Top-Down Causation as the Operation of Second-Order Context-Sensitive Constraints

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Thank Nancy, Bob & other organizers

Dennis & Bonnie
WHAT IS THE DIFFERENCE BETWEEN A WINK AND A BLINK?

Ethical and Legal Implications
Emergence of Causally Effective Mind

SOCRATES' getting out of jail - Vs Democritus and the atomists
reasons as causes for actions vs physical/mechanical causes of behavior

STOP before going to next slide
Aristotle: “Nothing Moves Itself”

- All change is from potentiality to actuality
- Two types of potentiality
  - Passive: to receive change (inanimate objects)
  - Active: to impart change (animate beings)
- Nothing has both types of potentialities with respect to the same quality
- Ergo: Nothing moves (changes) itself

SAY THIS FIRST

Nicomachean Ethics -

- throwing cargo overboard -
  - voluntary / involuntary -
  - depends on whether the "principle of motion" is "within" (internal to solution)

Unlike P. A believed in reality of change / motion
Aristotle: Physics VIII:5

- The cosmos does not cause itself
- No whole (totality) moves (changes) itself *qua* whole – A moves and B is moved
- Principle of motion is within, but animals do not move themselves *qua* wholes
- Self-movement of animals and humans: How to explain
  - *Orexis* (actual desire) moves the body
  - One part causes another part to move

Unlike Plato, Aristotle believed in reality of change.
Four Causes

- Formal — usually interpreted as form/shape, but in gazelle + soul? conceptual
- Final — goal, purpose, directionality
- Efficient —
- Material —

All four involved in self-motion → embeds organism in its environment

Nothing causes itself

Give gazelle example — lion chases gazelle —
1) gazelle attractor — triggers desire which triggers the
2) final, ongoing standing cause —

Formal cause — guides & shape
### Summary

**Aristotle**

- Whole is (organically) more than sum of its parts, and
- Environment (context) involved causally
- But...
- No whole to part causality (formal cause?)

### Correlative Issue

**Explanation**

- **Theoria** - deductive
- **Epeirikes** - inductive
- **Episteme** - pro to to Kairon - universal
- **Phronesis** - contextual - human sciences
  - law, ethics, medicine
Modernity
Atomism and Mechanism

- No mereological causation at all (part to whole, or whole to part) because
  - Whole no more than sum of its parts
  - Wholes are epiphenomenal
  - All causality is efficient causality

- Relational properties are secondary and epiphenomenal

No embeddedness in context

Newton - atoms move as a result of forceful impact

→ Discards 2 (maybe 3) of 4 causes

But: Keep principle that nothing moves itself
Aggregates vs. Wholes

- Compounds (aggregates) vs. Systemic totalities (organisms)
- For Aristotle: organisms are substances different from mere aggregates
- For Modernity:
  - Totalities are reducible to aggregates
  - Wholes are epiphenomena (causally inert) – no mereological causation –
  - Primary vs. Secondary qualities
    - Atomism: unnecessary to embed the organic whole in its environment (context)
Causality of Modernity

- Newtonian – reversible in principle
- Instantaneous events without duration
- No embedding in context
- Only efficient causality
  - Functions like dominos or billiard balls
  - *External* force impels change (whole cannot move itself)
  - Cause and effect can be logically described independently of each other

Correlative issue:

Explanation - because only efficient causality

**Deterministic** →

deductive-nomological model of explanation

Received view - only eff. causality
Modern Causality and Intentional Action

• What is the cause of action (as opposed to mere behavior)?
  – Desire/Intention/Motivation
    • Functions as an efficient cause
    • If it is an instantaneous event, there is no control or direction of behavior (Chisholm counterexamples)
  – The agent? Who/what is an agent? (principle that wholes cannot move themselves upheld)
  – What happens to purposiveness – teleology (which is apparently not reversible)?

