Models and Metaphors Lesson Plan

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Abstract: This document contains the basis course plan for one or several lessons on the usage of models and metaphors in theory and practice. Metaphors and models are heuristic devices for processing and structuring of information. In this lesson plan, we will show how they can be used to structure and interpret information in the scientific process, as well as applied as mechanisms in decision making processes. A series of case studies from different disciplines are presented to illustrate the width of the topic, and its various possibilities. The basics provided in this lesson plan can be adapted in function of the goals and aims of the course in which it is embedded.

Topic Learning Objective: After the completion of this topic, the student will be able to understand innate biases involved in the selection of a cognitive metaphor or model under consideration for application to a particular problem, with specific examples from the fields of Archaeology, Physics, History/Geopolitics, and Complexity Studies. The student will understand a variety of methodologies for evaluating choice of models.

OVERVIEW

A NOTE ON THE READINGS: Carefully read (meaning actually read, not 'skim,' 'scan,' 'speed-read' or any other substitute for conscious and effective data acquisition & appraisal) the topic introduction and the 'Issues for Consideration' before you do the assigned reading. They are designed to shape and focus your perceptions of the material and thus save you from trying to explore all of the thousand-and-one possible ways in which this unusual material might be relevant to us. This allows us to minimize lecture mode and spend more time on group discussion. As to the assigned readings, the most common mistake students make is to slog through the readings digging for those lessons that will help them. That way lies madness. Read the articles with the purpose of understanding what the author is trying to convey about his own subject—e.g., if the writer is talking about the thrills of watercolor painting, think about watercolor painting.

Introduction

Human beings are constantly confronted with new stimuli, information and noise. If we were to actively engage with all of this input, our brains would instantly overload. Instead, we filter incoming information in order to create predictable and understandable patterns that allow us to make sense of the world around us. Science operates very much in the same way. To gain knowledge of whatever it is we want to study, we use metaphors and models as pattern-seeking devices. Metaphors and models should not be seen as radically different or mutually exclusive elements. Instead, they are heuristic devices that can be placed on a wide range of formalism and specificity, from vague and general-purpose to detailed and formalised. The difference is therefore one of degree rather than qualification.

Metaphors are commonly used to express descriptive views of reality, often in colourful language and using a high degree of abstraction. Models, on the other hand, are more often expressed in mathematical or quantitative terms, using a high degree of formalism to express (causal) relationships. However, as they operate on the same range rather than holding qualitative differences, this also means that metaphors can be translated into models when causal relationships are specified and subjected to empirical tests. It has been stated that “the most evident challenge in research on complexity is to find models simulating the behavior of complex systems that can be used to predict their dynamics” (Cowan and Pines 1999, p. 710). Yet, even the most sophisticated descriptions are inherently metaphorical and are often inadequate to allow long-term predictions of a complex system’s behavior. The complexities of reality are, moreover, difficult to capture in a single framework. Oftentimes, several metaphors and models need to be combined in order to adequately describe the dynamics of the complex systems we study.

Think for example of the principle of “self-organized criticality” (SOC). Self-organization has been commonly discussed as a hallmark feature of complex systems. It entails the “spontaneous” emergence of global patterns or behaviors out of local interactions between components of a complex system without centralized interventions. The concept was pioneered by Per Bak and colleagues (1987 *Phys. Rev. Letters*), originally to explain the properties of the 1/f noise problem in physics. The concept was subsequently generalized to describe how energy input and dissipation throughout the systems leads to self-organization towards critical states existing on the edge between randomness and regularity, giving rise to typical features of complexity science such as phase transitions, fractals and power laws. It was used in various fields to describe a wide range of system dynamics such as patterns of cell division, organism development, city growth, multiscale plasma instabilities, *etc*. SOC

is famously described and explained through the metaphor of the sand pile operating “on the edge of chaos” as it is constantly self-organizing into a critical state through a series of smaller and bigger avalanches. The phenomenon is never observed in actual sandpiles (it has instead been noted that Bak’s original model assumed slightly elongated and ‘stickier’ grains in order to evoke this recognizable pattern, as such, it would perhaps be better to use the metaphor of a rice pile). Yet the metaphor persists as a very effective way of communicating the deeper dynamics and features of the mathematical model.

