A Second Expansion of Science

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Discourses are species in the ecology of language.

-- Klaus Krippendorff

What are the components of a scientific field?

According to Thomas S. Kuhn, the Postscript to *The Structure of Scientific Revolutions*

- Symbolic generalizations, definitions
- Beliefs, models and analogies
- Exemplars
- Values

Added later

- Guiding questions
- Techniques
- Anecdotes

Do a web search on “disciplinary matrix cybernetics”

What has system science contributed?

- How can we describe the field of systems science?
- Two 1998 articles with Eric Dent
- “Origins and purposes”
- “Underlying assumptions”

Do a web search on “Stuart Umpleby” then “recent papers”

Key groups

- General systems – U of Michigan, MHRI
- Cybernetics – UIUC, BCL
- System dynamics – MIT
- Systems approach – U of Penn
- Artificial intelligence – MIT, CMU, Stanford
- Learning organization – MIT

  Each group had its own meetings and its own journal

History and future of our fields

- During and after World War II several new systems fields were created
- Each field was addressing certain questions and invented concepts to deal with those questions
- The subfields can be defined by a set of variables

Dimensions identified by Eric Dent (most used)

1. From entities to relationships 6
2. From reductionism to holism 6
3. From linear to circular causality 6
4. From environment free to environment full investigations 5
5. From not knowing subjects to knowing subjects 5

Dimensions identified by Eric Dent (least used)

6. From determinism to indeterminism 3
7. From direction to self-organization 2
8. From not including the observer to including the observer 2

Six systems fields (number of dimensions used)

- Total quality management 4
- Operations research 5
- System dynamics 5
- Organizational learning 6
- General systems theory 6
- Cybernetics 8

The eight dimensions

- Pointed out by Eric Dent, define the systems sciences relative to earlier disciplines
- They also explain why systems science has had difficulty coming together as a unified field
- Different groups within systems science have emphasized different combinations of dimensions.

The aim of cybernetics

Whereas physics provides a theory of matter and energy relationships, the goal of cybernetics has been to create a common language of control and communication, of information and regulation, to aid research among social scientists, those interested in cognition, those working on information machines, and those working in the fields of design

History of cybernetics

- 1940s and 1950s Macy Foundation conferences in NYC on “circular causal and feedback mechanisms in biological and social systems”
- Engineering cybernetics – computers and robotics
- Biological cybernetics – study cognition
- Social cybernetics – systems affected by theories of them

Four models currently used in science

- Linear causality
- Circular causality
- Complexity or self-organization
- Reflexivity

1. Linear causality

- The way most dissertations are written
- Many statistical techniques, including correlation and regression analysis
- Hypotheses can be falsified
- Propositions can be assigned a level of statistical significance
- The objective is to create descriptions which correspond to observations

2. Circular causality

- Essential to any regulatory process – thermostat, automatic assembly line, driving a car, managing an organization
- Can be modeled with causal influence diagrams and system dynamics models
- Often a psychological variable is involved – perception of, desire for

3. Complexity theory

- Primarily a method of computer simulation – cellular automata, genetic algorithms
- A very general concept – competition among species or corporations, conjectures and refutations in philosophy
- Differentiation and selection – creation of new variety, selection of appropriate variety
- Explains emergence

4. Reflexivity

- A circular process – observe, act, observe, act….
- The observer is included
- Requires operations on two levels – observation and participation
- Appears to violate two informal fallacies – circular arguments and the ad hominem fallacy
- Involves self-reference, hence paradox, hence inconsistency

Which models are acceptable?

1. Linear causality – the dominant conception of science
2. Circular causality – used in first order cybernetics, but involves circularity
3. Self-organization – Stephen Wolfram's "new kind of science," complex systems
4. Reflexivity – second order cybernetics, appears to encounter logical difficulties

A decision is required

- Should traditions concerning the *form of arguments* limit the *scope of science*?
- Or, should the subject matter of science be guided by curiosity and the desire to construct explanations of phenomena?
- Cyberneticians have chosen to study certain phenomena, even if they need to use unconventional ideas and methods

Why should we not be deterred?