You need 2 different types of causes that function as efficient cause – external.
Desire?
Agent?
Chisholm - not guidance by instantaneous events

All bend aid "solution"
Kant and Teleology

- **Critique of Judgment – 1790**
- Kant follows Leibniz (and not Hume!) re causality
- Two types of goal-directedness:
  - Extrinsic physical ends: adaptability of means to an end (relative purposiveness)
  - Intrinsic physical ends: with respect to the relation between cause and effect (intrinsic purposiveness)
  - "Is both cause and effect of itself” 18 Scolia 64, AkV 371.
Organisms and Self-Cause

- Only living organisms exhibit intrinsic finality, and it is because of their capacity for self-organization, "a form of causality unknown to us"
- Intrinsic Physical Ends
  - "their parts, with respect to their existence and their form, are possible only in relation to the whole"
  - Unity of principle (growth, maturation and development) cannot be explained by means of "mere mechanism"
  - "Regressive and progressive dependency"

XIX occupied w/ classical thermodynamics Darwin

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Near and far-from-equilibrium systems

- Near equilibrium: all systems reach equilibrium regardless of their trajectory = ahistorical.
- Near equilibrium systems — "tend to eliminate non-uniformities and increase internal disorder" (Allen & Sanglier)
  - No near equilibrium system becomes more complex and ordered.

Dawson - Account of increased complexity. Deductive.

Reappearance of arrow of time (directionality).
Boltzmann's average - large number. Really microscopically still time reversible.
Modernity's Mistake:
Modeling everything as a linear system near equilibrium
AND
Retaining principle that "nothing can cause/move itself"
Dissipative Structures
Benard Cells

Whole macroscopic structure determines the specific movement of the component molecules.
Premio Nobel 1977

direction of convection cells unpredictable
Mechanical driving force of self organization is external heat source.

Whereas before molecules moved randomly once macroscopic structure abruptly emerges and molecules are constrained movement of
BELOUSOV-ZHABOTINSKY REACTION

- $A \rightarrow X$
- $B + X \rightarrow Y + Q$
- $X \rightarrow P$
- $Y + 2X \rightarrow 3X$

- Fourth step is \textit{autocatalytic}
- Positive feedback takes the system farther and farther from equilibrium – reaction speeds up
- At the threshold of instability a small perturbation or fluctuation can precipitate a bifurcation that takes the system to a new mode of organization

Acido malónico

\underline{Catalysts} - molecules that make other phenomena more likely

\underline{Autocatalysis} -

Driving force vs the endogenous dynamics (imports energy & nutrients)
Shape, direction & distribution of macroscopic waveforms are unpredictable.
INTER-LEVEL
True Self-Cause

- **Bottom-up:**
  - Individual, previously independent components, abruptly self-organize into complex dynamical wholes
  - Complex dynamical systems are *qualitatively* different — display irreducible emergent properties;
  - The whole is more than the sum or its parts — but it is not other than the parts that make them up

- **Top-down:**
  - "Global structures of process" actively and dynamically causally influence their components — but not qua other;
  - *The whole causes itself.*

Vs Bergson elan vital — (same Aristotelian principle of nothing causes itself)

How to explain this kind of "causality"?

Sensitivity to initial conditions ⇒ unique trajectory
Constraints

• Concept first used in physical mechanics
  – Ex: an object on an inclined plane is impelled by the geometry of the environment to move in a specific curve
  – Ex: particles connected by strings or rods
Constraints

Constraints= external, relational property
Causally effective but not as a mechanical, efficient cause
Relational properties that the parts acquire in virtue of being unified (not just aggregated) in a systematic whole are causally effective

Relational properties not secondary or epiphenomenal —

Bown
Lila Gatlin

*Information and the Living System*

- Shannon & Weaver (1949): "information" = not what is said but what *could be* said
- In conditions of complete randomness anything *could be* said but in effect *nothing is said.*
- When anything is possible and nothing is connected to anything, nothing can signify or communicate anything
- Potential information (message variety) is at its maximum, but real information is at its minimum

