

The Whys and Hows of Theory—Comparing Cognitive Science and Economics

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Journal Club by Helena (August 2024)

Discussion

1. Why did you classify yourself into economics or cognitive science?
2. How important is “theory” in your field of research and why?
3. List top three criteria or factors for “good theory”?

Abstract

Given the ongoing debates about the replication crisis, theory crisis, and cooperation among disciplines in cognitive science, it is instructive to compare cognitive science with economics. The two fields face common challenges, most importantly in that both study complex, open systems. The strategies for facing these challenges, however, are quite different. Economics was long dominated by theory. Cognitive science takes a multidisciplinary approach, and despite its attendant diversity is dominated by psychology, which itself often neglects theory. I defend economics' use of theory, characterizing its formal modeling tradition as an effective divide-and-conquer strategy for understanding complex, open systems. I argue that theory and experimentation ideally support one another, making replicability less of an issue. I also discuss the appropriate level(s) of analysis in economics and cognitive science as products of the systems they study. Finally, I compare the two fields' very different community structures, treating economics as a cautionary tale and advocating pluralism.

Keywords Philosophy of science · Economics · Cognitive science · Theory · Methodology

Are the differences necessary?

Subject matter
Complexity
Open Systems

“Economics is united by a strong theoretical tradition and a fairly unified modeling paradigm”

“Cognitive science is internally diverse and theory plays a major role in some parts but not in others”

Caveats

- Shaped by their history
- Parts focus on psychology specifically
- Elaborate on economic methodology in more detail
- Brief and to present perspective as a philosopher

Overlapping subject matter

The most basic commonality between economics and cognitive science is a non-trivial overlap in the subject matters of the two fields, especially in that **understanding judgment and decision-making** is of central importance to both. As a result, there has been mutual influence between them where this common subject matter is concerned: In cognitive science, **formal decision theory**—especially the concept of utility maximization—and Bayesianism play a prominent role in some research programs (see, e.g., Gopnik et al. 2004; Oaksford and Chater, 2007; Lieder and Griffiths, 2020).¹ In economics, there is an influential research program in **behavioral economics**, which advocates the integration of psychology and a more empirical approach (Camerer, 1999; Angner & Loewenstein, 2012); (see, e.g., Kahneman et al. 1990; O’Donoghue and Rabin 2000; Ariely et al. 2003; Farber, 2008). A subset of behavioral economists even pursue neuroeconomics, which sees neuroscience as enabling a revolution in decision theory (Camerer et al., 2005; Glimcher & Fehr, 2014).²

¹ It is not a coincidence that the parts of cognitive science which are closely connected to economics are especially theory-driven.

² While these relatively new research programs have spurred a significant increase in the interest and incorporation of empirical findings into economics, the greatest impact has come from those findings which can be integrated into the existing theoretical approach. Hence, neuroeconomics has had hardly any impact on mainstream or orthodox practices, whereas behavioral economics has led to new forms of utility functions being used, for example, to reflect empirically observed non-standard weightings of probabilities. See Gul and Pesendorfer (2008) for a discussion of why the impact of psychological and neuroscientific research is limited in this way.

Complexity

Complexity is an intuitive concept which can be defined in many ways (see Holt et al. 2011), but Simon (1962) provides a useful characterization for present purposes:

Roughly by a complex system I mean one made up of a large number of parts that interact in a non-simple way. In such systems, the whole is more than the sum of the parts, not in an ultimate metaphysical sense, but in the important pragmatic sense that, given the properties of the parts and the laws of their inter-action, it is not a trivial matter to infer the properties of the whole (Simon, 1962, pg. 468).

- Economic outcomes = activities of many individuals, but macro-level economics have other properties that cannot be easily be inferred from theories of individual behavior
- Individual = beyond biological parts like neurons or particular cognitive processes

1962). More recently, economists—especially those with a heterodox bent—have argued for a more pluralist approach to studying the economy to ensure that this complex system is studied from more angles (see Garnett Jr, 2006, for discussion). This is analogous to calls in cognitive science to pursue all levels of analysis, the idea being that no single level (e.g., the neuronal or “implementation” level or the abstract computational level) will suffice (Bechtel & Shagrir, 2015). Holt et al. (2011) have even heralded the arrival of the “complexity era” in economics. Similarly, Favela (2020) argues for “cognitive science as complexity science.”

