

International Conference

22-24 May 2019
Bonn, Germany

SIMPLICITIES AND COMPLEXITIES



BOOKLET OF ABSTRACTS

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SIMPLICITIES AND COMPLEXITIES

”Simplicities and Complexities” takes place from 22 to 24 May 2019 at the University of Bonn, Germany. It aims to bring together scientists and scholars from a spectrum of disciplines such as physics, biology, ecology, chemistry, and computational science, as well as from philosophy, sociology, and history of science. This conference is organized by the interdisciplinary, DFG- and FWF-funded research unit ”Epistemology of the LHC”.

Philosophers and scientists alike have often assumed simplicity to be an epistemic ideal. Some examples of theories taken as successful realizations of this ideal include General Relativity and Darwin’s theory of Natural Selection. These theories influenced early and mid-20th century philosophers’ understanding of the criteria successful scientific theories and practices had to meet, even when facing complex phenomena. However, this influence did not mean that the notion of simplicity was clear-cut. A suitable and encompassing definition of simplicity has yet to be developed. Some unanswered questions include: In what sense can and do physicists consider a theory, such as the Standard Model of elementary particle physics, as being sufficiently simple? How do ideals of simplicity differ when applied to disciplines other than physics? Biological concepts, for example, do not tend to refer to laws, whereas concepts from the social sciences frequently resort to notions of order and structure that are different from those of natural sciences. Are there, accordingly, simplicities (in plural) rather than a unified logic-inspired notion? Finally, are there cases where simplicity is simply a bad epistemic ideal, and not merely for the reason that it is often unreachable?

Throughout the 20th century the sciences have approached more and more complex phenomena, in tune with the increased social relevance of scientific knowledge. The perceived need to address complexity head-on has led to a broader reaction against simplification and reductionism within the sciences. However, if simplicity, in its various outfits, has proven an unreliable guide, what should it be replaced with? Looking at the various strategies of addressing complexity in the sciences and the disciplines reflecting upon them, it appears that the notion is at least as variegated as simplicity. To be sure, there exist measures of complexity as well as mathematical, empirical, or discursive strategies to deal with it, but they vary strongly from one discipline to another.

The aim of the conference is to analyze, differentiate, and connect the various notions and practices of simplicity and complexity, in physics as well as in other sciences, guided by the following questions:

- Which kinds and levels of simplicity can be distinguished (e.g. formal or ontological, structural or practical)? Which roles do they play and which purposes do they serve? Does simplicity, in a suitable reformulation, remain a valid ideal - and if so, in which fields and problem contexts? Or, instead, where has it been abandoned or replaced by a plurality of interconnected approaches and alternative perspectives?
- What about complexity? How is the complexity of an object of investigation addressed (represented, mirrored, negated, etc.) by the adopted theoretical and empirical approaches in different fields?
- Addressing complex problems, especially those relevant to society, requires institutional settings beyond the traditional research laboratory. How does the complexity of such settings relate to the complexity of epistemic strategies and of the problems themselves? In what sense can we trust the other players in a complex epistemic network?
- How should we conceive of the relation between simplicity and complexity? Are there alternatives to seeing complexity in opposition to simplicity? Does physics, in virtue of its history, maintain its special position in the contemporary debates on simplicity and complexity? What do reflections on the epistemic cultures of ecology, cultural anthropology, economics, etc. have to offer in terms of how simplicities and complexities can be balanced?

We invite contributors from a spectrum of disciplines, scientists and scholars reflecting on their respective and neighboring research fields, as well as historians, philosophers, and sociologists of science investigating the epistemologies, practices, and discourses of fellow epistemic communities. The conference will thrive on intense discussion surpassing disciplinary boundaries.

Cristin Chall (University of Bonn)
Dennis Lehmkuhl (University of Bonn)
Niels Martens (RWTH Aachen University)
Martina Merz (University of Klagenfurt)
Miguel Ángel Carretero Sahuquillo (University of Wuppertal)
Gregor Schiemann (University of Wuppertal)
Michael Stöltzner (University of South Carolina)

SCHEDULE

Wednesday 22 May

9:00 - 9:30 | *Opening*

Chair Niels Martens |

9:30 - 10:30 | **Simplicity vs. Complexity in Theoretical Physics**
Robert Harlander

10:30 - 11:30 | **Complexity and emergent simplicity in quantum materials**
Stephen Blundell

11:30 - 12:00 | *Coffee Break*

12:00 - 13:00 | **Detecting LHC Collisions: A Complex Endeavour**
Beate Heinemann

13:00 - 14:45 | *Lunch Break*

14:45 - 16:45 | **Parallel Session**

16:45 - 17:15 | *Coffee Break*

17:15 - 18:15 | **Award Lecture**
Simplicity of what? A case study from generative linguistics
Giulia Terzian & María Inés Corbalán

18:15 | *Reception*

Thursday 23 May

Chair Sophie Ritson |

9:00 - 10:00 | **Simplicity in Biological Complexity: the Case of Cancer**
Marta Bertolaso

10:00 - 11:00 | **Per aspera ad astra: ecology's way to simplicity has to embrace complexity**
Volker Grimm

11:00 - 11:30 | *Coffee Break*

11:30 - 12:30 | **Simplicities & Complexities in Chemistry – the Languages of Vague Ideas**
Thomas Vogt

12:30 - 14:15 | *Lunch Break*

14:15 - 16:15 | **Parallel Session**

16:15 - 16:45 | *Coffee Break*

Chair Daniel Mitchell |

16:45 - 17:45 | **Elephant and Ant. Complexity, Prediction, and Modeling Strategy**
Johannes Lenhard

Conference Dinner

— Friday 24 May

Chair Joshua Rosaler |

- 9:00 - 10:00 **Simplicity, Fundamentality and Effectiveness**
Richard Dawid
- 10:00 - 11:00 **Simplicities and Complexities in Particle Physics**
Michael Stöltzner
- 11:00 - 11:30 *Coffee Break*
- 11:30 - 12:30 **Indicator Politics: reducing complexities while using epistemic tactics of problem-invention**
Stefan Bösch
- 12:30 - 14:15 *Lunch Break*
- 14:15 - 16:15 ***Parallel Session***
- 16:15 - 16:45 *Coffee Break*
- 16:45 - 17:45 **The Uses of Complexity in Anthropology**
Talia Dan-Cohen
- 17:45 - 18:15 *Discussion & Closure*

Chair Martin King |

Talks to be held in Wolfgang Paul Saal

PARALLEL SESSIONS

Wednesday 22 May

Chair Miguel Ángel Carretero

Wolfgang Paul Saal

- | | |
|---------------|--|
| 14:45 - 15:25 | Simplifying Simplicity
Christian J. Feldbacher-Escamilla |
| 15:25 - 16:05 | Simplicity and Unification in Mathematical Explanation
Navia Rivas de Castro |
| 16:05 - 16:45 | Opacity in High Energy Physics – Induced by complexity?
Paul Grünke & Florian Boge |

Chair Markus Ehberger

Martini Seminarraum

- | | |
|---------------|--|
| 14:45 - 15:25 | Inconceivable simplicity; the rejection of Mendel's theory of heredity by his contemporaries
Mike Buttolph |
| 15:25 - 16:05 | From Simple to Complex: the Emergence of Multicellularity
Walter Veit |
| 16:05 - 16:45 | The quest for simplicity: DPT combination vaccine in the 1950s and 60s
Gaëtan Thomas |

Chair Cristin Chall

Curtius Konferenzraum

- | | |
|---------------|---|
| 14:45 - 15:25 | Simplicity in Statistical Model Selection
Chris Arledge |
| 15:25 - 16:05 | Interconnections of simplicity and complexity in the development of geometric concepts
Maximilian Holdt |
| 16:05 - 16:45 | Application of Computer Programs to Simulate the Folding of Conotoxins
Windol Charls Santos |

Thursday 23 May

Chair Miguel Ángel Carretero

Wolfgang Paul Saal

- 14:15 - 14:55 **The Price equation and the complex biological world**
Victor Luque
- 14:55 - 15:35 **Broken Symmetry: the bridge between simplicity and complexity**
Núria Muñoz
- 15:35 - 16:15 **Higgs Naturalness and Two Views of Wilsonian Effective Field Theory**
Joshua Rosaler & Robert Harlander

Chair Helene Sorgner

Martini Seminarraum

- 14:15 - 14:55 **Sociological knowledge between storytelling and modelling**
Lisa Kressin
- 14:55 - 15:35 **Situated Modelling: Anthropological Perspectives on Linking Complexity to Simplicities in Environmental Research**
Anja Klein, Krystin Unverzagt & Jörg Niewöner
- 15:35 - 16:15 **Complex socio-technical relations: a consideration of simplicity as principle of product development**
Fabian Pilz & Andrea Wolffram

