Conceptual Analysis and Quantum Gravity

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Unit for HPS and The Centre for Time

New Agendas for the Study of Time: Connecting the Disciplines

http://newagendasstudyoftime.wordpress.com/

Aim: **Develop a means of analyzing the temporal concepts in physical theories.**

"[...] by 'quantum gravity' we mean any approach to the problem of combining [...] quantum theory with general relativity. An immense amount of effort has been devoted in the last forty years to combining these two pillars of modern physics. Yet [...] there is still no satisfactory theory: rather, there are several competing approaches, each of which **faces severe problems, both technical and *conceptual***." *Butterfield and Isham, 2001*

Outline

I. Conceptual Analysis and the Concept of Time in Quantum Gravity

- **a. Frank Jackson's Conceptual Analysis and Concepts in Physics**
  - i. Jackson's Conceptual Analysis (JCA)
  - ii. A Problem with JCA
- **b. Two Desiderata for a QG Conceptual Analysis**

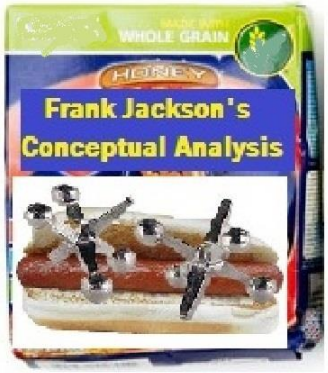
II. The Alternative Conceptual Analysis (ACA)

III. Case Study: Application of ACA to Carlo Rovelli's Partial Observables

I. Conceptual Analysis and *time* in physical theories

Jackson's Conceptual Analysis is "[...] perhaps the most explicit and detailed account of [conceptual analysis] available." Laurence and Margolis 2003

i. Jackson's Conceptual Analysis



Ingredients

- Concepts
  - A concept just is a term's meaning.
  - Some are complex, i.e., are composed of other concepts.
- Network Theory
  - A concept's structure is determined by its role in a theory.
    - This role can be put in terms of a definite description.
    - The referent of this concept is whatever satisfies this description.

Types of Conceptual Structure

Theory Theory

e.g., Network Theory

- Concepts form a **web** in which they are interrelated.
- A concept's meaning is determined by its **role in a theory**.

Classical Theory

- A concept has a definitional structure, .i.e., it's composed simpler concepts that express its **necessary and sufficient conditions**.

Prototype Theory

- A concepts has a probabilistic structure in that most are complex mental representations whose structure encodes conditions that their referents **tend** to have.

i. Jackson's Conceptual Analysis (JCA)
Usage

Use to solve the location problem.

- The location problem =df the problem of reconciling any given phenomena with one's lower-level ontology

Upper-level claims about the world, e.g., There is water.

Relation?

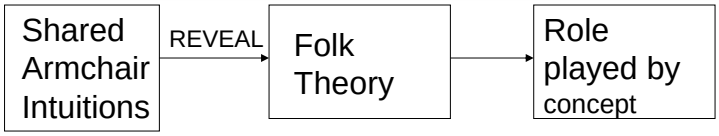
Lower-level descriptions, e.g., There is H_20.

JCA: Instructions- 2 Steps

STEP 1: Find out what counts as the referents of upper-level terms, e.g., 'water'.

- Establish the Shared Folk Theory
  - Why?
    - Concept=term's meaning=the role the concept plays in the theory
  - How?

STEP 1: Find out what counts as the referents of upper-level terms, e.g., 'water'.



- Once we have the folk theory, we can determine what role our concept plays in it.
- This role can be put in a definite description, e.g.,

  (Rw) Water is the stuff that fills lakes, falls from the sky, is colourless, odourless, etc., or which satisfies enough of the foregoing.

It's indicative of some of the properties its referent must have- STEP 1 COMPLETE!

Step 2: Determine whether statements involving the concept are entailed by lower-level descriptions.

Recall the location problem:

Upper-level claims about the world, e.g., There is water.