Open systems

As with complexity, *open systems* (Von Bertalanffy, 1950) can be defined in different ways (see Chick and Dow, 2005). For present purposes, the crucial observation is that there is basically **no limit to the causal factors** that can be **relevant** to the systems we are studying. Put differently, for any model of the system that one could develop, that **model** will be **incomplete** in that factors or forces from outside of the model will at least sometimes have an important influence on what happens within the system.

It is a common experience in experimental psychology, for example, to discover that we are studying sociology—the effects of the past histories of our subjects—when we think we are studying physiology—the effects of properties of the human nervous system. Similarly, business cycle economists are only now becoming aware of the extent to which the parameters of the system they are studying are dependent on the experiences of a population with economic events over the previous generation (Simon, 1980, pg. 33).

- Interactions are “hard to grasp” or “hope to ignore”
- Not possible to consider everything at once nor be sure the impact of things that are left out
- “Researchers in both economics and cognitive science must do their best given this difficult state of affairs.”

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2. *Theory and Experiment*
3. *Divide-and-Conquer and Levels of Explanation*
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Research toolkit for “real” science

- **Cognitive science**, formal, analytical modeling is an **option** vs practically **required** in **economics**
- Formal models are one important tool for theory development
 - Clearly lay out theoretical commitments and a theory’s implications
 - Modeling results for theories to be revised, refined, or expanded
- “Economics is special among the social sciences in that **formal modeling** has long been the method of research; a “formalist-deductivist” (Lawson, 2006) approach to its target topics (e.g., markets, choice) can even be taken as constitutive of economics (see also Robbins, 1932; Nelson, 1995).”
 - **Shared modeling paradigm** of individual choice as the driver and rationality assumptions (usually utility maximisation)
 - Experimentation become important part of the mainstream toolkit over the past few decades, but experiments tend to be based on theory or on theory-based model results and often serve further theory development. Robust empirical findings often lead to new variations or expansions of existing models.

and shaped by historical and sociological factors. We have already observed that economics and cognitive science (and psychology) have similar and even strongly overlapping subject matters; hence, their **methodological differences** are largely **due to history** and probably say more about the **scientists involved than about the phenomena they seek to explain**. Indeed, cognitive science *exists* as it is—with a

Historical perspective of earlier belief that “real science” requires formalization and precision (see, e.g., Ross, 2018).

- Economics tried to **emulate physics** (theory heavy and mathematical)
- Psychologists may instead think that “real science” requires performing **experiments** (Flis, 2019; van Rooij, 2021)



Example: Forecasting the future ice-cream market

Activity

1. Can you do this perfectly?
2. How would you do it?

Open system: no limit to the factors that might influence the ice-cream market

- Impossible to account for all of the factors so not point trying → ignore most of these factors according to a pre-established system
- Some important factors (from present POV and given our specific interests e.g. temperatures and ingredient costs) compared to others (e.g. the salesperson has really cool hair, or repelled by the politics of the owner).
- Use (schooled) intuition about the target system to place such factors on a spectrum of relevance and interest for present purposes.

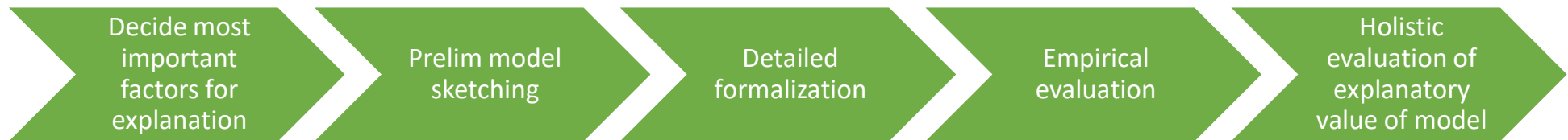
Ideal steps of economic modelling (Katzner, 2017):