Chair Paul Grünke

Curtius Konferenzraum

- 14:15 - 14:55 **Algorithmic Information Theory and the Eye of the Beholder: from General Complexity to General Intelligence**
Manuel García-Piqueras & José Hernández-Orallo
- 14:55 - 15:35 **Are Computer-Assisted-Proofs Really Complex? Complexity, Simplicity And Insight In Mathematics**
Paul Hasselkuß
- 15:35 - 16:15 **Cognitive and computational complexity in mathematical problem solving**
Markus Pantsar

Friday 24 May

Chair Markus Ehberger

Wolfgang Paul Saal

- 14:15 - 14:55 **Scaling and measuring gender (in)equalities: simplicities and complexities when reflecting on the ACT project**
Anne-Sophie Godfroy
- 14:55 - 15:35 **Organizational Complexity in LHC Experiments: Distributing Conference Talks as a Problem of Optimization**
Martina Merz & Helene Sorgner
- 15:35 - 16:15 **Subsuming complexity: research strategies in historical social sciences**
Ivan Ermakoff

Chair Miguel Ángel Carretero

Martini Seminarraum

- 14:15 - 14:55 **Balancing complexity and simplicity in ecology – strategies and challenges**
Tina Heger
- 14:55 - 15:35 **The Plurality of Simplicity in Molecular and Systems Biology**
Fridolin Gross
- 15:35 - 16:15 **Reductionism and Emergence in Theoretical Ecology: Challenges of "Species" as a Basal Unit**
Paul Grünke & Katharina Brinck

Chair Cristin Chall

Friesenhahn Tagungsraum

- 14:15 - 14:55 **Software Design: It's Complicated**
Michael Dorin & Sergio Montenegro
- 14:55 - 15:35 **A Logical Structure for Reducing Complexity**
Robert Moir
- 15:35 - 16:15 **The Saari triangle - both simple(x) and complex**
Jaakko Hakula

Keynote Talks

Abstracts for the keynote talks in alphabetic order.

THU
23 May
9:00

Simplicity in Biological Complexity: the Case of Cancer

Marta Bertolaso

University Campus Bio-Medico (Italy)

Complexity as a concept emerged as a necessary stance, from both an epistemological and an ontological point of view, once the reductionist approach proved to be inadequate in explaining a number of relevant biological phenomena. Simplicity as an epistemic goal has been similarly challenged too. No privileged explanatory models, in fact, seem to be available to account for all the organizational and evolving features of the living systems, for their persistence in space and time. Moving from the perspective of scientific practice, I will first highlight how at the crossroad of these two issues we can find recent philosophical reflections about biological robustness, and why carcinogenesis can be considered a paradigmatic example of how such dynamic stability of the organism can be compromised. I will thus show (i) how, in the effort of explaining carcinogenesis, the explananda shifts and converge towards a ‘simplified’ conceptualization of the compromised biological dynamics and (ii) how different explanans can be relevant in explaining the intrinsic complexity of such dynamic stability. From this analysis simplicity and complexity emerge as two sides of the same coin. This allows a pluralism of explanatory models in life sciences and asks for a deeper understanding of the relational ontology that holds the robust feature of the biological determinations that is, of the dynamically stabilized organization of the living beings.

WED
22 May
10:30

Complexity and emergent simplicity in quantum materials

Stephen Blundell

University of Oxford (UK)

Newly discovered compounds are becoming more and more complex, with long chemical formulae that seem to indicate that a simple understanding of their properties will not be possible. Nevertheless, all kinds of emergent behaviour can be observed: superconductivity, frustrated magnetism, magnetic monopoles, Weyl semi-metal, etc etc. Each compound is a new universe, with different rules, different particles and strange new laws. How do we understand this behaviour when underlying it, at the bottom, is “only” the Schrödinger equation? And are these new particles real? I will discuss some of these questions and argue that these phenomena are fully paid-up members of our ontology, the class of what we call real things.

Indicator Politics: reducing complexities while using epistemic tactics of problem-invention

Stefan Böschen

RWTH Aachen (Germany)

FRI
24 May
11:30

Since some decades, the problem of non-knowledge is raising more and more attention. Within agnotology studies the argument is put forward that ignorance is used strategically for influencing the public debate about selected problems, like tobacco and cancer or whether an anthropogenic climate change is happening. These insights can be generalized with regard to a specific view on how societies define and solve problems. The argument is that societal problem-solving processes can be described as linked series of socio-epistemic problems. This view highlights the fact that the form and relevance of complex societal problems are constructed in the course of multifaceted public debates. The thesis of my talk is that (collective) actors are using indicator politics as an epistemic tactic to reduce complexity while working at the invention of the problem to their advantage.

The Uses of Complexity in Anthropology

Talia Dan-Cohen

Washington University in St. Louis (US)

FRI
24 May
16:45

In the United States, the opposition between simplicity and complexity has been heavily politicized. Experts are either chided or cheered for being the defenders of complexity against a political tide that rejects complex explanations, analyses, and solutions. In the humanities and humanistic social sciences, the critiques of reduction and simplification have left a sense of the self-evident virtues of complexity that further entrench the sense that experts should stand for and with complexity. Yet if simplicity is so clearly tied to some dubious ideological projects, can we so confidently claim complexity as a neutral or even virtuous analytic by the logic of opposition? In my talk, I argue that we need to attend to the peculiar dynamics of complexity evaluations and their underlying logics more carefully than we have, not in order to reverse the binary, but in order to disrupt it. To make my argument, I focus on the tensions between positivist and postpositivist uses of complexity by drawing on two case studies: one involving the uses of complexity in cultural anthropology, and the other concerning the uses of complexity in archaeology.

FRI
24 May
9:00

Simplicity, Fundamentality and Effectiveness

Richard Dawid

Stockholm University (Sweden)

The quest for simplicity plays a foundational role in physical theory building: physics aims to describe the confusing multifaceted spectrum of observations we make about the world by a comparably simple set of principles and equations. It is a much more contentious issue as to what role criteria of simplicity play in theory building today. In the talk, I argue that simplicity criteria in fundamental physics today hinge on the projection of future physics and therefore, to the extent they are relevant, are of a substantially different character than the initial principle of simplification on which physics is based. I will distinguish three contexts: theories that are treated as fundamental at the given time without supporting any finality status; theories that are understood to be effective theories of a (more or less well understood) more fundamental level of theory building; and finally, theories that are associated with a final theory claim. Each of these contexts suggest a different view on the role of simplicity.

THU
23 May
10:00

Per aspera ad astra: ecology's way to simplicity has to embrace complexity

Volker Grimm

UFZ Leipzig (Germany)

Ecological systems are by definition complex. They consist of countless organisms that differ not only in their species identity but also in their properties and adaptive, autonomous behaviour. The structure and dynamics of ecosystems, their functioning and persistence result from the interactions between these organisms and with their abiotic environment. However, classical theoretical ecology ignores much of this complexity by adopting modelling approaches from physics, in particular the use of ordinary differential equations. These approaches do not capture the inseparable micro-macro link between organisms and the systems they comprise. Therefore, agent-based modeling is increasingly used to capture the micro-macro link. They are used to achieve structural realism, i.e. models that reproduce whole sets of patterns observed at the micro- and macro-level as well as at different temporal and spatial scales, and are therefore likely to capture the internal organization of ecosystems. Once such models exist, the search for general principles and theories begins with a systematic attempt to simplify and break them and thus identify essential elements. Despite their complexity in terms of their building blocks, ecosystems can be simple in terms of their dominant life forms and processes. Modern ecological theory development therefore attempts to embrace complexity, not to ignore it, and ultimately to identify a theory that is as simple as possible. An unresolved challenge is the modelling of biodiversity, because modelling means omitting factors that are not important for a particular question or situation, but in biodiversity most factors are mostly unimportant, but become indispensable under certain conditions.

Simplicity vs. Complexity in Theoretical Physics

Robert Harlander
RWTH Aachen (Germany)

WED
22 May
9:30

I will describe two cases of tension between simplicity and complexity in modern particle physics. The first one is related to the concept of Feynman diagrams. Combining clarity and rigor in an unrivaled way, they play an essential role in informal discussions as much as in precise theoretical predictions for processes at particle colliders. Current calculations may easily involve tens of thousands of Feynman diagrams, however. I will discuss in what way Feynman diagrams, even through their graphical representation, are still essential for such calculations. The second topic of the talk concerns the tension between basic theoretical concepts, such as supersymmetry or grand unification, and the complexity of the corresponding specific models, enforced on them by existing experimental data.

Detecting LHC Collisions: A Complex Endeavour

Beate Heinemann
DESY Freiburg (Germany)

THU
23 May
13:00

The Large Hadron Collider (LHC) and its experiments are the most complex scientific instrument ever built. In this talk I will focus on the particle detectors, recording the LHC collisions using the ATLAS experiment as an example. Various technologies are used to detect the different observable particles, and complex software algorithms are used to reconstruct the particles that were produced in the primary proton-proton collisions. Event selections are then designed, based on the objective of the analysis, to select out of the billions of events recorded those of interest. At various points in this process quality checks are performed that provide us with confidence that the detector and the software perform as desired. Finally, a simple physics quantity is measured such as the mass or lifetime of a particle. In this talk, I will describe this endeavour, and discuss the main challenges and limitations in extracting the simple, desired information through a complex process.