1964 - CUP
Context-Free Constraints

- Most random state: events are independent and equiprobable
- To communicate, imposing constraints is imperative
- Context-free constraints take system far from equiprobability
  - Ex: regular pulses on a lighthouse; even for an extraterrestrial it signifies "signal, signal, signal..." – even if the Martian does not know what it means
  - The same occurs with languages: every language has a "prior probability" distribution of letters
Thermodynamic embodiment of Context-Free Constraints

- A gas-filled container = equilibrium
- Insert piston → no longer homogeneous
- System can now do work
- Context-free constraints = Divergence from equiprobability
- Like all closed thermodynamic systems near equilibrium, when piston is removed the system returns to equilibrium

Embodiment

heat death of universe
Cost of Context-free constraints

- No pattern = no information
- To completely eliminate error = repeat a message over and over
- Same pattern repeated over and over = zero new information
- Transmission reliability is inversely proportionate to potential message variety

Darwin - complexification
Context-sensitive Constraints

- Shannon (1948) proved that if a message is correctly encoded error can be reduced without restricting the ability to transmit messages.
- The key is to make particles and processes interdependent.
- Coordinate and correlate!!!

Interdependence in and of itself has a lot of nice ethical implications.
Context-sensitive Constraints

- Establish divergence from independence (context-sensitive redundancy)
  - Ex: In language
  - Ex: In chemistry (catalysts)
  - Ex: Positive feedback
- Make components depend on what went before and what is around
  - Embeds system in its environment (contextuality)
  - Embeds system in time (historicity)

Calculated Conditional probabilities -
First and second order
Context-Sensitive Constraints

- First order CSC = Bottom-up causality
  - Establish interdependence among components → global complex dynamical whole with emergent properties
  - Expand system’s phase space
- Second order CSC = Top-down causality
  - From the whole to the parts
  - Contextual setting is not an epiphenomenon
  - Limits behavior of components
EMERGENCE

Complexification is the quintessential example of emergence
• Higher order properties are *qualitatively* different from that of aggregates
• Higher order levels of organization are not epiphenomenal
  – They are characterized by top-down causality
THE QUALITATIVELY NEW

EMERGENT

LEVEL OF ORGANIZATION

IS

THE ABRUPT ESTABLISHMENT

OF SECOND-ORDER

CONTEXT-SENSITIVE

CONSTRAINTS

Danger of reification (not other than and yet...) —
A RECONCEPTUALIZATION of Bottom-Up Inter-level Causality

• Catalysts, feedback, resonance, and "entrainment" function as first order context-sensitive constraints by making the parts depend on what happened before (time) and what is happening in the environment (context)

• Context-sensitive constraints (CSC) embed a system in time and space by making components interdependent
  – Bottom-up, first order csc enable complex systems to emerge

Mereological relationship

MIRROR NEURONS are embodiments of context-sensitive constraints (no need to establish how they emerge – they're hard wired)
**BOTTOM-UP CAUSALITY**

- First order CSC create "systems" "organisms," "communities"
  - Expand the system's phase space (i.e., whole can do more than the components alone)
  - *Without phase space expansion there is no evolution* – *First order CSC's are enabling constraints*
  - These self-organized systems can be described as "chaotic or complex attractors" in multi-dimensional phase space

Ej: ecología – Control distribuido que proviene de la interrelacion entre los componentes de un ecosistema, no desde arriba hacia abajo -- un ecosistema representa una heterarquia, no una jerarquia.
Complexification

- Complex-sensitive constraints make complexity possible!
  - Linguistic inflection in Asian languages
- Benard Cells and B-Z reaction = abrupt emergence of context-sensitive constraints in a far from equilibrium non-linear process
  - Discontinuous change
- Actual state of the system depends on history and environment
- The same with autocatalysis = catalysts take the molecules far from independence –
  - A becomes part of the external structure of B = A is no longer "out there" independent of B
  - The interdependence has created a global structure, system AB

Interesting problem of identity – where are the boundaries of complex systems
Point and Limit-Cycle Attractors

- Point attractors – typical of classical thermodynamics (determinism!)