Entail? Y: accept folk concept / N: eliminate folk concept

Lower-level descriptions, e.g., There is H20.

(P1) Water is the watery stuff of our acquaintance.

(P2) H_2O is the watery stuff of our acquaintance.

(C) So, water is H_2O.

In this case our folk concept of water is identifiable with our lower-level H_2O.

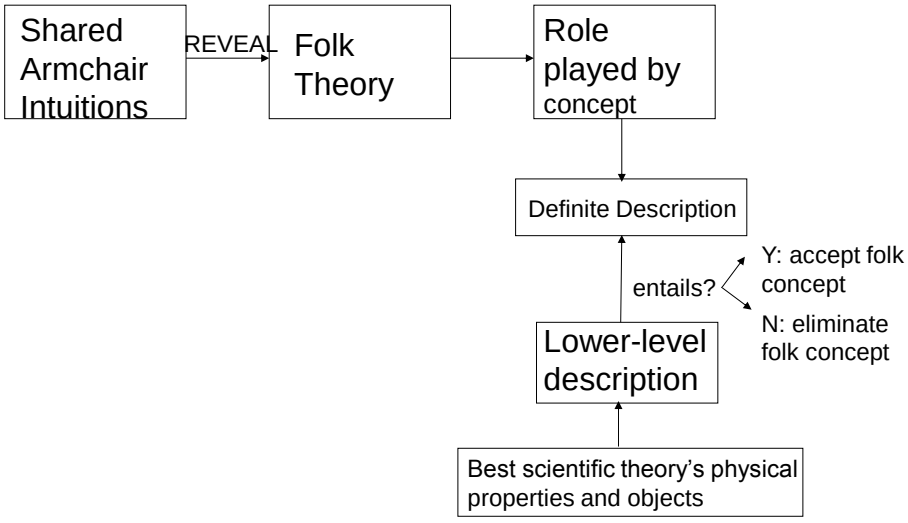
Location Problem Solved!

JCA Assumption

- We get our lower-level description from our best scientific theory.

> Jackson on how to establish 'H_2O's' referent:
>
> [I]t is reasonable to suppose that physical science, despite its known inadequacies, has advanced sufficiently for us to be **confident of the *kinds* of properties and relations that are needed to give a complete notion of non-sentient reality. They will broadly be of a kind with those that appear in current science**. (1998, 7)

JCA: The Big Picture



Application of JCA to Temporal Examples

Assume: *the present* is the only feature constitutive of *folk time.*
STEP 1: To your armchair!

Shared Armchair Intuitions → REVEAL → Folk Theory → Role Played by Concept → Definite Description

"People commonly believe that the present is an **objective feature of the world**. They talk, think and behave as if there were **a global now shared** by all, and they talk, think and behave in a manner **different from the way they do about what is here**."
Callender 2012, 90

(Rt) Time is an objective feature of the world, is a global now shared by all and is different from here.

STEP 2: Consult our best scientific theory to see whether there's anything that fulfils (Rt)

Definite Description:
(Rt) Time is an **objective feature** of the world, is a **global now shared by all** and is different from here.

entails? → Y: accept folk concept

There's a preferred reference frame and absolute simultaneity.

Neo-Lorentzian interpretation of Special Relativity

(Pt1) Time is the timey stuff of our acquaintance.

(Pt2) Something that is characterized by a preferred reference frame and absolute simultaneity is the timey stuff of our acquaintance.

(Ct) So, time is something that is characterized by a preferred reference frame and absolute simultaneity.

STEP 2: Consult a more reasonable 'best scientific theory' to see whether there's anything that fulfils (Rt)

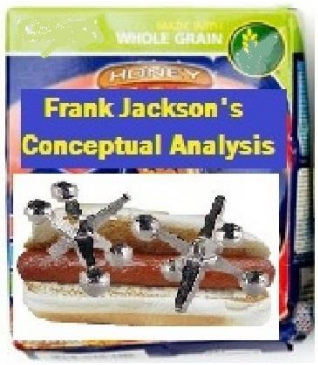
Definite Description:
(Rt) Time is an objective feature of the world, is a global now shared by all and is different from here.

entails? → N: eliminate folk concept

There's no preferred reference frame or absolute simultaneity.