Elephant and Ant. Complexity, Prediction, and Modeling Strategy

Johannes Lenhard
Univeristät Bielefeld (Germany)

THU
23 May
11:30

My main claim is that a turn in simulation occurred around 1990 that signals a new quality of simulation in terms of its social and cognitive organization. Computational chemistry will serve as primary example. So-called density functional theory (DFT) has not yet received much attention from the side of philosophy or history of science, whereas the 1990s turn propelled it into the arguably most widely used theory in all of chemistry and physics. This success, I argue, is based on networked and cheaply accessible computers as well as on how DFT is socially and cognitively organized, much like the power of ants depends on their organization.

FRI
24 May
10:00

Simplicities and Complexities in Particle Physics

Michael Stöltzner
USC (US)

Philosophers have long viewed elementary particle physics largely as a reductionist endeavor dominated by the quest for ever more encompassing and simpler descriptions of nature. Steven Weinberg's *Dreams of a Final Theory* – uniformly rejected philosophers of other disciplines – are a case in point. Yet to all those familiar with the complex conditions of scientific research in contemporary particle physics and the large number of theoretical and experimental strategies required to deal with petabytes of electronic data produced by the LHC, reductionism must at best seem a bold extrapolation from the unquestionable success of the standard model in 20th century physics to energy scales far beyond it. The aim of my presentation is to show, at the example of findings of our Research Unit, that particle physics can contribute to debates in a practice-oriented philosophy of science without reductionist aspirations. (i) There exists quite some philosophical scholarship concerning models in particle physics. But the recent popularity of model-independent searches suggests examining the boundary of the model concept and whether other strategies of simplification could replace it. (ii) Naturalness exemplifies the key role of guiding principles for theoretical model building. Given that searches for new physics have become exploratory to an increasing extent, are there comparable guiding principles for experimenters? (iii) While physics views simplification ultimately as nomological, other disciplines count on universal mechanisms. Yet present-day particle physics is full of mechanisms, most prominently the Higgs mechanism, and talk about real and virtual processes. Is this more than just a justificatory narrative connected to models or does it have any explanatory virtue?

THU
23 May
11:30

Simplicities & Complexities in Chemistry – the Languages of Vague Ideas

Thomas Vogt
USC (US)

This talk will highlight the role models play in chemistry. Using the periodic table of elements and the metaphor of chemistry as a language the question of how do elements persist in compounds relies on Paneth's dual use of the term element as simple and basic substances and leads to the various resulting concepts of 'atoms in molecules'. Taking into account the shape and size of matter has created an unprecedented exuberance of creating stuff out of elements and other chemical motives (molecules and nanoparticles assembled to hybrid structures) – a massive expansion of our structural vocabulary. This vast chemical compound space is contrasted by the sparsity of targeted functionalities. A ranking of structural motives allows the use of linguistic tools to characterize this diversity. Multiple realizations of physical and chemical properties by different chemical compounds open up the opportunity to derive heuristic rules using machine-learning, which is also being used to predict the outcome of reactions. It is anticipated that chemistry will become a proving ground for machine learning because the extracted rules and models can be vague. By maintaining a conceptual pluralism and resisting reductionism and embracing emergent phenomena when faced with complexities chemistry will become the gateway to other experimental sciences.

Award Lecture

Simplicity of what? A case study from generative linguistics

Giulia Terzian & María Inés Corbalán

Universidade Estadual de Campinas (Brazil)

WED
22 May
17:15

The Minimalist Program (MP) in generative linguistics is predicated on the idea that simplicity (and cognate notions) is a property, on the one hand, of the object of study – the human language faculty; on the other, of linguistic theories. Thus MP is guided by two types of simplicity considerations: substantive economy and methodological economy. Principles of m-economy work as general guidelines in the search for the best theory. S-economy principles in turn stem from the minimalist thesis that the language faculty is itself optimal. Minimalists often say or imply that we should expect the two to somehow converge; though they rarely offer arguments to this effect. At the same time, there is plenty of evidence indicating that the two notions are often conflated. This in turn engenders problematic reasoning patterns, for instance witnessing ambiguous moves from ascriptions of simplicity to the object of study, to ascriptions of simplicity to the respective theory (and viceversa). Against this backdrop our discussion will initially focus on the following: (1) What exactly is the relationship between m-economy and s-economy? (2) What is the justification for either family of principles? We'll see that existing attempts to address (2) fall into two broad categories: 'no miracles' arguments (s-economy) and arguments appealing to Ockham's razor (m-economy). Even if we granted, for the sake of argument, that the resulting justifications are individually satisfactory, we maintain that they leave an explanatory gap as to the alleged convergence of m-/s-economy. To fill this gap we explore a different proposal, drawn from recent work in cognitive science and in philosophy of science, that hinges on the idea that simplicity is an evolved, virtuous bias – one that is a condition of our scientific understanding and, ultimately, of successful scientific practice.

Contributed Talks

Abstracts for the contributed talks in alphabetic order (by first author).

WED
22 May
14:45

Simplicity in Statistical Model Selection

Chris Arledge

John Hopkins University (US)

Statistical model selection is a widely used paradigm that aims to select the statistical model that best fits the data from a candidate set of models. The paradigm has found applications in many scientific disciplines, ranging from astrophysics and cosmology to mathematical biology. One desideratum in statistical model selection is balancing goodness of fit with simplicity, where simplicity is related to the number of free parameters in the model. This is seen clearly in the context of information-theoretic selection criteria, such as the Bayesian information criterion and the Akaike information criterion. Such information-theoretic approaches aim to select the model with the least information lost in approximating the data. Furthermore, such criteria weigh simplicity by including a term that penalizes models with excessive complexity, thereby increasing the models' score. A natural question to ask is how to interpret this selection for simplicity. In what follows it will be argued that in statistical model selection, parametric simplicity should not be interpreted as a guide to truth, but rather as a pragmatic feature of the selection methods that informs predictive accuracy. There are several formal features of the information-theoretic criteria that support this verdict, including asymptotic inconsistency and parameter degeneracy. Furthermore, it can be shown that in some cases the criteria penalize the parametric complexity of models that contain parameters unconstrained by the relevant data. As such, the best interpretation of the simplicity considerations in these model selection methods is as an instrumental value that can increase predictive accuracy.

Inconceivable simplicity: the rejection of Mendel's theory of heredity by his contemporaries

Mike Buttolph

University College London (UK)

WED
22 May
14:45

As is well known, Mendel's researches on peas were published in 1866 and in the following 35 years no-one suggested that the work had any great significance. When it was 'rediscovered' in 1900 it gave rise to the new and still-thriving science of genetics. Many of those who then became acquainted with Mendel's work felt the need to explain why its significance had been so long unappreciated. During the 1890s Hugo de Vries came across Mendel (1866) in the course of routine literature research, and was the first to publish results shaped by mendelian thinking. He said of Mendel's paper of 1866: "This memoir, too good for its day, had been little known and forgotten." This passage encapsulates the two classes of reasons that have been advanced for the fact that Mendel's work was not seen to be of importance when first published, or in the thirty five years following. In the first years after the 'rediscovery', scientists could not believe that their forebears had not recognised Mendel as a great innovator, and constructed 'noncognitive' explanations – Mendel himself had been unknown, his work had been published in a minor journal, and so on - that is, it was 'little known and forgotten'. However, in due course it became clear that there were those who had known of Mendel's work, starting with the distinguished Viennese botanist Carl Nägeli. So then there were constructed a series of rational or cognitive reasons – Mendel had deployed new methods, studying the transmission of single characters rather than the appearance of the plant as a whole, his mathematical analysis had been incomprehensible to his readers, and so on – the paper was 'too good for its time'. These conjectured internal factors may well have influenced some individuals, but when Mendel's work is read against the intellectual milieu of the late nineteenth century it seems likely that his conclusions were rejected for a rather broader reason, that is, because of the implied conclusion that patterns of biological inheritance are unbelievably simple.

Software Design: It's Complicated

Michael Dorin & Sergio Montenegro

University of St. Thomas (US)

FRI
24 May
14:15

An ongoing engineering problem is the continuing creation of software source code too complicated for humans to properly review and understand. Further exacerbating the problem is a lack of a proper understanding of exactly what "complicated" and "complex" mean. The definitions of these words are often misconstrued, and some sources even indicate they are the same. Some systems are inherently complex, but this does not mean they have to be complicated. Complicated systems cause problems with initial software development and ongoing maintenance. This research begins by examining and affirming the definitions of "complicated" and "complex," as well as exploring the notion of "simple" in the field of software engineering. This was accomplished through surveys wherein software engineers quantified the basics of what they think is complicated and simple. Cross-examination of the bug reports of prominent software projects against the concerns identified by the surveys illustrates the real problems connected to complicated software, as well as revealing benefits related to simpler software implementation. The survey

results identified common elements based on whether they make source code complicated and are simple. The results from reviewing reported bugs on the components of a LAMP (Linux, Apache, MySQL, PHP) server confirm that when source code is more complicated, it also has more faults. By establishing the parameters of complicated and complex, a protocol can be defined to reduce the development of complicated software and encourage simplicity.