This example also shows that even though metaphors and models are often born within disciplinary boundaries and serve purposes specifically related to the questions and preoccupations of that field, at the same time, transposing heuristics across disciplines is often very attractive, and could potentially hold significant explanatory power.

Four general modes of concept exchange between disciplines can be distinguished: tool transfer, model migration, methodological analogies and metaphor move (Wimmer and Kössler 2006). Tool transfers involves the transmission of a research tool such as a statistical techniques, for example Bayesian analysis, across disciplines. Model migration entails not only transposing the mathematical or statistical techniques, but also the full theoretical underpinnings and empirical terms of the model, and finding corresponding propositions and terms in the importing field (see *infra*). Methodological analogies are far less strict and demanding forms of concept exchange, focusing rather on strategies influencing methodological aspirations. One classic example is the role of non-linear physics in reshaping the notion of causality in the social sciences and the quest to find the “governing laws” of society. Finally, metaphor move entails the usage of a metaphor formed in one discipline to describe or illustrate complex (causal) models in other fields. Metaphors offer new perspectives and focus on less salient properties of a system under study by linking them to the primary properties of the metaphorical image. At the same time, metaphor move can be risky. Whenever a metaphor is transposed along with all of its normative implications, the danger of misinterpretation is always lurking (for example in the usage of the genetic concept of “fitness” in social systems) (Wimmer and Kössler 2006). All four modes of concept exchange will be further illustrated by a series of examples derived from the fields of archaeology, physics, military history and complexity science.

Case 1: Archaeology

The field of archaeology is preoccupied with studying the human past, mainly through its material remains. In order to make sense of this material and come up with interpretations of past societies, archaeologists have used a wide range of theoretical perspectives, often from other disciplines. This practice of “theory borrowing” has been applied to such an extent that some have claimed archaeologists have hardly ever produced any notable theory of their own. We will not focus on the validity of such claims (although recent contributions have convincingly argued against such claims, for example Lucas, G (2015) The mobility of theory. Current Swedish Archaeology 23: 13–32). Instead, we will look at a specific example of a theoretical framework being applied in archaeology, that of the adaptive cycle.

Originally developed in ecology and resilience theory as a counter narrative against prevalent equilibrium-based models of ecosystem dynamics, the adaptive cycle described non-linear and multi-scalar patterns of change in ecological systems. In each cycle, extended periods of stability and incremental changes within a basin of attraction alternate with rapid episodes of change and

transformation. Individual cycles operate on a specific scale and are in turn integrated in a nested hierarchy of scales operating on smaller and larger spatial and temporal dimensions. The adaptive cycle concept quickly gained a prominent position as a major theoretical framework in resilience theory. In recent years, the concept of resilience has increasingly gained popularity in archaeology, as archaeologists increasingly sought to position themselves in debates with wider contemporary relevance regarding sustainable development and long-term dynamics within coupled human-environment systems and potential societal response options to environmental challenges.

Criticism levelled at the adaptive cycle has focused on its seemingly superficial parallelism with other models. It has been argued that because of the general nature of the dynamics it can potentially describe and its tendency for oversimplification of complex system dynamics, the framework is rendered no more useful than a mere metaphor for system change (For example: Gotts. 2007. 'Resilience, Panarchy and World-Systems Analysis'. *Ecology and Society* 12 (1): 24). The paper of Bradtmöller and colleagues describes how, despite this criticism, archaeology has started to operationalise the adaptive cycle, moving away from a metaphorical towards an empirical usage of the framework. The adaptive cycle therefore offers a great case study for the process of concept exchange, as well as the transformation from metaphor and model. Read the paper carefully and discuss how this example can be generalized towards your own field and background.

Case 2: Physics

A famous metaphor in physics concerns the interpretation of microscopic particles. In 1905, Albert Einstein published a groundbreaking paper on the *photoelectric effect*, in which he showed the photons (a type of elementary particle that carry the electromagnetic force) behave as discrete, quantized packets -- i.e., they have a "particle-like" nature. However, there are other situations in which photons behave like waves. For example, if photons are passed through a double-slit apparatus, the resulting interference patterns are most easily interpreted in terms of constructive and destructive interference of wave-like photons. This seeming paradox, known as the "wave-particle duality," is a cornerstone of quantum mechanics, and it highlights the dangers of applying metaphors too literally. According to Einstein,

"It seems as though we must use sometimes the one theory and sometimes the other, while at times we may use either. We are faced with a new kind of difficulty. We have two contradictory pictures of reality; separately neither of them fully explains the phenomena of light, but together they do."