Einsteinian interpretation of Special Relativity

JCA's Looking Good...



Found a ready-made conceptual analysis for *time*?

NO!

ii. A Problem with JCA

- Recall: We get our lower-level description from our best scientific theory.

Assuming that we can just read our ontology and metaphysics off a scientific theory is problematic.

-May ignore other ontological and metaphysical options the theory may have.

-Risks incorporating entities or metaphysics that are redundant, irrelevant or inconsistent.

UPSHOTS:

We should be aware of other readings and, at least, qualify our analysis.

The concepts read off a theory should not be taken for granted- such concepts are themselves in need of analysis.

Shopping List

From JCA's problem:

1. Don't problematically read scientific concepts off a theory.

In view of quantum gravity target:

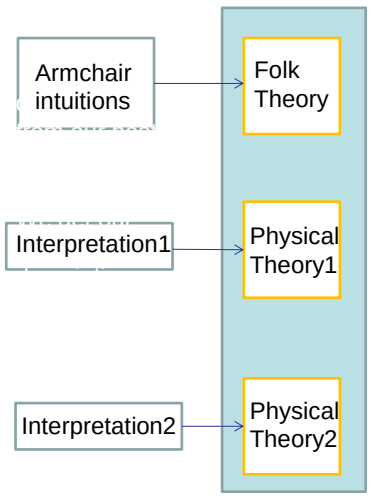
2. Be applicable to more than one scientific theory.

3. Include and integrate an analysis of folk *time* with the analysis of *time* in physical theories.

II. The Alternative Conceptual Analysis

The Alternative
Conceptual Analysis

ACA Instructions



Principle Underpinned Network

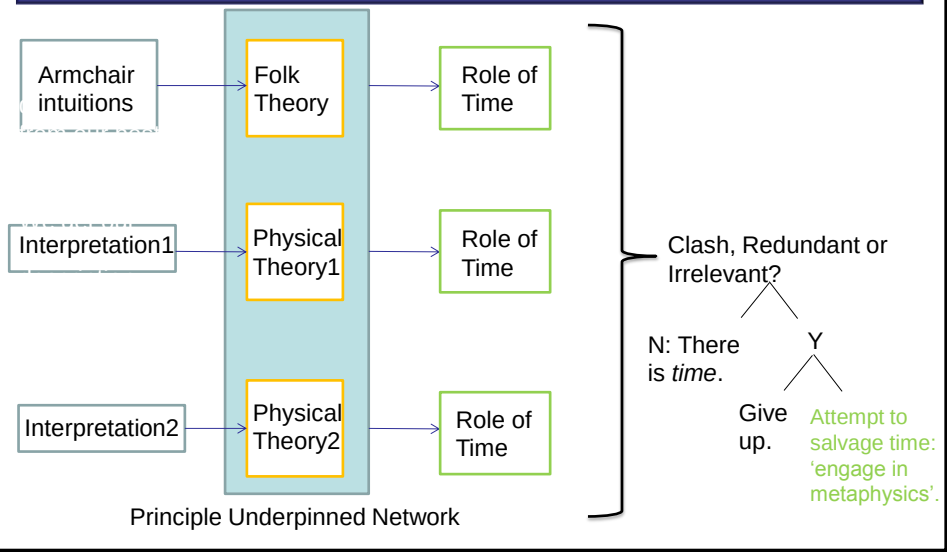
STEP1: Obtain the theory(s) being examined.

-Folk: consult intuitions about possible cases.