FRI
24 May
15:35

Subsuming complexity: research strategies in historical social sciences

Ivan Ermakoff

University of Wisconsin-Madison (US)

How do social scientists investigating large-scale historical events and processes handle the complexity of their objects of investigation? Events and processes unfolding on wide-ranging spatial and temporal scales (e.g., demographic transitions, structural transformations, institutional developments, shifts in norms and mores, regime breakdowns, revolutions) elude the simplifying procedures of experimental protocols. On this score, historical social scientists' predicament resembles astrophysicists': they have to confront phenomena that present themselves as intricate and seemingly indomitable bundles of interaction effects. Herein lies their complexity. Unlike astrophysicists though, historical social scientists have not been able to subsume this complexity to the formalism of general laws. The purpose of this paper is therefore to analyze, first, which research strategies social scientists have been pursuing to make complex historical objects intelligible and, second, which representations of complexity these strategies reveal. To this end, the paper focuses on studies of political and social revolutions. This empirical focus brings into relief three research strategies of complexity reduction that have broad relevance for historical social sciences. All three are exercises in pattern identification. As such, they provide stepping-stones towards analytical simplicity. Morphological inquiries track formal structures in the apparent maze of historical phenomena through the use of descriptive techniques of data formalization. Variable-centered studies investigate patterns of conjunction among empirical categories elevated to the status of explanatory variables. Genetic analyses ground their explanatory claims in the specification of generative processes.

WED
22 May
14:45

Simplifying Simplicity

Christian J. Feldbacher-Escamilla

University of Düsseldorf (Germany)

There exists a variety of notions of simplicity such as the notion of ontological and explanatory parsimony, the simplicity of a model via counting the model's parameters, the simplicity of theories via counting components of normal forms of axioms of the theory, etc. These notions are employed in a variety of approaches such as, e.g., the approach of explanation by unification, inference to the best explanation and non-ad hoc hypothesising. Many of them rely on the assumption that the underlying notion of simplicity bears some epistemic value, which makes a relevant epistemic difference between unified vs. case-by-case explanation, simple vs. complex models, general vs. ad hoc hypotheses. To assume such an extra epistemic value of simplicity goes hand in hand with the assumption

that simplicity is truth-apt. And one important way to argue for the truth-aptness of simplicity consists in putting forward constraints of the model selection literature and to show that simpler models are less prone to overfit erroneous data than complex models are. However, this strategy is based on the particular notion of the simplicity of a model in form of the number of the model's parameters, and it is unclear how this notion of simplicity relates to the other mentioned ones. In this paper, we argue that these notions are related to each other via structural equations. By applying an idea of Forster and Sober (1994) we show how, e.g., probabilistic axioms or laws can be reformulated as structural equations; these can then be used to assign numbers of parameters to such axioms or laws, and hence allow for applying established complexity measures that simply count the number of parameters. By this, one can provide an exact translation manual for the number of parameters approach to the other notions of simplicity; and this, in turn, can be employed for transferring the epistemic value of simplicity granted for the former domain to the latter one.

Algorithmic Information Theory and the Eye of the Beholder: from General Complexity to General Intelligence

Manuel Garcia Piqueras & José Hernández-Orallo

University of Castilla-La Mancha (Spain)

THU
23 May
14:15

Solomonoff-Kolmogorov-Chaitin complexity of an object gives an objective notion of simplicity (not absolute because of its dependence on the machine). It is a key concept in Algorithmic Information Theory (AIT), which unites computation, information theory and probability theory; given an object, we have that the higher is the minimum length of a program that produces it, the higher is its information content and the chances that it is random are increased (García-Piqueras, 2017). AIT has established deep connections between far reached disciplines. For instance, the way that laws of physics are preferred: Leibniz argued that it is always possible to produce formulae valid for any data set, even those randomly obtained, but their selection relies on their simplicity (Chaitin, 2010). Perhaps, the standard model is so powerful and useful because its lagrangian can be beautifully printed in a mug. Moreover, Solomonoff's prediction error theorem (Solomonoff, 1978) assures the existence of a general procedure for inductive inference, a weighted average of all possible programs that are consistent with the evidence, where short ones are given a higher probability. AIT also joins cognition, psychometrics, simplicity and compression (Hernández-Orallo, 2017). One of the long-standing questions about complexity is why some problems and phenomena with high Kolmogorov complexity look easy to us. The answer is literally on the eye of the beholder: cognitive complexity, i.e., difficulty, is seen as the simplest hypothesis or solution in terms of Kolmogorov complexity, or a variant, such as Levin's K_t (Levin, 2013), that fits the evidence. In the same way general intelligence can be understood as performance on a range of tasks up to a level of difficulty, we claim that the same notion can be applied to the generality of scientific theories.

THU
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Scaling and measuring gender (in)equalities: simplicities and complexities when reflecting on ACT project

Anne-Sophie Godfroy
University of Paris-Est Créteil (France)

The aim of the paper is reflecting on gender equality measurements in the conceptual framework of the ACT project (H2020 2018-2021 www.actongender.eu). ACT project is about developing communities of practice (CoPs) as an instrument to spread gender equality plans (GEPs) in research and academia, to share knowledge and to exchange good practices in this field. One of the aim of the project is the evaluation of the outcomes of the project, both the outcomes of the GEPs themselves and the outcomes of communities of practice as an instrument to better implement GEPs. The paper will reflect in a first part on the complexities : diversity of social and academic contexts across countries and disciplines, diversity of the organizational culture, diversity of the gender cultures and regimes, interactions with other ongoing policies or circumstances, for example budget cutting, merging of universities, demographic structure of the academic staff, etc. Granularity issues and variations due to scales are another important factor of complexities in this field. At the same time, some simplicity has to be preserved to be able to make measurements and comparisons, to assess some progress or backlash, and first of all to be able to describe the studied phenomena. Categories have to be defined and correlations are supposed in order to provide a conceptual framework to support the implemented actions and introduce some explanatory framework to justify the structure of GEPs. This reflection will be developed in the second part of the paper. In conclusion, we will examine the necessary balance between simplicities and complexities in the context of the ACT project.

FRI
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The Plurality of Simplicity in Molecular and Systems Biology

Fridolin Gross
University of Kassel (Germany)

The relationship between "traditional" molecular biology and systems biology is often seen as a kind of competition in the sense that both approaches appear to deal with the same kind of biological problems, while offering very different strategies for their solution. One way of further illuminating this relationship is in terms of the different ways in which they understand simplicity and complexity. Proponents of both approaches agree on the basic fact that living systems are highly complex, and both at the same time rely on the hope that this complexity is limited in a way that enables human understanding. However, they offer different heuristic strategies in order to tentatively reduce the apparent complexity, thus effectively assuming different kinds of hidden simplicity behind it. Traditional molecular biology aims at explaining biological phenomena in terms of "small" mechanisms. More specifically, it assumes functional modularity and in addition adopts a certain "informational" perspective on biological systems according to which mechanisms can largely be understood in terms of simple sequential chains of signaling. Approaches within systems biology relax some of these underlying assumptions, but they have to introduce simplifying assumptions on their own in order to end up with tractable representations. Some systems biologists, for example, replace functional modularity by a kind of structural modularity and think that large networks can be understood in terms

of much smaller units, so-called network motifs. Others drop modularity altogether and instead assume that simplicity resides in the coherent dynamical behavior at the level of the whole system. In this contribution I am going to discuss various examples in order to illustrate the plurality of perspectives on simplicity and complexity in the realm of molecular and systems biology. Acknowledging this plurality is indispensable in order to achieve fruitful interaction between the different approaches.

Opacity in High Energy Physics - Induced by complexity?

