Metaphors and Myth: The Roots of Analogical Structures in Macroscopic Physical Science

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A Preliminary Summary in the Form of Some Claims

Macroscopic physical science exhibits imaginative structures known from conceptual metaphor theory. They are created by metaphorically projecting small-scale image schemas (polarity, scale, substance, container, path…) upon the medium-scale perceptual gestalt of forces of nature (water, wind, fire, ice, food, light, motion…).

The perception and conception of forces of nature is an age old affair—we find these structures in language all the way back to mythic culture. In other words, much of the conceptualization found in modern continuum physics is of mythic origin.

Since different forces (fluids, electricity, heat, substances, motion, gravity) are conceptualized in terms of the same basic metaphoric projections, they are rendered similar to the human mind—we see them as having analogous structure.
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1. **LINGUISTIC PHENOMENA IN MACROSCOPIC PHYSICAL SCIENCE — HEAT**

Examples of expressions involving heat. There are no examples of literal use of language:

- All bodies contain heat…
- How do you collect heat in a passive solar house?
- This means heat flows “downhill” from hot to cold.
- … heat is an agent of vast importance in chemical reactions and engineering processes
- Law of the dependence of the active force of heat upon the tempera… (Clausius)
- This exterior heat lets the crust become crispy
- Heat makes me dizzy…
- Clouds and storms follow the warm water. pumping heat and moisture high into the atmosphere…
- Heat must balance cold…

Expressions for heat use the following schematic constructs:

- Container, store, hold, accumulate; lack of, abundance of; collect
- Flow, transport, extract emit/absorb, exchange; heat moves
- Balance (law of balance of…)
- Use, produce, generate heat
- Heat as location, landscape; level, intensity, degree, scale of heat
- Balance of heat and cold, hot and cold; thermal tension
- Power, force of heat
- Heat is an agent: Heat causes, drives, makes, counteracts, lets, balances
- Heat is a patient: Pump, force, make, counteract, block, hold (back), enable, prevent, oppose, let/allow heat

- Heat is a powerful agent…
1. **LINGUISTIC PHENOMENA IN MACROSCOPIC PHYSICAL SCIENCE — A NARRATIVE...**

*Sadi Carnot (1824): Réflexions sur la puissance motrice du feu*

Every one knows that *heat* can produce motion. That it *possesses vast motive-power* no one can doubt, in these days when the steam-engine is everywhere so well known. *To heat also are due the vast movements* which take place on the earth. It causes the *agitations of the atmosphere*, the ascension of clouds, the fall of rain and of meteors, the *currents of water* which channel the surface of the globe, …. Even *earthquakes and volcanic eruptions* are the result of heat.

According to established principles at the present time, we can compare with sufficient accuracy the motive *power of heat* to that of a *fall of water* […] . The motive power of a fall of water depends on its height and on the quantity of the liquid; the motive power of heat depends also on the *quantity of caloric* used, and on what may be termed, on what in fact we will call, the *height of its fall*, that is to say, the difference of temperature of the bodies between which the *exchange of caloric* is made.
2. **Forces of Nature and Myth – Origin and Examples**

In the previous examples, we recognize a recurring *medium scale cognitive structure* → *Force of Nature*. This structure has *perceptual origin* → the *Gestalt of Force*.

**Examples…**

**Heat as a force of nature**

Very basically, we perceive **heat** as a unit/gestalt. We know when we have a thermal experience…

**Examples of forces of nature**

**Water, wind, light, fire**, cold, food, motion, substances…

**Psychological and social forces**

Justice, knowledge, anger, love, **music** (Johnson, 2007)…
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2. Forces of Nature and Myth – Origins in Mythic Culture

When Heaven and Earth Were Created

Creating and maintaining tensions so that Maat can flow and life go on...

In Egyptian mythology, Shu (wind) separates Nut (sky) from Geb (Earth). The sky needs to be supported let it falls down upon Earth.

With the separation of sky and Earth, an ur-tension is created that maintains processes. There is a flow from higher to lower level that drives other processes...

This mythic conceptualization of an image of nature and natural processes sounds very modern—or maybe conceptualizations in physics are mythic.

http://www.civilization.ca/civil/egypt/images/reli28b.jpg
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2. Forces of Nature and Myth – Imaginative Structure

The Perceptual Gestalt of Forces of Nature

Figurative Structure of Forces (basic aspects)

- **Intensity** (quality, derived from polarities; tension as differences of intensity)
- **Substance** (quantity)
- **Power** (as a measure of causation)

Macrosopic Physics is a collection of theories of Forces of Nature

**Gestalt of Forces**

Additional Schemes
- Balance, Resistance
- Letting, Enabling
- Container, Path, Process
- Figure-Ground Reversal
3. Imaginative Structures in Macrosopic Physical Science