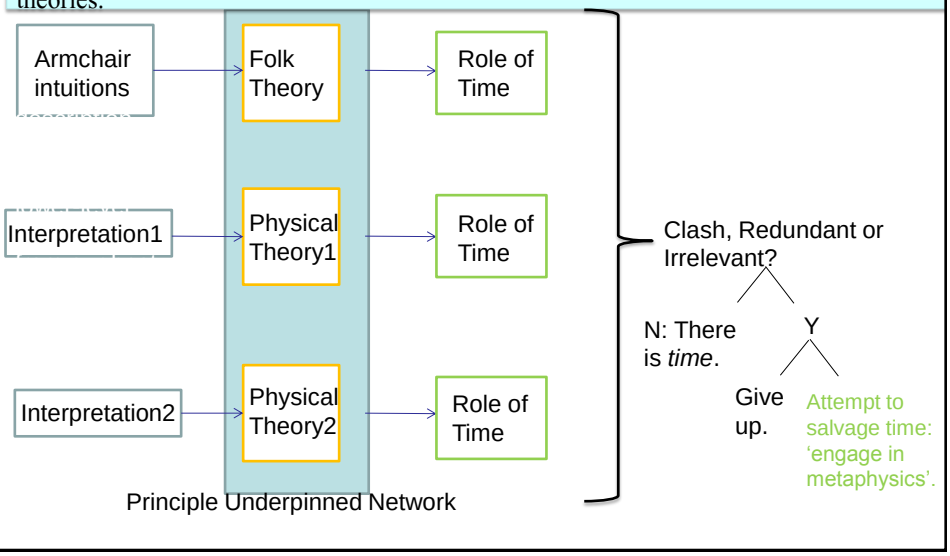
-Scientific: consult an interpretation of the theory.

-Multiple theories?: treat them as parts of a single network underpinned by metaphysical/ontological principles.

STEP2: Determine what role *time* plays in the network.
First, preliminarily identify it through surface readings.
Then, determine whether temporal roles clash, are redundant or irrelevant.



1. Don't problematically read scientific concepts off a theory.
2. Be applicable to more than one scientific theory.
3. Include and integrate an analysis of folk *time* with the analysis of *time* in physical theories.



III: Application to Rovelli

Partial Observables: Motivational Preliminaries

Rovelli says:

Classical General Relativity (GR) is *fully relational*.

-GR describes the world as a set of interacting fields.

-Its manifold has no physical content.

His Strategy for Creating a Coherent Quantum Gravity

1. Spacetime=A Dynamical field (lesson from Einstein in GR).
2. Every dynamical field has quantum properties (QM).
3. So, spacetime itself must exhibit quantum properties.
4. So, these properties must be represented in QM terms.
5. But, existent quantum field theories rely on a fixed, non-dynamical background metric.
6. So, gotta make a background-independent QFT.

Partial Observables: Demoting 'special' time.

AIM: Redefine 'observables' in a 'relativistic' (≈relational) manner.

Observables=df the quantities involved in physical measurements.

v. *Conventional observables*:

-make reference to 'special' time variable

-occurs at a moment of time, e.g., position *at a time*

Rovelli initially puts this in terms of a nonrelativistic pendulum case.

But, it is worth examining:

The structure "described for the example of the pendulum is completely general, and **is present** in all relativistic and nonrelativistic fundamental systems." Rovelli 2002

i. Underpinning Cartesian Principles

ONT: Fundamentally, there are only physical objects.

ONT$_S$: Space is nothing more than a relational property that physical objects can have.

P$_t$: Time is only a conventional measure of a relational property that physical objects can have.