Paul Grünke & Florian Boge

KIT (Germany) & RWTH Aachen (Germany)

WED
22 May
16:05

High Energy Physics (HEP) is a field of research in which the use of Computer Simulation (CS) abounds. Searches for particles, as well as the determination of their properties, depends on CSs from experimental design to evaluation of data. In recent years, Machine Learning (ML) techniques have become more and more important in HEP, e.g. for the task of separating signal from background data (cf. Baldi et al. 2014 or the 2014 Kaggle Higgs Boson challenge). Even more recently, the HEP community has begun to explicitly acknowledge the “black box”-nature of ML algorithms and associated, induced features of opacity (e.g. Chang et al. 2018). It is often claimed that this opacity is caused by the complexity of the models involved in ML. In this talk, we want to distinguish between different kinds of opacity: (i) opacity induced by complexity, which is a feature of all traditional experimental procedures in modern HEP; (ii) opacity induced by method, which is the specific opacity that accompanies searches using ML techniques. We then argue that – since CSs as well as ML techniques are algorithmically transparent – both kinds of opacity are contingent on the epistemic situation of cognitive agents: It is in principle always possible to overcome the opacity induced by complexity by learning more about the functioning of, and interrelations between software packages at ATLAS or similar experiments; and it is in principle always possible to overcome opacity induced by the method by tracking the procedures that the computer undergoes during its training. In a final step we want to change the focus from the question how the machine is learning to the question what the machine is learning. In this context, we define a third kind of opacity: model-opacity, which describes the opacity that is caused by the underdetermination of the connection between ML model and the underlying physical phenomenon. We claim that model-opacity is a candidate for fundamental opacity.

FRI
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Reductionism and Emergence in Theoretical Ecology: Challenge of "Species" as a Basal Unit

Paul Grünke & Katharina Brinck
KIT (Germany) & Imperial College London (UK)

"Nature", the system of all living things and their interrelations, is one of the most complex systems we know. Ecologists have the goal to understand and formalize exactly these interrelations – and are hence confronted with the demand to reduce complexity at different scales all throughout their work. Especially when aiming to find unified theories, which describe patterns across different species, spatial, temporal and dimensional scales, massive simplification is necessary. The most prominent simplification in ecology, also stemming from the descriptive history of the scientific discipline, is the identification of species as equal basal units. This choice of central observable entails several problems, including skewed data sets through an observational bias towards larger species, the ambiguous definition of the term across scales (e.g. mammals vs. bacteria) and the interdependency of roles (e.g. bacteria as species and as part of the species or rather ecosystem "human being"). Species are the result of the attempt to understand the natural world from a reductionist perspective – however, due to the described difficulties they don't necessarily serve as useful building blocks for modeling emergent phenomena and whole ecosystem dynamics. We argue that within our current framework for complex systems, useful building blocks need to be invariant in different contexts and roles, which is not given in ecology. We therefore conclude that in order to understand and to formalize the complexity of ecological systems and to understand natural phenomena across scales, either a better understanding of the building blocks or a new mathematical framework needs to be developed.

FRI
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The Saari triangle - both simple(x) and complex

Jaakko Hakula

The American mathematician, Donald G. Saari, has developed geometric methods in order to help researchers and students in voting theory to better understand, explain and construct paradoxes having haunted the scientific community for years. Voting methods are numerous, and using different methods the same group of voters can end up with different outcomes. The more candidates (alternatives) and voters in the system, the more complexities and discrepancies arise ("the curse of dimensionality"). An election or decision outcome not necessarily reveals the true preferences of the voters but moreover the choice of an election rule. As voting methods are prototypes of general aggregation rules, same kind of inconsistencies may occur in other disciplines (e.g. economics, statistics etc.) as well. The Saari triangle is a geometric profile representation (i.e. an equilateral triangle simplex), the pedagogical importance of which is its property to visualize paradoxes of preference aggregations in the three-candidate settings, especially in applications of positional and pairwise voting rules. The simplicity of the triangle looks trivial, but on a deeper look, the very mathematical complexity is revealed: profiles can have hidden symmetries of higher dimensional spaces, leading to unintended election outcomes. The complexity is dramatically increased along with the amount of candidates and voters. The simplest case of three alternatives defines a $3! = 6$ dimensional profile space invalidating the use of standard graphs to connect profiles with election outcomes. Profiles for six

alternatives define a $6! = 720$ dimensional space, and those for ten candidates, a possible situation in presidential primaries in the USA, expand into a $10! = 3628800$ dimensional space! The Saari triangle reflects both (methodological) simplicity and complexity. Different ontologies and epistemologies of the target systems to be voted for may result in either simpler or more complex interpretations.

Are Computer-Assisted Proofs really Complex? Complexity, Simplicity and Insight in Mathematics

Paul Hasselkuß

University of Düsseldorf (Germany)

THU
23 May
14:55

Computer-assisted proofs (CAPs) have produced outstanding results in mathematics, yet mathematicians often regard them as complex, messy and error-prone and refuse to use CAPs on these grounds. My talk will analyse and question this behaviour: Building upon examples from the controversy on Appel and Haken's (1989) proof of the four-color conjecture, I will argue that two often made objections against the acceptance of CAPs are in fact made using two distinct concepts of complexity: The first claims that CAPs are too complex insofar they are messy and error-prone, the second claims that CAPs are too complex insofar they do not give us insight into why a theorem is true. Then, I will question whether both objections are actually correct. The first objection may hold with regard to Appel and Haken's initial proof, but not with regard to later improvements, e.g., Gonthier's (2008) fully formalized proof. Dealing with the second objection, I argue that the notion of being too-complex-to-provide-insight presupposes that a proof's 'insight' could be judged in an (at least) intersubjectively stable way. However, this assumption can be questioned on the basis of recent empirical studies of mathematicians' proof appraisals by Inglis and Aberdein (2014, 2016) who were able to show that proof appraisals involve multiple different dimensions. Mathematicians disagree in their judgements on any quantity that can be represented as a combination of these dimensions. Based on the study's data I argue that insight can be represented as a linear combination of two of these factors; thus, the notion of being too-complex-to-provide-insight is subjective: It cannot warrant the exclusion of CAPs from mathematics.

Balancing complexity and simplicity in ecology - strategies and challenges

Tina Heger

University of Potsdam (Germany)

FRI
24 May
14:15

Ecology studies organisms and their interactions with the biotic and abiotic environment. Ecology thus by definition is dealing with complex study objects. During the history of this science, diverse methods have been developed to deal with the complexity, ranging from formalized descriptions of observations to mathematical abstractions. From time to time, there have been calls in ecology to search for simple 'laws'; meanwhile, however, there seems to be consensus that striving for simplicity in ecology cannot mean to look for laws in as strict a sense as in some areas of physics. Besides methodological strategies of dealing with complexity, the formation of sub-disciplines, each focusing on a smaller section of the overall topic of ecology, was an organizational strategy to cope

with complexity. For example, population ecology is focusing on processes taking place within a group of organisms consisting of only one species, whereas community ecology rather is dealing with interactions of organisms belonging to different taxa (e.g. food webs). These existing strategies are certainly valuable and have helped to increase knowledge and understanding of ecological systems and processes. However, they themselves bare challenges. Each simplifying method by necessity leaves aside certain aspects of the studied phenomena that might turn out to have a major influence; and the separation of research along sub-disciplines hinders the exchange of knowledge, potentially blocking a more complete understanding of the study objects. In the presentation, I will highlight some strategies of balancing complexity with the aim of reaching simple conclusions in ecology. I will give examples for the challenges ecologists are facing, and discuss current ideas on how to overcome them. One of these ideas is the hierarchy-of-hypotheses (HoH) approach, which posits that a hierarchical representation of complexity in some cases can help to build a bridge towards simplicity.

Interconnections of simplicity and complexity in the development of geometric concepts

WED
22 May
15:25

Maximilian Holdt
University of Kiel (Germany)

”Mais Dieu a choisi celui qui est le plus parfait, c’est à dire celui qui est en même temps le plus simple en hypotheses et le plus riche en phenomenes; [...]” (Discours de métaphysique; A VI, 4 B, 1538) With these words Gottfried Wilhelm Leibniz argued for the possibility of describing the best of all possible worlds via laws, which do, by their very nature, guarantee epistemic simplicity as they demand similar behaviour of different objects. Aside from Leibniz’ religious arguments however it is not self-evident why and how such a description should be possible. Mathematics, arguably, solves the task of being simple while still describing a manifold of objects through idealization, as is most readily seen in the development of geometric concepts. The progress from Euclidean to Riemannian Geometry shows how modern mathematics gets more complex, as being able to describe increasingly many objects, while also allowing for more simplicity through substituting, e. g. whole theories or spaces as single elements of overarching spaces as in gauge theories and corresponding moduli spaces. However, going back to Euclidean concepts of geometry, a different kind of simplicity as well as complexity can be discovered, where the abstract concepts are more intrinsically linked to observable objects. Such structures differ epistemologically from their modern counterparts as they can’t be described only in terms of pure mathematics. Rather one has to account for phenomenological aspects and the interplay between signifier and signified. In my talk I would like to study the aforementioned different kinds of complexities and simplicities by focusing on the development of the straight line to the geodesic and I will argue for their different ontological status, using Ernst Cassirer’s terminology of symbolic functions.