Salesperson's really cool hair on ice-cream demand

Politics of the owner on ice-cream demand

Ingredient costs on ice-cream demand

Temperatures on ice-cream demand



Open system: no limit to the factors that might influence the ice-cream market

Over time, this means that economists study systems of interest by building up a **library of models** that collectively cover more and more of the **space of possibilities and accommodate increasing levels of complexity** (Veit, 2020). And because this process is used systematically by the whole mainstream economics community, there is a **clear** sense in which the library of models as a whole can be used to tell a **story**; the models are not disjointed, but overwhelmingly stand in clear relationships to one another, supplementing and complementing each other. If an economist perceives that an apparently important aspect of the real system has been left out of or inadequately studied by existing models, it is generally **clear how to remedy the problem**—by expanding or combining elements of existing models to include the new factor, according to established modeling principles.⁶

Formal modeling deals with complex open systems

“Analytical models especially are often criticized for being too simple, too idealized, too abstract, and too different from the real world to tell us much about it (models are often on the defensive)”

Regimented approach that has them **prioritize potential system features, focus, prove, and repeat with time and patience.**

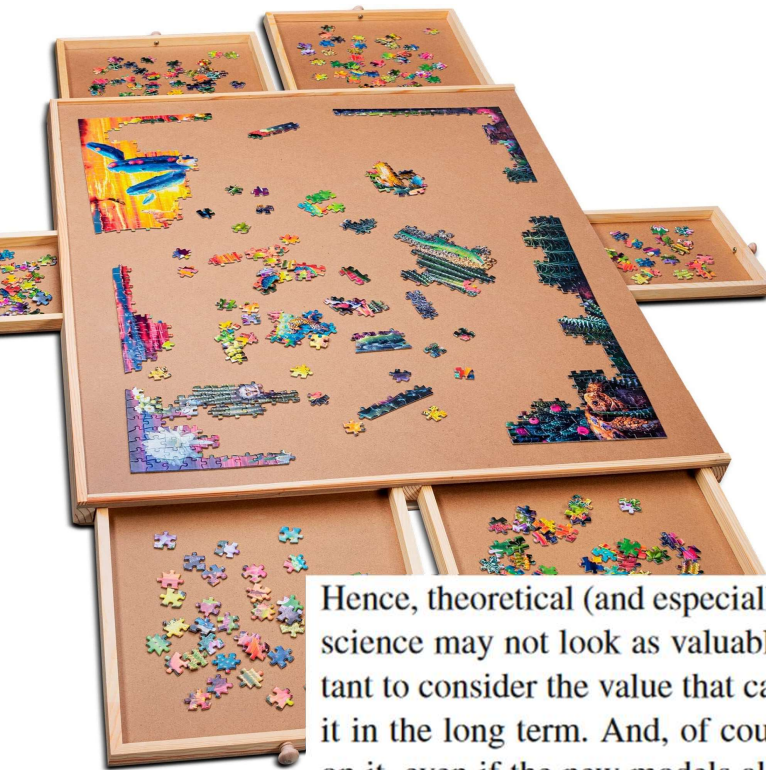
⁶ In his keynote at the Lorentz workshop, Kaznatcheev (2022) argues that we can see how theoretical a field is by looking at the structure of community engagement with others' work; more theoretical fields are more cumulative, meaning that they have more long chains of substantial, direct engagement with prior work. This seems to match economics perfectly, although the hypothesis has (to my knowledge) yet to be tested empirically.

⁷ Note that I'm not claiming that models or theories are getting closer and closer to some objective truth. The claim, instead, is that descriptively, economists aim to provide better models and improved understanding, at least from the perspective of other economists. See for example McCloskey's analysis of economics from the perspective of rhetoric (McCloskey, 1998).

Work in progress

Hence, theoretical (and especially formal) work in cognitive science may not look as valuable as it really is; it is important to consider the value that can be created by building on it in the long term. And, of course, to actually try building on it, even if the new models also look too simple, in order to potentially realize that value.

