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## CAUSALITY AND IMPLICATION

### Intuitive causality and logic

This section recalls the main traits of the intuitive causality and logic defined in "NATURAL MODEL".

"Physical bodies" are constructed by collecting repetitive patterns of sense impressions into secondary images, apparently more "real" than their originations.

Similarly, one selects some pattern of event-images apparently always followed by another one and under names respectively "cause"/"effect" collects them into the secondary image under the symbolic name "causality".

Like in the case of "physical body", one attributes to this secondary construct "causality" the unshakable "physical reality" and certainty, unlike to its "cause/effect" instances.

And, having constructed the "physical world" by populating it with "physical bodies", one orders it with the principal orderer "causality".

A particular type of Reflection ("STRUCTURES OF MIND"), which we shall call "Inference", maps events ordered by causality into symbolic structures of expressions related "deductively" by Implication, shortly "ER structures". Inverse operation regresses "inductively" expressions to their territory of events.

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Due to intuiting causality as unshakably "real", deduction appears as "necessary" or "certain".

Induction, on the contrary, retrieving the originating events of symbolic expressions, gets affected by their uncertainty and fuzziness.

Causality maps to the primary logical operator "implication". Other subordinated orderers: such as "and", "or", etc. order particular patterns of causes and effects.

Common sense taking the illusory "reality" at its face value, considers the intuitive causality/logic as an evident rule of practical behavior, applying it instinctively to the day-to-day practice. One knows intuitively that hitting a nail with a hammer will drive it into the wall and that standing in the way of the oncoming bus will cause not a little misery. In the social praxis people tending to stand in the way of oncoming buses are isolated in lunatic asylums with others who cast similar doubts on causality and logic.

However, extended over intellection, the common sense unveils the prejudices it has gathered through the daily practice, and rigorous rationality starts by overcoming it.

The following sections deal with causality from the point of view of rational scientific models.

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## Historic overview

In the context of the physical reality causality appears as a principle manifested by concrete instances of causation or action of cause(s) upon effect(s). We shall use the universally employed terms "action" and "interaction" (local, at distance, etc.) as a strict synonyms of causation instances.

Causality became a crucial issue of foundations of physics as result of the discovery of quantal phenomena and involved controversy between continuous and discrete view of the base of physical reality.

After long discussions of Einstein with Bohr and Born, the issue of causality, whether accepted or not, boiled down to the Principle of Locality, shortly "Locality" and the Principle of Separation, shortly "Separability". We shall examine their original, rather confused formulation and some refinements which unluckily did not succeed to eliminate the ambiguity of both principles and of founded in them causality.

We shall try to disambiguate it in the next section.

At the outset, Einstein's rather crude formulation asserted that by virtue of Locality an object may act only on its immediate neighborhood. Then, taking two objects A and B far apart in space, Separation states that external influence on A has no direct influence on B, which is a clear corollary of Locality. He added that Locality is used consistently only in field theory.

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If this axiom were to be completely abolished, the idea of the existence of quasi enclosed systems, and thereby the postulation of laws which can be checked empirically in the accepted sense, would become impossible. This view of how interactions propagate through space should be contrasted with the primitive magical view (which is also the view of QM(; -)) (Einstein 1948 and The Born-Einstein Correspondence)

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Although one tends to get the intuitive gist, the formulation is so ambiguous that it hardly means anything. What exactly is an "object"? Or a "system"? What's the "immediate neighborhood"? Doubtless other objects related by what we designate in "NATURAL MODEL" as "Contact". One does not see how interaction of A with its neighbors may "propagate" and in particular - propagate to B. It would presuppose a chain of intermediary objects touching one another between A and B and one of them failing would annihilate the interaction. Yet, sun's gravity interacts with earth without any intermediary objects, unless we disenter the old billiard balls. In brief, the locality based propagation and interaction seem no less magical than the QM's view, BTW its magic alleged and not substantiated. Toning down the alleged magic of the QM, Einstein asserted:

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On the basis of quantum theory there was obtained a surprisingly good representation of an immense variety of facts which otherwise appeared entirely incomprehensible.