- In practical affairs we have learned to cope with self-reference
- We commonly see ourselves as participants in a multi-player game
- We lose nothing by adding a new dimension to science
- The science we practiced before we can still practice, when we want to

How cybernetics is different from some other fields

Artificial intelligence and cybernetics

- Build useful machines
- Electrical engineering and computer science
- Use a realist epistemology
- Make analogies between brains and machines
- 1956 Dartmouth University

- Understand human cognition
- Philosophy and neurophysiology
- Experimental epistemology
- Test philosophical theories with biological investigations

Dissipative structures and self-organizing systems

- 1970s
- Prigogine, et al.
- New order emerges when more energy is put into a system
- Additional energy is necessary
- Boiling water on a stove

- 1960s
- Ashby, von Foerster, et al.
- New order results from the way elements combine
- Form, pattern are fundamental
- The magnetic cubes in a box

Complex adaptive systems and cybernetics

- 1980s
- Santa Fe Institute
- Cellular automata, genetic algorithms
- Emergence is a key issue, rather mysterious

- 1960s and 1970s
- Biological Computer Lab at UIUC
- Emergence results from a system “going to equilibrium”

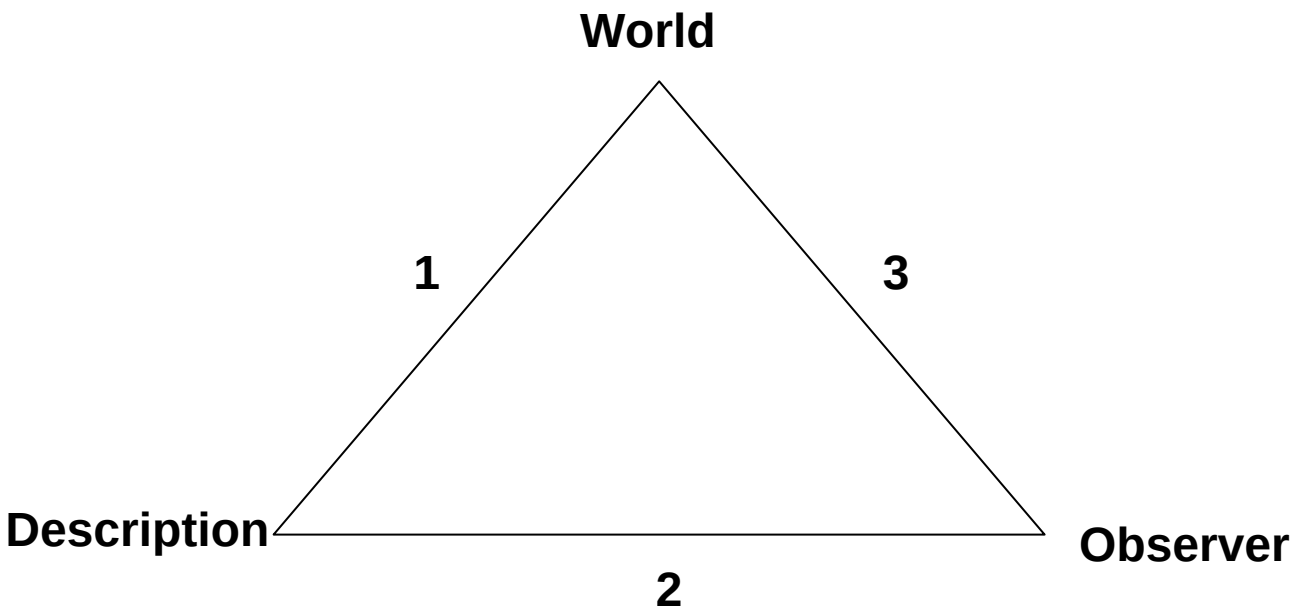
Economics and cybernetics

- Equilibrium theory
- Create mathematical models and test them
- Scientists are separate from the system itself
- There is no theory of how theories are used to manage the system

- Reflexivity theory
- Social systems are composed of thinking participants
- People observe and participate
- Theories, when adopted, change the way that social systems operate

The second expansion of science

- Currently, interest in reflexivity is creating another expansion of science which emphasizes that theories in the social sciences have an effect on the phenomena being studied
- As a result it is necessary to create a “second order science” which describes the effects of first order theories on the phenomena of interest.