Strategy of ignoring complexity



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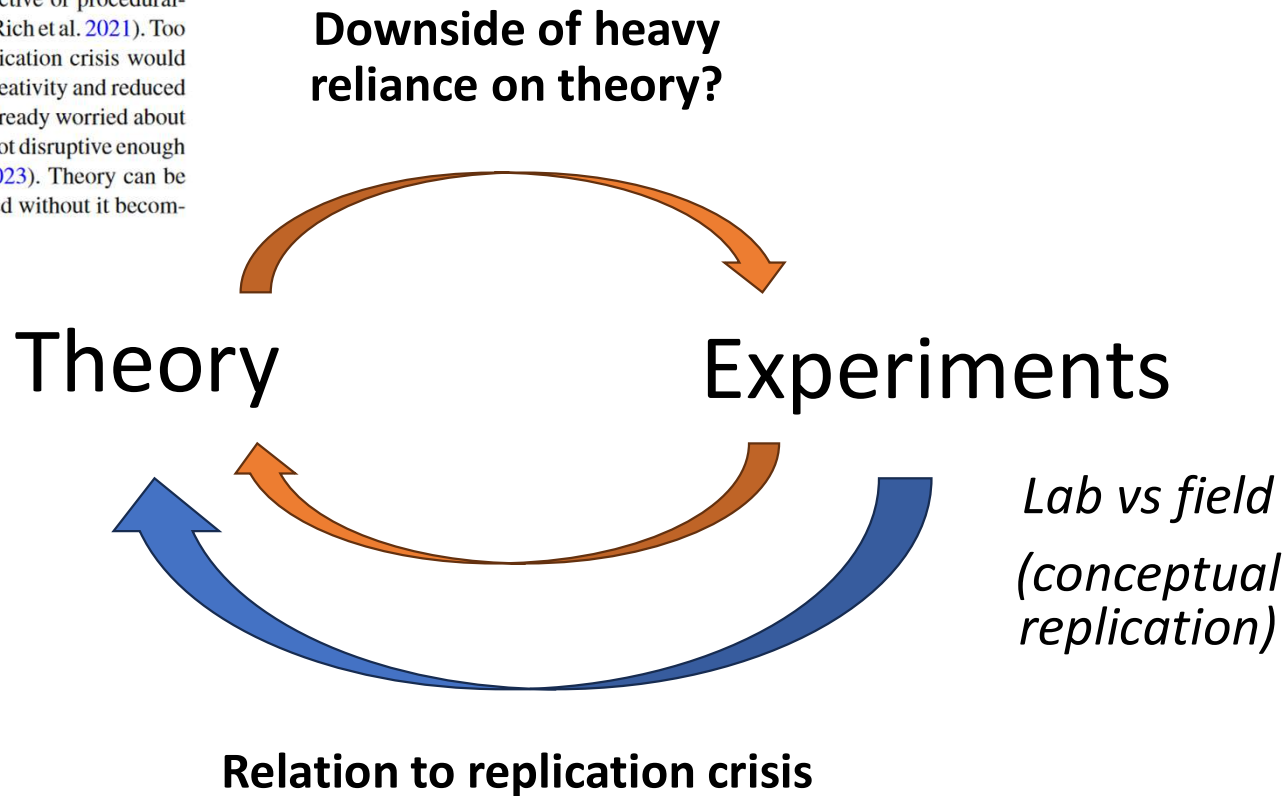
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Theory and experiments

This impression fits well with recent discussions about the need to avoid making research too objective or proceduralized (see, e.g., Field and Derksen, 2021; Rich et al. 2021). Too much regulation in response to the replication crisis would bring its own problems, such as stifled creativity and reduced innovation,¹⁴ at a time when some are already worried about science becoming too conservative and not disruptive enough (see, e.g., Stanford, 2019; Park et al. 2023). Theory can be promoted and its value can be recognized without it becoming a straight jacket.



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Divide-and-Conquer and Levels of Explanation (Hierarchical and decomposable)

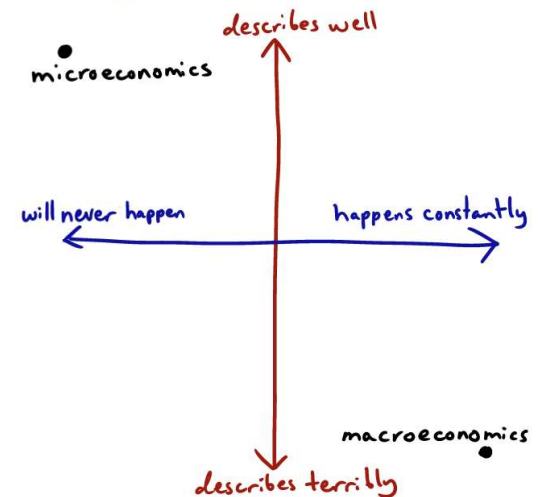
Simon (1962) argues that complex systems which are hierarchically organized could evolve more easily, giving us some reason to think that the complex systems we are trying to study have **hierarchical structure**. By hierarchical structure, he means that the complex system is made up of nested subsystems. Furthermore, the systems will be **“nearly decomposable”** in the sense that there is much more important **interaction within a subsystem than between subsystems**; the impact of one subsystem on another can be largely understood as an aggregate impact (the subsystem as a whole has an impact) rather than in terms of the individual impacts of the parts. Especially in light of the challenge of open systems described above—that there is no limit to the ‘external’ factors that could have an important impact on the system under study—it is clear why a hierarchical and nearly decomposable system would be much easier to study than an arbitrary complex system. If the system has such a structure, then the subsystems can be fruitfully studied individually, even though they are connected.