Situated Modelling: Anthropological Perspectives on Linking Complexity to Simplicity in Environmental Research

Anja Klein, Krystin Unverzagt & Jörg Niewöner
HU Berlin (Germany)

THU
23 May
14:55

Dealing with complex social-ecological phenomena is a crucial issue in sustainability debates. Participatory models and models of complex systems are two ways of handling this. We suggest situated modelling as an alternative framework to address complexity in this context. Coming from Socio-Cultural Anthropology and Science and Technology Studies, we take environmental simulation modelling as our object of ethnographic research – participatory modelling and models of complex systems, respectively. Employing an STS-inspired focus on knowledge practices, we frame complexity and simplicity as performative practices of world-making. Anthropology has become highly aware of the performativity of research as a dimension of complexity, along with a methodological tendency to aim for holistic representations of complex social phenomena. On the other hand, modelling in the environmental sciences and physics, when employed for causal explanation and prediction, tends to aim for universal generalisation and complexity reduction. We argue that methodological reflection combining insights and experiences from both disciplines can enable us to reach a workable notion of reflexive simplification. We suggest “situated modelling” as an alternative approach to deal with complexity. We will give two examples from recent ethnographic fieldwork of how practices of simplification are situated and performed: one of a working group of earth system modellers and one from a participatory modelling project. Rather than striving for the single most accurate simplification of complex events, situated modelling acknowledges the contingency of simplifications and tries to turn this insight productive. We focus here on the performativity of models. As a research framework, situated modelling relates positive, predictive and quantitative approaches to reflexive, contextualising and qualitative approaches. It does so in ways that move beyond integration and critique.

Sociological knowledge between storytelling and modelling

Lisa Kressin
University of Lucerne (Switzerland)

THU
23 May
14:15

The discipline of Sociology contains ‘two cultures’ with divergent conventions concerning claims for simplicity and complexity. These two ‘methodological communities’ can be characterized as applying 1) quantitative, substantial and 2) qualitative, interpretative approaches towards the study of the social. The former is aiming for formalized explanations, trusting in a unified scientific method that tests hypotheses, structures its data in terms of variables and their interdependencies, at best aiming for laws based on causation. Controlled complexity reduction is the main goal and necessity for the whole *modus operandi*. Without predefined classifications, descriptive and inferential statistics would not be applicable and hypotheses could not be tested. Standardized survey instruments secure simplified forms of the social, directly written into the data. In contrast, qualitative, interpretative approaches delegitimize these simplifications, which produce a social world that is too different from the researched one. Even worse, simplifying practices shape the social by its scientifically created categories in a non-reflective way. Being an empirical science in their understanding does not necessarily mean curating simplicity but

to mirror the complexity of the empirical (social) world. Therefore, they use less standardized forms of data collection and emphasize understanding than explaining. Due to their different structuring of the research process, both communities make use of different quality criteria, each having their own problems. The quantitative communities' request for reproducibility has experienced many 'crisis', hinting at the possibility that complexity reduction is not a one-way-only-street. Qualitative communities in contrast have to find alternative quality criteria to legitimate their claims to be scientific. Backed by my empirical work into the current dominant understanding of legitimate empirical research practices within German-speaking Sociology, I show how the divergent positions towards questions of complexity and simplicity create not only symbolic but social boundaries within the discipline of sociology.

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The Price equation and the complex biological world

Victor Luque

University of Valencia (Spain)

Traditionally, evolutionary biology has been portrayed as a historical science unable to formulate laws, and only capable of delivering coherent narratives. Due to its high degree of complexity and historical nature, biology is usually considered a messy science (Tawfik 2010). Nevertheless, my aim is to challenge part of this received view using the Price equation as a mathematical framework. The Price equation is an abstract representation of evolutionary change. The Price equation has been recently identified as the fundamental equation of evolution (Queller 2017) because it requires the fewest assumptions and all the other historical fundamental equations of evolution can be easily derived from it with additional assumptions. I claim that the Price equation can play the same role in evolutionary biology that other fundamental equations (Newton's second law of motion, Schrödinger's equation, etc.) play in physics. The idea here is that the proper use of the Price equation is to motivate the development of more detailed (complex) evolutionary equations that use its same basic language and logic. For these reasons, the Price equation is a unifying framework tool in order to include new parts to the structure of evolutionary theory, such as non-genetic inheritance, evo-devo, niche construction, ecology, and so on. In addition, there is invariance on the Price equation (Frank 2012), and this is a key property in physics equations, partially responsible for their predictive power. Therefore, the Price equation offers an opportunity to integrate the simplicity approach of mathematical abstraction with the complex biological world.

Organizational Complexity in LHC Experiments: Distributing Conference Talks as a Problem of Optimization

Martina Merz & Helene Sorgner
University of Klagenfurt (Austria)

FRI
24 May
14:55

At CERN's Large Hadron Collider, experiments involve 3,000 people working together. In her analysis of earlier experiments, Knorr Cetina (1995) described these collaborations as semi-detached corporations with little formal hierarchy and without centralized decision-making. Today's LHC collaborations are characterized by a massive scaling up, e.g. a factor of ten increase in membership compared to earlier experiments. We observe that physicists perceive of this sharp increase as giving rise to novel organizational challenges. Organizational complexity is enhanced further by heterogeneity in the constituency (origin, expertise, seniority) and the distribution of work across time and space (long life-time, members from around the world), while the ensuing physics results are expected to be collectively coordinated achievements. We will analyze a particular case of how collaborations handle organizational complexity while balancing the interests and needs of the collaboration with those of individual members. Physicists set up the considered case as a problem of optimization: How should the collaboration distribute 600-700 conference talks annually among its members to ensure, both, a fair distribution and a competent representation of the collaboration? Based on qualitative interviews, we analyze the associated organizational strategies; the rationales, criteria, and algorithms for selection; the unexpected problems and challenges that arise in practice. We contextualize our analysis by an investigation into physicists' explicit and implicit notions of organizational (and more generally, social) complexity and by reflecting on how this notion can be theorized to more adequately account for the particular conditions of knowledge production at the LHC.

A Logical Structure for Reducing Complexity

Robert Moir
University of Western Ontario (Canada)

FRI
24 May
14:55

Using mathematical models to represent structural relationships between certain features of a phenomenon is a ubiquitous strategy in science for overcoming descriptive complexity. The advantage of this approach is to reduce those features of the phenomenon we care about (given the sorts of questions we are asking) to a conceptual simplicity, which facilitates a range of descriptive, predictive and explanatory tasks. The difficulty for epistemology of science, however, is that in practice these tasks are accomplished in extraordinarily varied ways, even within a given scientific discipline, which obscures any clear logical structure of the modeling process. This talk will show how we can discern a clear structure to the modeling process using 'effective logic', an informal logic for approximate inference [1]. In this framework, we can view problem-solving strategies in science, including mathematical modeling, as maps between the scientific languages used in practice that allow us to make stable inferences. From this perspective, then, mathematical modeling strategies are successful for two main reasons: they are 'inferentially stable', i.e., maps between scientific languages preserve the information about the phenomenon we care about; and they reduce 'inferential complexity', i.e., they reduce the difficulty/cost of drawing inferences. Ensuring inferential stability while minimizing

inferential complexity is then seen to underlie a wide variety of solution methods to problems in applied mathematics, computational science and beyond. We will illustrate these notions through a scientific case study involving computing impact probabilities for near-Earth objects. We will emphasize that the applicability of the concepts is quite general, thus elucidating a clear pattern of using abstraction to reliably make scientific problems simple enough to solve.

[1] Moir, RHC. "Effective Validity: A Generalized Logic for Stable Approximate Inference." in 'Fields Institute Communications: Algorithms and Complexity in Mathematics, Epistemology, and Science,' Ed. Corless, Fillion & Kotsireas, forthcoming February 2019.

THU
23 May
14:55

Broken Symmetry: the bridge between simplicity and complexity

Núria Muñoz

One of the clearest examples of simplicity as a guiding epistemic value is physicist's search for a unified theory of everything in the second half of the 20th century. However, fundamental physicists —traditionally particle physicists— met with great difficulties in their attempts to find an all-encompassing central equation. Aggravating their difficulties was the fact that the concept of fundamentality was being contested by condensed matter physicists, who began demanding their share on the podium of the fundamental physical sciences, coinciding with a decline of public opinion on the relevance of particle physics in the 1970s. This campaign was led by Nobel laureate Philip Anderson, who made explicit what was already widely recognised amongst condensed matter physicists: that complexity arises out of simplicity in non-predictable ways and that "the understanding of the new behaviour requires research [...] as fundamental in its nature as any other." (Anderson 1972) and that a theory of everything would be a theory of almost nothing. This is expressed in Anderson's well-known paper "More is Different", which describes the mechanism through which this quantitative to qualitative transition takes place, known as symmetry breaking. Anderson published it unaware that this idea had already a long-standing tradition in philosophy and biology, under the name of emergence. While emergence was traditionally linked to an anti-reductionist position, it was never Anderson's intention to oppose reductionism, but rather to put forward the compatibility between the two. I will argue that physics maintains indeed a special position in the debates on simplicity and complexity. Condensed matter physics —almost at the bottom in the "hierarchy of the sciences"— support to the emergence-compatible-with-reductionism view has been crucial for the proliferation of simplicity and complexity as mutually connected epistemic values, without one dominating over the other.