World
1
3
Description
Observer
2

The epistemological triangle

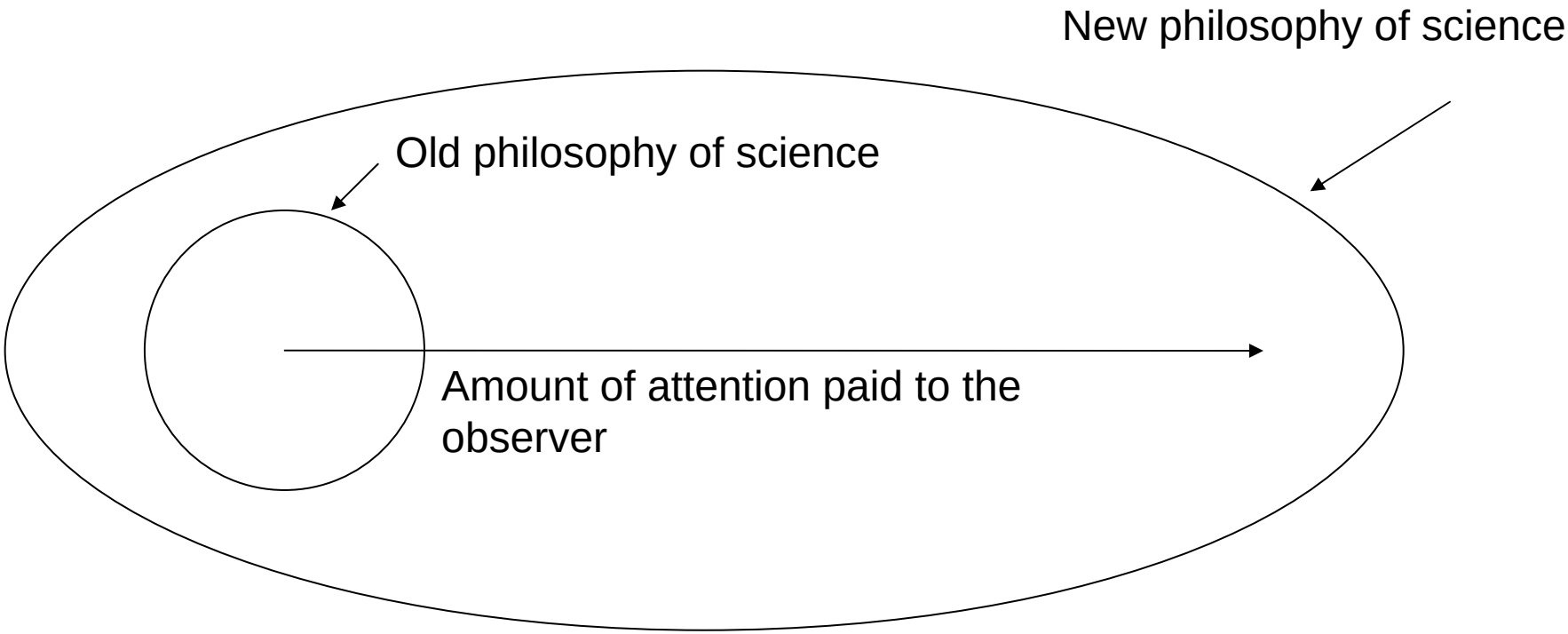
- Consider Popper's worlds 1, 2, and 3
- Side 1 is the classical philosophy of science – construct accurate descriptions of the world
- Side 2 is the biology of cognition – how an observer a reality
- Side 3 is social cybernetics – observers participate as well as observe
- Move from side 1 to the whole triangle

The new point of view

- In addition to descriptions of the external world (1)
- We include the observer (2) and
- The effect of ideas on society (3)
- We then have a larger conception of the practice of science which includes both the process of observation and the process of participation

The Correspondence Principle

- Proposed by Niels Bohr when developing the quantum theory
- Any new theory should reduce to the old theory to which it corresponds for those cases in which the old theory is known to hold
- A new dimension is required
- By applying the correspondence principle to the phil. of science, we change not just one theory or one field but all of science



An Application of the Correspondence Principle

Our conception of science is the obstacle

- Practicing managers and social scientists will readily agree that human beings are both observers and participants in social systems
- Indeed, they say this idea is “not new”
- But this perspective is not permitted by the current conception of science
- Our conception of science needs to be expanded in order to encompass social systems

How science has changed

- After World War II systems science expanded science by adding eight dimensions
- We are now expanding the philosophy of science by adding two dimensions
- The result will be a more realistic approach to social science

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Presented at the annual conference of the International Society for the Systems Sciences

San Jose, CA

July 15-20, 2012