How should we make sense of these findings? In fact, most practicing physicists are comfortable with *both* viewpoints, and they freely adopt one or the other depending on the physical scenario in question. Thus, we realize that both the wave and particle interpretations are simply effective descriptions of the photon that have different regimes of validity and are useful in different circumstances; neither should be interpreted as absolute truths.

Case 3: History/Geopolitics

There is a difference between studying complexity from outside the system in an academic environment vs practicing as an actor *within* a complex environment...

"[T]here is a vast difference between the perspective of an analyst and that of a statesman. The analyst can choose which problem he wishes to study, whereas the statesman's problems are imposed on him. The analyst can allot whatever time is necessary to come to a clear conclusion; the overwhelming challenge to the statesman is the pressure of time. The analyst runs no risk. If his conclusions prove

wrong, he can write another treatise. The statesman is permitted only one guess; his mistakes are irretrievable."

Henry A. Kissinger

Your Neustadt and May required reading passages focus on the use of historical case studies as guides or cautionary tales for potential ramifications of strategic decisions that need to be made in real time. Make sure you pay attention to the details behind the development of "Alexander's Question," which was asked, but never answered by decision-makers during the US Government 1976 response to a feared epidemic of swine flu. Specifically, the decision-makers were convinced that the outbreak would be severe due to projections based upon the 1918 influenza epidemic, and Dr. Russell Alexander, a public health professor at the University of Washington, asked "what fresh data from anywhere, including the Southern Hemisphere, would cause his colleagues to revise or to reverse their judgement that the country should get ready to be immunized *en masse* starting next summer?

Pay attention to the framework for evaluating metaphor choices proposed in Chapter 13 and consider whether or how that assessment methodology might apply to other fields of study.

Case 4: Complexity science

Complexity science as well often makes use of metaphors to illustrate complex causal models. One of the most cited examples is the so-called "butterfly effect". At its most general, the butterfly effect entails the idea that small things can have non-linear impacts or consequences in a complex system. More formally, it relates to the sensitive dependence on initial conditions in chaos theory, which states that a small change in the initial state of a deterministic nonlinear system can result in large differences in a subsequent state. The term is commonly related to the works of Edward Lorenz (1917–2008), an American meteorologist and mathematician who strongly contributed to the development of chaos theory. In his attempts to provide more accurate weather predictions, he found the prevalent linear models to be ineffective, especially over extended time periods. Due to the heavy sensitivity to initial conditions, the metaphorical flap of the butterfly's wings in a distant location - let's say somewhere in the Atlantic Ocean - could potentially result in a tornado at some other point - let's say in the tropics - at some time in the future. While the image is most commonly associated with Lorenz, he did not coin the term, nor did he develop the underlying principles itself. Chaos theory and the sensitive dependence on initial conditions were described in the famous three-body problem of Henri Poincaré in 1890, who in later work even proposed that such phenomena could be applied in meteorology. The metaphor of the butterfly having a far-reaching rippling effect was first described in "A Sound of Thunder", a short story by Ray Bradbury about time travel, published in 1952. It was only many years later that Lorenz switched to the more evocative image of the butterfly in his papers and presentations. According to the man himself, his colleague Philip Merilees provided the title "Does the flap of a butterfly's wings in Brazil set off a tornado in Texas?" for a talk at the 139th meeting of the American Association for the Advancement of Science in 1972.

The imagery has proven to be a tantalizing one, and has found widespread application in many fields. It was even used as the title for a 2004 movie starring Ashton Kutcher (https://www.imdb.com/title/tt0289879/). Oftentimes, however, the term is misused when applied outside of chaos theory. American general Stanley McChrystal writes in his book Team of Teams (2015) how the term has become synonymous with the idea of "leverage", that is, the idea of a small thing having a disproportionately big impact. Moreover, it is often assumed that this small change could then be used as

some sort of lever that can be manipulated to influence the system towards a desired outcome state. Some have developed this idea to suggest the application of ‘triggers’, focusing on minimal perturbations to generate overall organisational change at minimal cost (Holland 1995 Hidden Order: How Adaptation Builds Complexity). This conceptualisation is, however, deeply flawed. In reality, most small things in a complex system may have no effect or only a minimal one. Additionally, it is impossible to know the result of such perturbations beforehand. Even if we know which triggers may cause change, the outcomes may vary due to the changing nature of variables in the system itself (Wimmer and Kösler 2006). In general, however, it is unlikely that we can figure out which triggers cause specific changes. In these cases, it becomes extremely difficult to unravel cause and effect in complex systems, limiting the effectiveness of the leverage/trigger approach.