Cognitive and computational complexity in mathematical problem solving

Markus Pantsar

University of Helsinki (Finland)

THU
23 May
15:35

In the research of mathematical cognition, one of the key questions is the complexity of cognitive processes involved in mathematical problem solving tasks. In the commonly used paradigm of computational modelling of cognitive tasks, such tasks are characterized functionally, i.e., purely in terms of their input and output. In the case of mathematical problem solving, this paradigm allows the application of computational complexity measures in determining the complexity of cognitive tasks. In computational complexity theory, complexity of problems is characterized through the concept of Turing machine. More specifically, the complexity of a problem is defined as the complexity of an optimal algorithm for solving the problem. An optimal algorithm refers to an algorithm run by a Turing machine that takes the least amount of computational resources (time or space). In this talk, I argue that while useful, focusing on the computational complexity measures can be ill-fitted in characterizing mathematical problem solving processes in several ways. I will present examples from mathematical practice that show human problem solvers to often use characteristically suboptimal problem solving algorithms. These are already present in mental arithmetic and are evident in many important aspects of Cognitive and computational complexity in mathematical problem solving mathematical problem solving, including diagrams and the spatial arrangement of symbols. I will conclude that in order to respect such integral parts of real-life problem solving processes, we must focus on humanly optimal, rather than computationally optimal problem solving algorithms. However, the humanly optimal algorithms are not universal and thus the resulting concept of cognitive optimality must take into account the culturally determined aspects of mathematical problem solving, ranging from the symbol systems to the cognitive tools used in the problem solving processes.

Complex socio-technical relations: a consideration of simplicity as principle of product development

Fabian Pilz & Andrea Wolfram

University of Magdeburg (Germany) & RWTH Aachen (Germany)

FRI
24 May
14:15

Increasing requirements on today's products, as well as possibilities resulting from globalization and digitization, lead to a growth of increasingly complex products. However, design principles from the field of design engineering call for a product to be designed as simple as possible. However, product simplicity is not only defined by the instrumental functions of the product, but also by the knowledge and experience of the user. In this paper, existing concepts for the description of simplicity and complexity in mechanical engineering as well as in sociology will be analyzed. It will be examined whether the product complexity can be defined as a function of social groups.

WED
22 May
15:25

Simplicity and Unification in Mathematical Explanation

Navia Rivas de Castro

University of Santiago de Compostela (Spain)

In recent literature, there is an appeal to standard desiderata for good scientific theories. These include empirical success, power of unification, simplicity, explanatory power, fertility and so on. When it comes to analysing the explanatory power of unification and simplicity in mathematics, we all come across the idea that the simpler and more unified theory explains better than the more complex and less unified one. For instance, authors such as Baker (2005, 2009, 2017) argue that unification in mathematics plays such an important explanatory role that it commits us with the existence of mathematical entities, leading us to a platonist approach to abstract objects. In particular, Baker (2017) offers a unified argument that explains both the already well-known case of the period cicada and the mechanism of the rear wheel of brakeless fixed-gear bicycles and gear ratios. His aim is to show that these distinct physical phenomena share the same explanatory core under a single explanatory pattern about unit cycles, hence maximizing topic generality and unification and highlighting its scientific value. This way, mathematics would go beyond representation by adding a series of premises that include the relevant mathematical facts applied to the cicada case. The aim of this paper is to analyse these unified arguments to see if we gain any explanatory power by unifying or simplifying the explanation of the two cases and hopefully have a clearer picture of the role of simplicity and unification in mathematical explanations. This case will provide some evidence that, contrary to what Baker defends, it is quite plausible that unification does not always yield more explanatory power for it may compromise cognitive salience and make arguments more obscure in topicspecific explanations that do not benefit from mathematics' ability to explain various phenomena under one argumentative pattern.

Higgs Naturalness and Two Views of Wilsonian Effective Field Theory

THU
23 May
15:35

Joshua Rosaler & Robert Harlander

RWTH Aachen (Germany)

This presentation merges the contents of two articles on the Higgs naturalness principle: Both works consider implications for the interpretation and formulation of quantum field theory of Wetterich's 1984 claim that fine tuning problems such as the one associated with the Higgs mass are artifacts of badly chosen expansion parameters. Paul Hasselkuß Joshua Rosaler Robert Harlander Higgs Naturalness and Two Views of Wilsonian Effective Field Theory "Naturalness, Wilsonian Renormalization, and 'Fundamental Parameters' in Quantum Field Theory" Abstract: The Higgs naturalness principle served as the basis for the so far failed prediction that signatures of physics beyond the Standard Model (SM) would be discovered at the LHC. One influential formulation of the principle, which prohibits fine tuning of bare Standard Model (SM) parameters, rests on the assumption that a particular set of values for these parameters constitute the "fundamental parameters" of the theory, and serve to mathematically define the theory. On the other hand, an old argument suggests that fine tuning of bare parameters merely reflects an arbitrary, inconvenient choice of expansion parameters and appears to dispense entirely with the notion of fundamental parameters. We argue that these two interpretations of

Higgs fine tuning reflect distinct ways of formulating and interpreting effective field theories (EFTs) within the Wilsonian framework: the first takes an EFT to be defined by a single set of physical, fundamental bare parameters, while the second takes a Wilsonian EFT to be defined instead by a whole Wilsonian renormalization group (RG) trajectory, associated with a oneparameter class of physically equivalent parametrizations. From this latter perspective, no single parametrization constitutes the physically correct, fundamental parametrization of the theory, and the delicate cancellation between bare Higgs mass and quantum corrections appears as an eliminable artifact of the arbitrary, unphysical reference scale with respect to which the physical amplitudes of the theory are parametrized. While the notion of fundamental parameters is well motivated in the context of condensed matter field theory, we explain why it may be superfluous in the context of high energy physics. "Higgs Naturalness and Renormalized Parameters" Abstract: It has been argued that one influential formulation of the Higgs naturalness principle, which precludes fine tuning of Standard Model bare parameters, does not reflect the sort of coincidence that is often attributed to it, on the grounds that the values of bare parameters are unphysical and chosen as a matter of mathematical convention. In response, some have argued that the correct, salient formulation of the naturalness problem concerns the behavior of renormalized parameters, on the grounds that these are the genuinely physical parameters of the theory. Contrary to this view, we emphasize that except in on-shell schemes, renormalized parameters have much the same element of conventionality as the bare parameters of finitecutoff parametrizations in the Wilsonian approach. For this reason, we argue, one may doubt the salience of "renormalized" formulations of the Higgs naturalness principle for reasons similar to those raised in the case of "bare" formulations.

Application of Computer Programs to Simulate the Folding of Conotoxins

Windol Charls Santos

WED
22 May
16:05

In protein structure prediction, the sequence of amino acids along the polypeptide dictate its three-dimensional structure, which in turn will determine how it will function. One case of this is the folding of conotoxins, which are also disulfide rich peptides. How it folds such that the right disulfide bonds are formed is not that well-understood. There are many interactions between all the amino acids, and computing them by hand is untenable. Therefore, chemists have used computer simulations to bridge the disparity between the plenitude of protein sequences compared to the relative scarcity of protein structures. Computer simulations are applied in protein folding to model a simplified version of the system, and extrapolate the results to the more complex real-life case. Computer simulations started from using programs which simulate the interactions of amino acids using force fields in programs such as CHARMM, AMBER, and Gromacs. More recently, Deepmind's AlphaFold used artificial intelligence to predict the distances of pairs of amino acids and the angle of the amide linkages to simulate a complete structure. These efforts attempt to bridge from simplicity (amino acid sequence) to complexity (predicting the structure) and back to simplicity (function). This paper will inquire about how computer programs such as CHARMM, AMBER, and Gromacs, serving as virtual laboratories, approximate proteins, specifically conotoxins, and predict their folding. Part I will discuss the complexity of predicting protein folding. Part II will show the various methods in predicting protein folding. Finally, Part III will explain the role of computer programs as virtual laboratories to predict the folding of conotoxins.

The quest for simplicity: DPT combination vaccine in the 1950s and 60s

WED
22 May
16:05

Gaëtan Thomas
EHESS Paris (France)

My presentation will investigate the history of combination vaccines in the postwar period, through a case study of the main intervention of this type, i.e. the vaccine against diphtheria pertussis tetanus (DPT). I will focus on the history of its development and use in France in the 1950s and 60s, delving into the immunological and industrial issues at stake. My sources will be publications, public and corporate archives (Mérieux Foundation). This presentation aims to show how the ideal of simplicity, fully expressed in the quest for combination vaccines, has been crucial to the pharmaceutical industry and public health experts during this period. While the discussion of immunization technologies often revolves around the dual operation, innovation-standardization, neither of these sufficiently encapsulates the activity of managing the increasing number of injections with the goal of maintaining immunization as a consolidated device and acceptable public health intervention. My presentation will attempt to augment and reframe this lexicon by introducing the term “simplification,” which captures the process of integrating the growing number of vaccines into unified devices. I argue that this operative term could also provide a better understanding of the rationale for other important health interventions during the latter half of the twentieth century (antibiotic combinations, AIDS treatments for example), thereby offering a valuable analytical tool to historians of science and medicine.