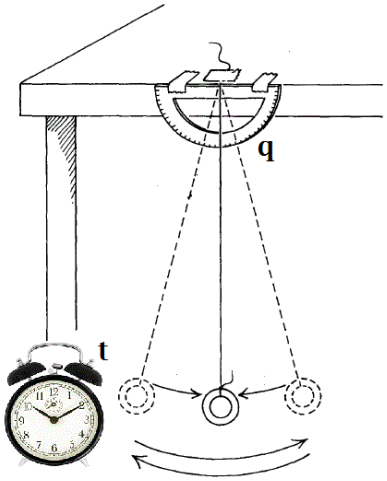
ONT$_t$: Whatever time measures is nothing more than a relational property that physical objects can have.

ii. Partial Observables and Nonrelativistic Pendulums

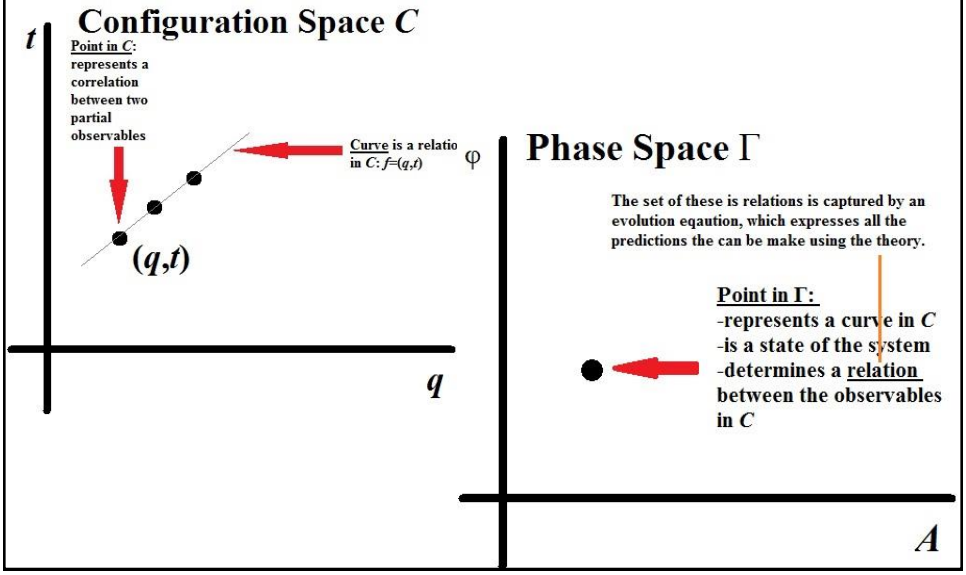
Partial observable=df *a physical quantity to which we can associate a (measuring) procedure leading to a number.*

Complete observable=df *a quantity whose value (or probability distribution) can be predicted by the theory.*

(q, t)



Graphic Representations



Summary and Alleged Role in Rovelli's Account

To sum up,

-Partial observable: is not itself predictable and is a measure.

-There are correlations between partial observables.

-These are cashed out in *C*.

-A curve in *C* is a state of the system.

-Evolution equation can be obtained through relations between *C* and Γ.

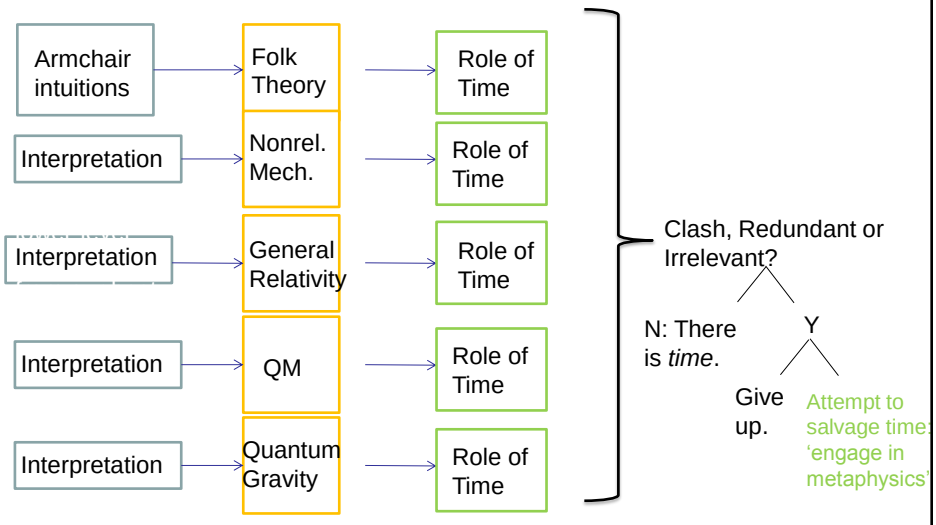
Regarding these notions, Rovelli contends:

t is on 'an equal footing' with other variables; it isn't 'special'.

