingencies that have provided an environment wherein the "to be explained" occurs and where regularities alone fail to be explanatory. It "works with meaning and contexts, with how context influences our thinking and bestows meaning to our actions." (Faye, 2014) 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.

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 1 is derived from Lissack and Graber, 2014, Lissack, 2016b, 2017b)

To the extent that a business assessment or policy decision is based upon a Science 1 type theory, it is critical to recognize the assumptions about human behavior which were made so as to allow any related statistical analysis to be performed (Csaszarand Levinthal, 2016). Most of the time, these assumptions are NOT articulated nor otherwise made explicit. The absence of that explicitness prevents consideration of variations in those very assumptions. Consideration of such variations may lead to very different assessments and decisions. Therefore, it is essential for our SBE inquiries to be explicit about the potential effects of changes in underlying assumptions. The technique for doing so we call **Second-Order Science** (c.f. Lissack, 2016a, 2016b, Mueller, 2014, Riegler and Mueller, 2014, Umpleby, 2014).

The Assumptions Needing to be Questioned

SBE inquiries involve assumptions which answer the following questions:

1) What is being observed?
2) How do the observed actors interact (with each other and with their surroundings)?

3) How is meaning ascribed to observations (both by the actors being studied and by the scientists doing the observing)?

The answers to these questions tend to be assigned at the beginning of an inquiry, and then, like the saying in the once ubiquitous Ronco rotisserie ads, "you set it and forget it." The assumptions become pre-suppositions, taken for granted as the very basis of the inquiry, and hiding the possibility of change. Once the SBE scientist has established answers to the questions above and performed whatever research which underlay a given model, the effects of other potential answers are usually met with a ceteris paribas claim. But, if the test is real-world applicability, being satisfied with initial assertions is not good enough. As described above, Second-Order Science is the science which examines what happens to scientific query and results when ceteris paribus constraints are relaxed. Lissack (2016a, 2017a) identified nine (now expanded to ten) categories of such constraints. For purposes of discussion, we will label these categories as "**UCPs**" -- Unexamined Critical Presuppositions. These ten categories (and there may be more) describe the answers to the three questions above.

What is being observed?

Graining: The size of the items being examined as parts of the system being examined. 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. The issue here is making the range of potential choices regarding size of the unit of analysis explicit and recognizing that a choice amongst them was made.

Clustering: The extent to which the units being examined are afforded the status of being clustered together as sub-systems, where the resulting sub-system in then ascribed "item" status in terms of graining. As with graining, the issue here is making the range of potential choices explicit.

Homogeneity: Are the observed actors described as being homogeneous (in whole or part) for the sake of statistics or for the sake of having properties being examined reduced to a set of categories. When the individual actors are only being considered as representative members of a category, the inquiry is asserting a degree of indexicality – the notion that items stand for the category as a whole. Quantitative indexicality is the extent to which numbers are used to represent the objects of study. (c.f. Rosch, et al., 1976, Corazza, 2004, Johnstone and Kiesling, 2008). Studies of traffic flows (stadiums, highways), for example, have a heavy dependence upon homogeneity which is expressed as quantitative indexicality. By contrast, long-tail marketing is based on a rejection of the homogeneity concept (outliers being marketed too are not represented by the asserted indexical). The relative success and failures of polling and market surveys have as much to do with whether the population to be described is capturable by a quantitative indexical as it is with how that indexical is calculated.

Parts and wholes: The extent to which the items being examined (the actors, the system, etc.) 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. It is the skin that integrates both the environment of the holon for its parts and the parts for the environment. (c.f. Checkland, 1988, Schillo, et al., 2003) To the extent that either models or the processes being modeled are holonic, it is likely that descriptions which apply to the role of "part" will differ from those which apply to the role of "whole." Further complexity is introduced to the extent that the system or situation being modeled is "nearly decomposable" (Simon, 2002). Much meaning will be found in the representations of and subsequent interpretations of the "nearly."

How do the observed actors interact (with each other and with their surroundings)?

Attention: The extent to which the actors being studies are afforded the ability to attend to particular information items (on a scale which might include being ignored). This UCP is very hard to model in a quantitative manner that, in turn, is reflective of real-world situations. Instead, assumptions tend to be made for the sake of the model itself. What we pay attention to (and what we ignore) are potent factors in any real-life situation and, as such, their representation or lack thereof in any SBE model represents the kind of ceteris paribus assertions which decision-makers need to be made explicitly aware of.

Communication: The extent to which the actors in the system are afforded the ability to exchange information (both within and outside the system). This UCP is easy to model if one ignores the content of the communication and conversely very hard to model when one is concerned with the meaning being transmitted rather than the mere the act of message transmission. As with attention, assumptions tend to be made for the sake of the model itself. Communications can play important roles in real-life situations. Potentialities and limitations regarding communication abilities in any SBE model are likely to play a significant role in the ability of that model to mirror the real-world to the satisfaction of decision-makers.