From Simple to Complex: the Emergence of Multicellularity

WED
22 May
15:25

Walter Veit
University of Bristol (UK)

For decades Darwinian processes were framed in the form of the Lewontin conditions: reproduction, variation and differential reproductive success were taken to be sufficient and necessary. Since Buss (1987) and the work of Maynard Smith and Szathmáry (1995) biologists were eager to explain the major transitions from individuals to groups forming new individuals subject to Darwinian mechanisms themselves. Explanations that seek to explain the emergence of a new level of selection, however, cannot employ properties that would already have to exist on that level for selection to take place. Recently, Hammerschmidt et al. (2014) provided a ‘bottom-up’ experiment corroborating much of the theoretical work Paul Rainey has done since 2003 on how cheats can play an important role in the emergence of new Darwinian individuals on a multicellular level. The aims of this paper are twofold. First, I argue for a conceptual shift in perspective from seeing cheats as (i) a ‘problem’ that needs to be solved for multicellularity to evolve to (ii) the very ‘key’ for the evolution of multicellularity. Secondly, I illustrate the consequence of this shift for both theoretical and experimental work, arguing for a more prominent role of ecology and the multi-level selection framework within the debate then they currently occupy.

Information on Location & Travel

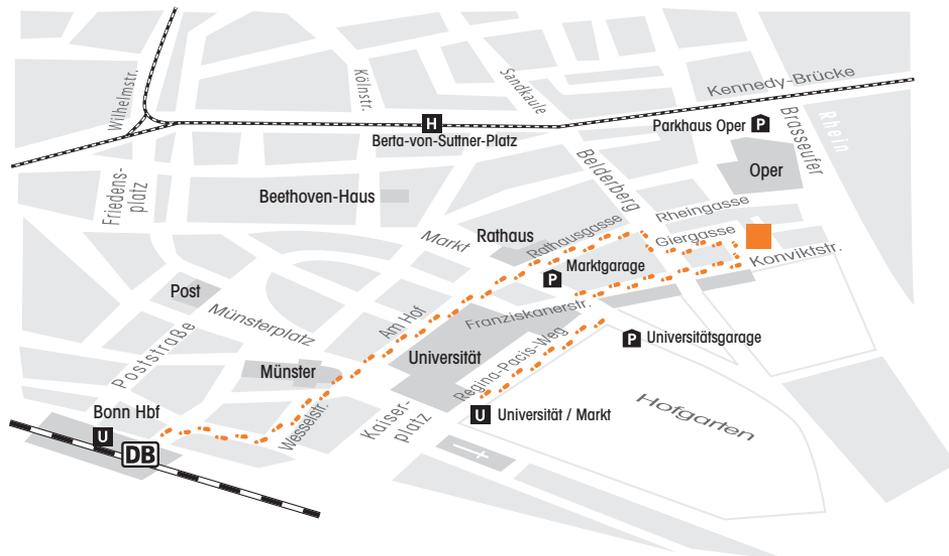
The venue of the conference is the **Universitätsclub Bonn**, Konviktstraße 9, 53113 Bonn, located directly at the university and the river Rhein. (Further information can be found at <https://www.uniclub-bonn.de/>)



It is best reached by foot from Bonn main station (~ 12 min.), the metro station Universität/Markt (~ 7 min.) or the bus station Bonn Markt (~ 5 min.).

All Keynote Lectures will be held in the Wolfgang Paul Saal. The Parallel Sessions will be held in four rooms (Wolfgang Paul, Curtius, Martini & Friesenhahn). See the schedules for detailed information.

We are looking forward to welcoming you there.



The following airports are nearby:

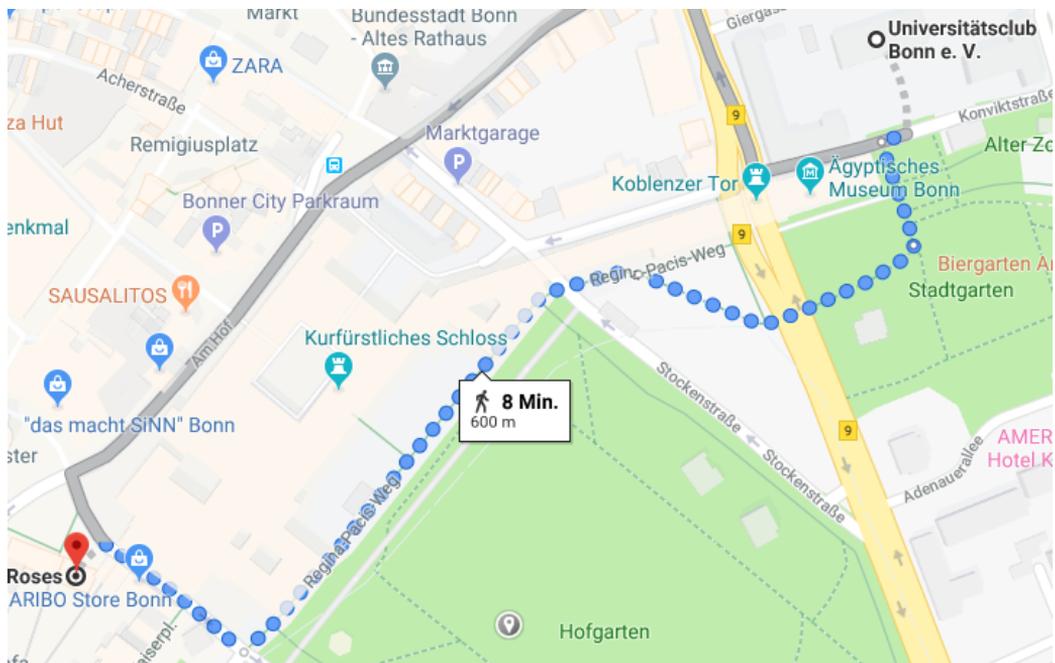
- **Cologne-Bonn.** Intercontinental airport.
Take the Airport bus SB60 to Bonn and get off at "Bonn Markt".
A taxi - airport to Universityclub Bonn - about 45€.
- **Düsseldorf.** Third-largest intercontinental airport in Germany.
0h50 by RE (i.e. Regional Express, the least expensive trains) to Bonn Hauptbahnhof (central station)
- **Frankfurt (am Main).** Largest intercontinental airport in Germany.
1h40 by RE (i.e. Regional Express, the least expensive trains) to Bonn Hauptbahnhof (central station) or 0h45 by ICE (more expensive than RE, and are best booked in advance to reduce costs) to "Bonn / Siegburg" and continue with the Metro line 66 to "Bertha-von-Suttner-Platz."
A taxi from "Bonn / Siegburg" is about 30€.

All information on public transport in Bonn can be found at <https://en.swb-busundbahn.de/>

Conference Dinner & Suggestions for Lunch

Please note that registration to the conference dinner was required beforehand.

The conference dinner will be held at the restaurant **Roses**, located at Martinsplatz 2a, close to the conference venue. The menu will be available at the foyer of the Uniclub. Please indicate your choice to our staff located there on Wednesday.



There are several options to have lunch around the Universitätsclub. Here are some suggestions (in arbitrary order):

Café Blau
Franziskanerstraße 9, 53113 Bonn
<http://cafeblaubonn.de/>

Ichiban Sushibar
Stockenstraße 14, 53113 Bonn
<http://www.ichiban-sushibar.de/>

Biergarten am alten Zoll
Brassertufer, 53113 Bonn
<http://alter-zoll.de/>

Roses
Martinsplatz 2A, 53113 Bonn
<https://roses-bonn.de/>

Vapiano
In der Sürst 1, 53113 Bonn

Mensa und Cafeleven
Nassestraße 11, 53113 Bonn

Dim Sum
Markt 5, 53111 Bonn
<http://dimsum-bonn.de/>

Tuscolo Münsterblick
Gerhard-von-Are-Straße 8, 53111 Bonn
<http://tuscolo-muensterblick.de/>

May May
Am Hof 24, 53113 Bonn

Em Höttche
Markt 4, 53111 Bonn
<http://www.em-hoettche.de/>

Mandu
Franziskanerstraße 5, 53113 Bonn

Uni Burger
Stockenstraße 1-5, 53111 Bonn

PommFritz
Am Hof 26, 53111 Bonn
<https://pommfritz.business.site/>

Ruland Pizza Pasta Vino
Bischofspl. 1, 53111 Bonn
<http://www.ruland-bonn.de/>