What does this mean, and how do we interpret slogan to forget about time?

To ACA!

ACA and Rovelli's Account



Cartesian Relational Network

Sketch of an analysis of the role of time in Partial Observables: 'Equal Footing'?

Observable	Role: Measurement of	Type of Relation Involved	Duration of the Observable
t	Local succession	Temporal?	Momentary
q	Position of pendulum	Spatial	Momentary
(*q*,t)	*q* and *t*	Correlation: Spatial and Temporal?	Momentary

t and *q* are both just conventional measures of the **relations among objects**, not some background, independent parameters.

But, *t* appears to be a measurement of local succession.

ONT violated? Not necessarily: develop as a relation, e.g., each event is temporally 'next to' another just as objects can be next to each other spatially at a time.

So, q and t seem to be on equal footing.

Sketch of an analysis of the role of time in Partial Observables: 'Equal Footing'?

Observable	Role: Measurement of	Type of Relation Involved	Duration of the Observable
t	Local succession	Temporal?	Momentary
q	Extension of bob	Spatial	Momentary
(*q*,t)	*q* and *t*	Correlation: Spatial and Temporal?	Momentary

Consider the correlation involved with (*q*,t).

Local simultaneity appears to be required.

ONTt: Whatever time measures is nothing more than a relational property that physical objects can have.

Not clear that t and q are on equal footing re correlations of complete observables: an instant seems to be privileged.

iii. Partial Observables and QM

Partial observables

-e.g., q and t

-determine self-adjoint operators in K (of rigged Hilbert space $S \supset K \supset S'$)

Their eigenstates $|q,t\rangle$ are in S.

-correspond to a quantum event

-'kinematical state'

- The scalar product of these states in Hilbert space determines the probability that one event happened given that the other event happened.

Partial Observables and Probabilities

- Suppose there are two events (q, t) and (q',t') in the extended configuration space.
- We observed (q',t').

What is the probability of observing (q,t)?

- No realistic measuring device will give $\Delta q=0$ or $\Delta t = 0$.
- For two regions R and R', if a detector at R' has detected the pendulum, what is the probability that a detector at R' detects the probability?

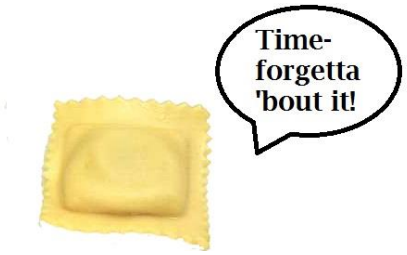
We can recover the conventional probability interpretation of the wavefunction if we assume that $\Delta t \ll mq^2/\hbar$.

Relational Interpretation of QM

"QT must be understood as an account of the way distinct physical *systems affect one another* **when** they interact, and not the way physical systems 'are'." (2004, 215)

- Thus, these simultaneity relations may clash with ONT and his 'equal footing' claim.
- These apparent clashes highlight the need for the role of such simultaneity in the network to be further examined.

Rovelli Conclusion



- Given his relationalist commitments and his slogan, there is **much conceptual cleanup work to be done**!
- Brief examination of just **partial observables illustrates the need** to suss out and assess presupposed temporal concepts and try to fit them in his relationalist network.

ACA Conclusion

- ACA does seem **applicable** to Rovelli: has a network that appears to be underpinned by Cartesian **principles**.
- Appears useful for **schematizing** and **evaluating** his temporal concepts.

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