Anticipation: The extent to which either individual actors or the system as a whole is afforded the ability to anticipate what a not yet incurred interaction might do with regard to a stated variable or condition which is explicitly examined with regard to any of the other nine UCPs. Real-world actors anticipate. As with communication and attention, it is difficult to model this UCP in a quantitative manner that in turn is reflective of real-world situations.

Memory: The extent to which a prior state of an item, the system, or a data point treated as information by either an actor or the system is preserved for access and afforded some ontic status. In turn, that "memory" is allowed to be recalled, labeled, or brought forth as a current input. While many SBE models make use of the concept of memory, few do so in a manner reflective of real-world situations.

How is meaning ascribed to observations (both by the actors being studied and by the scientists doing the observing)?

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. (c.f. Bach, 2012, Loucks and Pechey, 2016) SBE inquiries are highly likely to be context-dependent. Marketers are well aware of such context dependence, but few other SBE sciences make context dependence an explicitly articulated variable.

Mindset Dependence: The extent to which observations, data, and interpretations are dependent upon the belief set and habitus of the observer. Dependence is further qualified by the notion of "taken for grantedness." Husserl used the term "fundierung" to describe the "taken for grantedness" of that belief set and habitus. The key insight here is that the observations are not objective, but, instead, are dependent upon the prior beliefs, engrained models, and heuristics available to the observer. (c.f. Haugaard, 2015, Rips, 2011) Most sociology, psychology, and political science inquiries cite literature which makes explicit, or at minimum alludes to, mindset dependence as a general concept. What is missing, much of the time, is explicit descriptions of what is assumed to be in the fundierung relationships or habitus -- which in turn affect both the observed behaviors and the interpretations thereof. For example, asking the attendees at the Iowa State Fair to randomly guess the weight of a hog is likely to crowdsource a correct answer, whereas asking that same question to traders on the floor of the NY Stock Exchange is not. Neither observation will tell you much about the efficacy of crowdsourcing. The difference is mindset in terms of both fundierung and habitus. The Iowans have had far more exposure to hogs and due to more experience about guessing their weights can do it without much thought as to "how." The New Yorkers have neither exposure nor related experience and thus will need to focus on "how" to guess before guessing.

Values chosen for UCPs matter. But, most of the time those values are hidden from view. Not only are the values themselves seldom stated in the explication of the research and its results, but the very idea that the values were ***chosen*** by the research team from amongst a range of other possible values is also suppressed. Thus, some of the very data which decision-makers need to better use scientific theory and models in their decision making is denied to them. Presuppositions can be critical to the real-world success or failure of the models based on them.

Looking at the list of UCPs above, it seems clear that the values assumed for some of them will play a major role in the reliability asserted with regard to predictions, especially causal predictions. Both context and mindset can be significant determinants 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? Outside of science itself, actions by the public, or governments, or significant actors may pre-suppose that the predictions made are reliable and that the expected causal consequences are clear. As 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."

But, and this is an important but, if the predicted causal consequences do not occur (perhaps due to exigencies, perhaps due to context, or perhaps due to insignificant attention being paid to the role of indirect causation), the underlying model will be deemed “faulty” by the relevant decision-makers. (Witness the debates about polling following the 2016 elections.) They will further tend to question the underlying theory. Such questioning is not a problem of the science per se, but rather a consequence of the SBE work failing to consider exigencies, paying insufficient attention to the role of indirect causation, or ignorance of hidden constraints such as context.

The issue is not with the modeling per se being done, but with the absence of communication about critical assumptions which inform that model. No SBE scientist has an omniscient window on "truth." The assumptions made to allow for modeling and statistics are based upon the beliefs of the scientists performing them – not on "truth." If SBE is to maintain a foundational role, it must find a way to get scientists to explicitly recognize and communicate about these assumptions AND to be willing to rerun analyses to test for fragility/robustness if other assumptions were made. Our supposed faith in models and statistical reliability disguises our fear of dealing with the ambiguous, the uncertain, and the unknown. An r-squared of .89 cannot “explain” the motivations which distinguish a committed protester from a suicide bomber. But, the safety of hundreds may depend on having just such an understanding.

Next Steps (Experiments to be Done):

Scientific research in the special and sentient sciences has faced an increasing number of challenges regarding robustness, reliability, and relevance. In September 2016, the SBE Division of the National Science Foundation issued a “Dear Colleague” letter seeking new approaches to deal with questions of robustness and reliability. In theory, the Second-Order Science approach outlined above can help to address some of these challenges. What is needed is for that theory to be tested in practice. Experimental projects are necessary to determine (at least on a preliminary basis) if examining projects for sensitivity/robustness to UCPs is a means of operationalizing queries regarding robustness and reliability.