Soft Serve Cone



KNOW YOUR BRANCHES OF ECONOMICS:

- HOW WELL THEORY DESCRIBES SCENARIOS IT CONSIDERS
- HOW LIKELY THOSE SCENARIOS ARE TO OCCUR IN REALITY

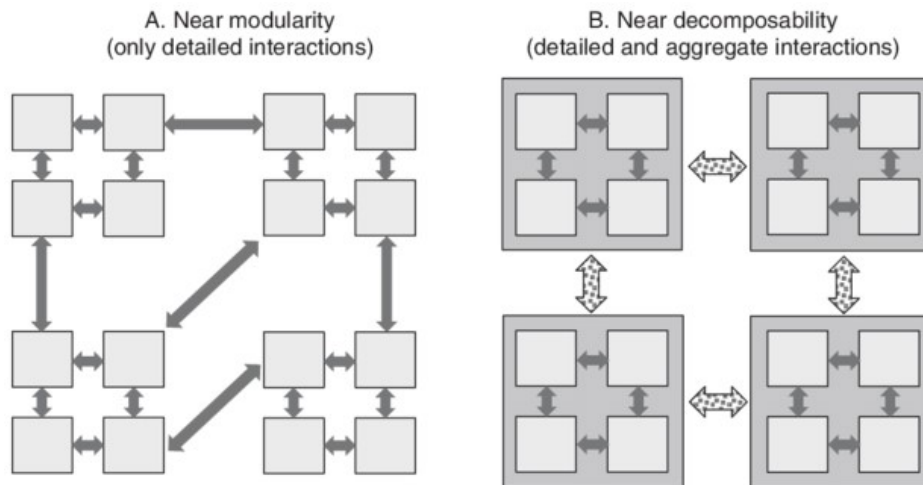


Divide-and-Conquer and Levels of Explanation (Hierarchical and decomposable)

Caveat: don't just focus on one level, but decomposability means we can represent higher-level without representing all lower-level interactions

What is consumption equivalent in cognitive science?

- Maybe cognition has no counterpart (special subsystem deeply influencing others)?
- Mind's modules can be studied individually
- But how are these modules coordinated/unified → goals and coherent behaviour



deserving a central place in cognitive science. Whereas in economics the permeation of consumption provided an argument for a focus on the individual level, in cognitive science a permeation of central processing would (to me) seem to provide an argument for computational level modeling—what the central processing *does* would seem to be an essential question and a prerequisite for understanding much of the rest. Indeed, Minsky's focus is at this level, with an attempt to describe abstractly what the (parts of the) mind are doing.

Are the differences necessary?