Think of other real or potential applications of the metaphor of the butterfly effect and discuss in your group what the strengths and pitfalls of such an application would be.

Questions for Consideration

Each member draft two thought provoking questions for students to read prior to the required readings.

1. Is your internal model of "how the world works" the *source* of pattern recognition or intuition?

2. How does “Alexander’s Question” apply to projects you have worked on in the past or to policies you have been subjected to which you may consider “ill-conceived”?

3. What are the main models and metaphors that you use and how does this usage impact your own work on a daily basis?

4. How has changing perspectives through the usage of different metaphors and models impacted your ideas about the world in your past? How did you do it?

5. How does your brain and limbic system (below your conscious intentionality) respond differently to labeling an abstract concept “The Butterfly Effect” versus “Sensitive Dependence on Initial Conditions”? Which term is more emotionally evocative? Does that make it more, or less effective at conveying the underlying concept?

6.

Required Readings (97 pages)

1. Tiha von Ghyczy, "The Fruitful Flaws of Strategy Metaphors," *Harvard Business Review*, September 2003, pp.86-94. [Posted here with the author's permission.] The notion of a "cognitive metaphor" is central to this course.

2. Neustadt and May, Thinking in Time: The Uses of History for Decision-Makers 1st Edition. Read pp 48-57 (1976 swine flu), bottom of 152-153 (“Alexander’s Question”), and Chapter 13, “What to do and How: A Summary, on pp 232-243.

3. Smaldino, Paul. 2017. ‘Models Are Stupid, and We Need More of Them’. In *Computational Models in Social Psychology*, edited by R. Vallacher, S. Read, and A. Nowak, 311–32. New York: Routledge.

4.. Wimmer, A., and R. Kössler, eds. 2006. *Understanding Change. Models, Methodologies and Metaphors*. New York: Palgrave Macmillan. https://www.palgrave.com/gp/book/9781403939418. Read Part I (chapters 2 to 4) on Chaos and Order in Climate Change, pp. 37-63.

5. Kuhn, Thomas S., The Structure of Scientific Revolutions, University of Chicago Press, 3rd ed. 1996, Chapter 1 “Introduction”, p. 1-9

6. Bradtmöller, Marcel, Sonja Grimm, and Julien Riel-Salvatore. 2017. ‘Resilience Theory in Archaeological Practice – An Annotated Review’. *Quaternary International*, Adaptive Cycles in Archaeology, 446 (Supplement C): 3–16. https://doi.org/10.1016/j.quaint.2016.10.002.

Additional Resources

John Lewis Gaddis, Preface, Chapter 1, "The Landscape of History," and Chapter 2, "Time and Space," in *The Landscape of History: How Historians Map the Past* (New York: Oxford University Press, 2004), pp.ix-34. This is the introduction to a discussion of the nature of the historian's craft, written by America's foremost diplomatic historian and historian of the Cold War, author of a seminal work on that conflict, (*Strategies of Containment*). In and of itself, it may seem like something of interest only to professional writers of history. In these pages, Gaddis is setting the stage for a scientific argument that will be directly relevant to this course.

Michael Fullilove, "Obama ought to take up cricket," *Financial Times*, December 9 2008. This is a metaphor-laden piece circulated amongst the NWC faculty by Dr. Bud Cole. It came to me with a comment inserted by a retired USA ambassador, which I think is value-added: “If you believe as I do that national security decision-making styles are closely analogous to national sports and games, then this is instructive. My theory is that the Russians play chess (a rule-bound strategic game), Americans play football and baseball (supremely tactical games in which the closest thing to strategy is psyching out the other side), and the Chinese play weiqi (a strategic game in which the tactical decisions are all about what to sacrifice short term for long-term advantage). The Saudis, in this optic, indulge in professional wrestling, in which one pays someone else to fake the game. Be that as it may, the case for the British decision-making style, as exemplified by cricket, is worth reading.”