A proper test would involve ten to twelve ongoing research projects in or tangent to the SBE domain which are projected to be ongoing for at least another year and which publish interim results. (Interim results are necessary in order to have data for peer reviewers to assess. Ongoing projects are necessary so that there is time for the Second-Order science data to be considered in the context of the underlying research projects themselves.) Let us call these projects the First Order Subjects (FOS). The subject matter of the FOS to be examined is open, and ideally, the examined set will include variety. Any scientific research project in the special and sentient sciences makes a series of assumptions and presumptions concerning the world, the context of the research and the content of the research. Some of these assumptions are well articulated; some are not. Some of the rationale behind the choices made in asserting these assumptions are well articulated; some are not. Restricting the inquiry to those FOS projects which publish interim results provides access not only to the process, results, and artifacts of the first order science subjects but also the opportunity to see if feedback regarding their projects from a Second-Order Science perspective makes any difference as the FOS projects progress.

Each targeted FOS would be asked to name a significant number (20-25) of potential reviewers to conduct the Second-Order Science inquiry. These peer reviewers would be asked to rate the perceived sensitivity of the FOS's methods/results to potential changes in the underlying assumptions/presumptions on a scale ranging from fragile to robust (where fragile would indicate a high degree of potential sensitivity/dependence to potential assumption changes and robust would indicate a belief that the results/methods should remain fairly constant regardless of any such change.) Assumptions/presumptions would be rated along the nine UCP categories outlined above with the results then provided to the original FOS research team. Because the input will be coming from a team of reviewers known to the FOS project team, it will be possible for both the team and the reviewer to explore perceived fragilities and how they might be addressed. A one year later follow-up will then examine if possession of this Second-Order data made any difference in research method, presentation of results, or presentation of FOS project relevance.

If several such Second-Order Science projects are undertaken, the ability of Second-Order Science to make a difference regarding traditional SBE and Science 2 inquiries will be clear. The proposed projects outlined above are discrete, replicable, and measurable. If they produce meaningful results (defined as observable and measurable changes in process, results or artifacts produced by the underlying FOS projects), at least a partial solution to the challenges NSF's SBE Directorate outlined in September 2016 will have been operationalized. If after such project inputs, the underlying FOS projects undergo no change, then further traditional SBE work can be done to examine how and why reflexive input (c.f. Brookfield,2000) on critical assumptions had little to no effect on ongoing research projects. (Or, in the alternative, how it was that the UCPs proved to NOT be critical assumptions.)

Doing Second-Order Science

Second-Order Science is a study of the processes, results, and artifacts produced by ordinary (or first order) science. The goal of a Second-Order Science inquiry is to test the fragility/robustness of both processes and results with regard to potential changes in the values assumed for the UCPs. When looking at artifacts, the Second-Order scientist would examine how the assumed values for the UCPs affect 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 UCP 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.

By failing to make the assumptions which go with the hidden UCPs explicit, SBE 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 or more of the UCPs themselves. 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." (Kahneman, 2011)

Instead of actively discussing the multiple approaches which may all be interpretations, enactments, decodings, or embodiments of a model, Science 1 often leads us to act as if there is but one meaning defined by its label. Science 2 implies that a continuous major task is to extract, from the phenomena Science 1 wishes to represent, the facts which have to be considered during the process of the scientists’ accounting for it. Facts will include not only objects but also actions, events, and the choices re attended-to meanings on the part of the observed actors which the accountant deems relevant. (c.f. Norreklit et al., 2010, Rorty 1991, Vaihinger, 1924)

Two sets of choices qualitatively distinguish the data sets of Science 2 from those of Science 1. First is the choices of attended-to meanings on the part of the observed actors and second is the choice of relevant variables by the scientist. This paper is arguing that much more attention needs to be paid to both of these choices. They need to be laid out as explicitly as possible, tested for variance effects, and communicated as part of the results. SBE without such explicitness only works in a world which is static and well known. Such worlds are not the general concern of managers nor decision-makers (c.f. Csaszar and Levinthal, 2016). By definition, these folks are concerned with change and potential change – not stasis. They cannot deal with a warning of ceteris paribus unless they are given the tools to understand potential variations. It is the role of Second-Order Science to help create such understanding.

The caution here is to ensure that we do not adopt the Freidman (1953) standard -- where a model is judged not on the realism of its assumptions but only on the accuracy of its predictions (Pfleider, 2014). Science 1 models may have high short-term predictive accuracy, but if the assumptions which provided that accuracy are not exposed, made explicit, and variance tested for fragility and robustness, then even medium-term dependence may be risky. Unlike the world of physics, humans keep changing their world. If SBE is to be useful, it must explicitly take into account such changes. Stasis is but an illusion.

"All interpretations made by a scientist are hypotheses, and all hypotheses are tentative. They must forever be tested, and they must be revised if found to be unsatisfactory." (Mayr, 1982)

Meaningful SBE demands explicit consideration of UCPs. Second-Order science inquiries must be viewed as a prerequisite for the successful integration of SBE work into the real-world assessments and decisions made by managers and policy makers. SBE without such consideration is belief, not science, hidden inside a model. Second-Order Science may be the future of SBE.

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