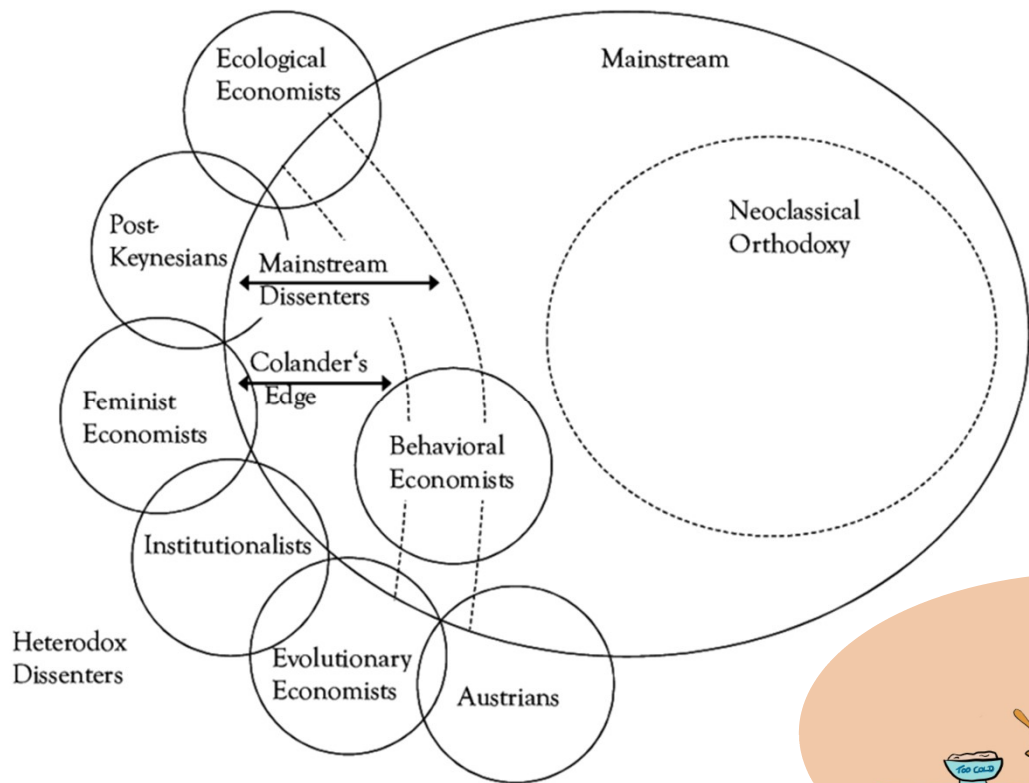
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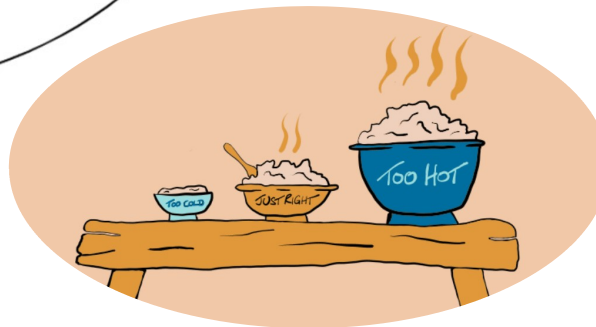
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Theory as a Community Project



- *Diversity in Divide-and-Conquer and Levels of Explanation*
- *Cumulative Theory Development*



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More questions than answers...

What makes a good theory?

JUNE 25, 2022
IRIS VAN ROOIJ

June 20-24, 2022, the [Lorentz Workshop “What makes a good theory? Interdisciplinary perspectives”](#) (organised by Berna Devezer, Joshua Skewes, Sashank Varma, Todd Wareham, and myself) took place. In total some 45 participants came together in a hybrid venue, on-site at the [Lorentz Center](#) and online in [Gather.town](#). Participants came from a large variety of disciplines, including cognitive science, psychology, philosophy, linguistics, computer science, neuroscience, biology, statistics, artificial intelligence, economics, and more.

I'm thrilled that I am able to share the amazing keynote talks with you. In these brief (15 min) talks, each speaker was asked to address one or more of the following 3 subquestions of the workshop theme:

1. What criteria define good theories?
2. How can we tell that a theory meets the criteria?
3. How do we get good theories, i.e., what tools and methods may be employed to develop them; what practices and processes may facilitate their emergence?

Keynotes

- What makes a good theory, and how do we make a theory good? (Olivia Guest)
- What not to expect of theories (Angela Potochnik)
- Identifiability as a tool for developing theories and generating better measurements (Manjari Narayan)
- Mathematical models and alternative values (Patricia Rich)
- Community makes good mathematical theory (Artem Kaznatcheev)
- What makes a good theory? Learning from linguistics (Giosué Baggio)
- Cognitive theories that provide understanding (Sashank Varma)
- What makes a good theory? (Coty (Cleotilde) Gonzalez)

<https://irisvanrooijcogsci.com/2022/06/25/what-makes-a-good-theory/>