BCG Strategy Gallery. This website was created as an in-house educational tool by The Boston Consulting Group, a famous Fortune 500-level business-consulting firm that specializes solely in providing strategic advice. It is described on p.92 of the Required Reading by Tiha von Ghyczy. Poke around in it. At some point you may be asked to login, which you can do using your *FaceBook* account. The Strategy Gallery is designed to foster an exploration of strategic thinking from new, often unusual perspectives and to transfer insights from different fields to business strategy. It stresses the use of "strategy metaphors": "One of the benefits of the strategy metaphor lies in its ability to make the invisible visible—to reveal what is not yet known or understood."

Cowan, George A., David Pines, and David Meltzer. 1999. *Complexity: Metaphors, Models, and Reality*. Cambridge: Westview Press.

Gunderson, Lance H., and C. S. Holling. 2002. *Panarchy: Understanding Transformations in Human and Natural Systems*. Washington, DC: Island Press.

Visual explanation of the adaptive cycle framework: https://www.youtube.com/watch?v=rjiXraKDoTA and https://www.youtube.com/watch?v=a3-Bf8H2yIs

Lesson Presentation:

Slide 1

Title slide

Slide 2

https://www.smithsonianmag.com/videos/category/future-is-here/christ-on-a-cracker-apophenia-pareidolia/

Play from 0:13, stop at 1:46

Slide 3

Models and metaphors as pattern-seeking devices → filter information

Humans are hard-wired to process information with metaphors and models. But:

Slide 4

All Models are Wrong, but some are useful: choice of model is essential!

Slide 5

General introduction: concept exchange (see general introduction of lesson plan)

Slide 6

Presenting case studies

Slide 7

Example of metaphor move from ecology/archaeology: adaptive cycle.

The model describes non-linear and multi-scalar patterns of change in ecological systems. It has been criticized of seemingly superficial parallelism, leading it to be considered no more than a "metaphor of system change". Students will discuss the operationalisation of AC in archaeology: specifying temporal and spatial scales + drivers & effects of change

Slide 8

Example from physics: wave-particle duality. Choosing when to apply which side of the model!

Slide 9

Full .mp4 Nautical Fasmid Clip

Slide 10

Europe was broken very badly after WWI. Physical, demographic, and cultural devastation was widespread, and the recovery was stymied by a global depression. Western Europe recognized the threat of a remilitarized Germany, but did not have the economic strength to seriously oppose it. As tensions continued to rise, Chamberlain and other European leaders decided that the Sudetenland and abrogation of promises of support to Czechoslovakia were a small price to pay for peace.

Slide 11

Chamberlain was hailed at the time as a prescient and competent diplomat, but history would judge the agreement differently, directly connected with Churchill's selection as Prime Minister. The "Ghost of Munich" - that any concession to aggression was a sign of weakness and appeasement - would be reinforced so many times in the model game space of global diplomats

Slide 12

(Japan in Manchuria, Mussolini in Abyssinia, Greek Civil War, Korea, Cuba, Soviet invasion of Hungary, and the Berlin Airlift) that it became an automatic framework for evaluation of decisions to escalate involvement in Vietnam. As Neustadt and May illustrate in your required reading - there was a much better historical model to use, even without the benefit of hindsight.

Senator William J. Fulbright may have been the first to compare the US involvement in Vietnam to the Athenian Sicilian Expedition in 415 B.C., a debacle that opened Greece to Persian dominance and the eventual rise of Macedonian hegemony under Alexander.

After the late 1960s, the "Ghost of Munich" was replaced by the "Ghost of Vietnam" as the operational default model in geopolitical analysis (Soviet Union in Afghanistan, US in Beirut and Somalia, and the rationalization of inaction in Rwanda to name a few).

Slide 13

Thucydides reason for writing his history of the Peloponnesian War:

"It will be enough for me, however, if these words of mine are judged useful by those who want to understand clearly the events which happened in the past and which (human nature being what it is) will, at some time or other and in much the same ways, be repeated in the future. My work is not a piece of writing designed to meet the taste of an immediate public, but was done to last forever (Thucydides, I.22; Thucydides, *The Peloponnesian War*. Translated by Rex Warner. New York: Penguin Classics, 1985, p. 48). "

Slide 14

Complexity: metaphor of butterfly effect and chaotic attractors

Slide 15

Conclusions: reflection on what we learned, what surprised us, what didn't we like, how will this be useful for us in the future,...