Images of Quantities

Equation of Conductive Transport of a Fluid Like Quantity

$\dot{j}_n = -k_n \frac{\partial \mu}{\partial x}$

$\dot{j}_C = -k_C \frac{\partial T}{\partial x}$

Flow

Gradients, Slopess Level Differences

Imagery Schemas

Substances

Caloric

Differences of Potentials are Differences of Levels:

They are Conceptualized as Driving Forces for Flows
4. **Analogy in Macroscopic Physical Science**

*Laws of balance in continuum physics*

**Amount of substance**

\[
\frac{\partial \rho_n}{\partial t} + \frac{\partial}{\partial x} \left( j_{n,\text{cond}} + j_{n,\text{conv}} \right) = 0 + \pi_n
\]

**Entropy**

\[
\frac{\partial \rho_S}{\partial t} + \frac{\partial}{\partial x} \left( j_{S,\text{cond}} + j_{S,\text{conv}} \right) = \sigma_S + \pi_S
\]

**Momentum (in a single dimension...)**

\[
\frac{\partial \rho_p}{\partial t} + \frac{\partial}{\partial x} \left( j_{p,\text{cond}} + j_{p,\text{conv}} \right) = \sigma_p + 0
\]
4. ANALOGY IN MACROSCOPIC PHYSICAL SCIENCE

Constitutive relations in continuum physics

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<td>$\sigma_S = \alpha_S i_S - \varepsilon_S$</td>
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<td>$\pi_{nA} = -k c_A c_B$</td>
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**SUMMARY: ROOTS OF ANALOGICAL STRUCTURES AND REASONING IN MACROSCOPIC PHYSICS**

- Physical processes are perceived (and classified) as *Forces of Nature*.
- Force is a *perceptual unit* (gestalt) that, when analyzed, shows three main aspects: those of *intensity* (tension), *quantity* or size (extension), and *power*. All three are *imaginative structures*. Relations between these aspects are *understood metaphorically* through the *projection of additional image schemas*.
- Forces are rendered imaginatively through the use of (conceptual) metaphors—there is a *metaphoric network* that *structures our understanding of a force*.
- All forces are structured in basically the same manner; this makes them similar to our mind which allows us to use *analogical reasoning*.
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**SUMMARY: WEB OF IMAGINATIVE STRUCTURES FOR CONCEPTS (TEMPERATURE)**

**CONCEPTUAL MAP FOR TEMPERATURE**
**BASED UPON THE HOT ← COLD POLARITY (→ HOTNESS)**

**MEDIUM-SCALE PERCEPTUAL UNIT:**
**HEAT AS A FORCE OF NATURE**

**LINGUISTIC FORMS (SYMBOLIC UNITS) RELATING TO TEMPERATURE**

**SMALL-SCALE PERCEPTUAL UNIT:**
**POLARITY OF HOT ← COLD**

**Linguistic forms:**
symbolic units or linguistic signs (sound-concept pairings)

**Projection (bottom-up)**

**Informing (top-down)**

**Continuum Thermodynamics**

*Hotness* is a single-dimensional manifold and *temperature* is a mark (coordinate) on this manifold.

*Polarity* (perceptual opposition)

Differences are the most basic of all types of perception.

(1) *Polarity (perceptual opposition)*

Differences are the most basic of all types of perception.

(2) The word *Hotness* lexicalizes the entire *hot ↔ cold* polarity or perceptual opposition (→ tension).
**Summary: Web of Imaginative Structures for Concepts (Heat)**

**Conceptual Map for Heat**

*Based Upon the Heat as Force of Nature Schema*

- **Large-Scale Perceptual Unit:** Heat as Agent in Story-World
  - Time → Story Schema → Agency
  - Large-Scale Perceptual Unit: Heat as Agent in Story-World
  - Linguistic Forms (Symbolic Units) Relating to Heat
    - Thermal Power: Making energy available using energy
    - Caloric: Current of Caloric Production Rate of Caloric
    - Temperature: Thermal Level

- **Medium-Scale Perceptual Unit:** Force of Nature
  - Causation: Force Dynamic Schemas
    - Power of Heat (2)
    - Caloric (1)

- **Small-Scale Perceptual Units**
  - Power of Heat (2)
  - Caloric (1)
  - Hotness

**Continuum Thermodynamics**

- Caloric is the thermal fluid quantity that is stored in bodies, can be transported and can be produced (→ entropy).
- Power of Heat is equivalent to stress power.

**Linguistic Forms:** symbolic units or linguistic signs (sound-concept pairings)

1. *Caloric (thermal charge)*: There is no direct perception of quantity of heat responsible for the formation of this image.
2. *Power of Heat*: Indirect perception: Heat causes other things to happen or is made to happen by other things.
3. *Energy*: related concepts apply equally to all other forces of nature: fluids, electricity, chemical processes, motion, gravity.
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REFERENCES