- Periodic or Cyclical Attractors

- Chaotic, Strange, or Complex Attractors
Point and Limit Cycle Attractors

Ex. pendulum - history unimportant classical thermodynamics

Predator/prey relationships

Steady state oscillation
Chaotic or Strange Attractors

Turbulent flow -
hurricanes -
looks random chaotic

Multidimensional dynamic patterns
Constrain behavior
Paisajes de competencia o adecuación

fitness landscapes
deterministic -

Lorenz butterfly
Phase Space
Paisaje Ortogenetico —
Strange Attractors

- Sensitivity to Initial Conditions
- Unpredictable in detail
  - But a bound trajectory
  - Very much like the causation of motives and intentions!

- Each trajectory is in effect unique
  - Increasing individuation very much like intentional human action, and the formation of character

Ex: writing a book, running for office —
TOP-DOWN CAUSALITY

Second-order context sensitive constraints (from the emergent whole to the parts) alter the prior probability of the components' degrees of freedom (Recall Benard cells);

• As a result, the specific behavior of the individual parts/components is restricted by a) the context) and b) the history and trajectory of the attractor in which it is embedded.
• Top-down causality restricts, limits options – but is not deterministic or predictable
INTENTION (MOTIVATION) AS A COMPLEX DYNAMICAL SYSTEM

- When neurons "entrain" and self-organize into a complex system as a result of positive feedback, patterns of coherent, globally synchronized neural waves appear that embody emergent properties such as meaning and consciousness.
- Intentions (motivation) are neurologically embodied in these global dynamical structures.
- They are structures of process characterized by complex attractors — intentions are self-organized, emergent, neuronal attractors.

Entrainment — a type of phase correlation

Edelman's reentrant pathways
A DYNAMICAL SYSTEMS HYPOTHESIS ABOUT INTENTIONAL CAUSALITY

- Neuronal attractors embodying intentions (motivation) are characterized by their emergent properties — including subjectivity/consciousness and meaning;
- Intentional attractors cascade into behavior by resetting the intrinsic natural frequency of the individual neurons (including motor neurons) — and thereby restricting their degrees of freedom;
- In such a way that the resulting behavior incorporates the emergent properties of the intentional attractor that constrained its trajectory;
- And that's the way intentions cause actions top-down!

Explain Searle's: perception (mind fits world) — action (world fits mind)
This reconceptualization provides a non-reductionistic account of emergence and top-down causality
Hinton, Plaut & Shallice

• Artificial neural nets to read words
  – Superficial dyslexia (ex: “bed” for “bad”)
  – Deep dyslexia (ex: “bed” for “cot” or “band” for “Orchestra”!!!
    • Occurs when positive feedback is included in neural network
• “The system has self-organized a semantic attractor” – i.e., with emergent properties

Constrains output such that it satisfies the semantic content of embodied in the self-organized constraints of the attractor
Neurological Evidence

- **Motor Neurons --**
- **Joaquin Fuster - Cortex & Mind** -
  - globally coherent brain waves are basis of mind
- **Walter Freeman - How Brains Make up their Minds** -
  - olfactory system based on historical and contextual attractors
- **E. Thelen & L. Smith (1994) - A Dynamic Systems Approach to the Development of Cognition and Action** -
  - motor development = self-organization of motor attractors

Resonance in music

[Handwritten notes:]

- Temporal coding of CSC
- gait recognition
  - trot, canter, gallop
FREE WILL

- Actions without cause are arbitrary, not free
- How to be held responsible for actions made without conscious awareness?
- Conscious awareness and meaning are embodied in complex/strange neuronal attractors that constrain behavior top-down (Gregory and Ramachandran’s “Free Won’t”)

Chance is a chancy foundation for moral responsibility