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But on one point, curiously enough, there was failure: it proved impossible to associate with these Schrodinger waves definite motions of the mass points - and that, after all, had been the original purpose of the whole construction. The difficulty appeared insurmountable until it was overcome by Born in a way as simple as it was unexpected. The de Broglie-Schrodinger wave fields were not to be interpreted as a mathematical description of how an event actually takes place in time and space, though, of course, they have reference to such an event. Rather they are a mathematical description of what we can actually know about the system. They serve only to make statistical statements and predictions of the results of all measurements which we can carry out upon the system. It seems to be clear, therefore, that Born's statistical interpretation of quantum theory is the only possible one. The wave function does not in any way describe a state which could be that of a single system; it relates rather to many systems, to an 'ensemble of systems' in the sense of statistical mechanics. (Einstein, 1936)

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It hardly tones down anything. "On the basis of quantum theory" sounds ambiguous. If it designates the QM of "these Schrodinger waves", one hardly sees the immensity of well represented facts. After all the objective of quantum physics consists in postulating and empirically discovering particles and none has been discovered by so meant QM. All were discovered by field quantizing methods having nothing to do with Schrodinger waves. Born's statistical interpretation only confirms that Schrodinger waves cannot represent and coordinate events.

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So we are back at Locality, separability and their refinement with respect to crude version we saw above.

Under the press of Bohr's repeated critiques, Einstein dove steadily deeper in his understanding of the roots of his commitment to separability. In a 1948 article he pointed out that field theories like general relativity assume separability in the most extreme possible form, since, in effect, they regard each point of the space-time manifold as a separable physical system, endowed with its own, independent physical state in the form of, say, the value of the metric tensor at that point. (Einstein 1948, 321).

It does not sound very convincing either. Abstractions have sense for Einstein only as coordinating representations of events. If a "system" should represent one or more events, one hardly sees how it could be embodied by a point.

Einstein himself contradicted the idea of a "system" reduced to a point or even to a monolithic "matter" particle. In his letter to Lorentz of 23 May 1909 he wrote:

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We are, to be sure, all of us aware of the situation regarding what will turn out to be the basic foundational concepts in physics: the point-mass or the particle is surely not among them. the field, in the Faraday-Maxwell sense, might be, but not with certainty.

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Sounds like intuition of the United Theory in spite of weak and strong interaction fields not yet being discovered. He writes further:

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I am not at all of the opinion that one should think of light as being composed of mutually independent quanta localized in relatively small spaces. This would be the most convenient explanation of the Wien end of the radiation formula. But already the division of a light ray at the surface of refractive media absolutely prohibits this view. A light ray divides, but a light quantum indeed cannot divide without change of frequency. As I already said, in my opinion one should not think about constructing light out of discrete, mutually independent points. I imagine the situation somewhat as follows:

... I conceive of the light quantum as a point that is surrounded by a greatly extended vector field, that somehow diminishes with distance. Whether or not when several light quanta are present with mutually overlapping fields one must imagine a simple superposition of the vector fields, that I cannot say. In any case, for the determination of events, one must have equations of motion for the singular points in addition to the differential equations for the vector field.

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In the same letter he reiterated his view of locality (embodying causality):

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... that which we conceive as existing ("real") should somehow be localized in time and space. That is, the real in one part of space, A, should (in theory) somehow "exist" independently of that which is thought of as real in another part of space, B. If a physical system stretches over the parts of space A and B, then what is present in B should somehow have an existence independent of what is present in A. What is actually present in B should thus not depend upon the type of measurement carried out in the part of space, A;

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This causal view of physics and of quantum physics in particular has been contested by the partisans of the rudimental QM and of its "Copenhagen Interpretation". The physical failure and the fatuous shamanist pseudo-philosophy of this "acausal" approach, contrasted with the vertiginous accomplishments of contemporary causal models, to wit the Extended Relativity and the Quantum Field Theory are discussed in "FOUNDATIONS OF QUANTUM PHYSICS",

Any doubt that may still persist with respect to causality is due to Einstein's ambiguous metalanguage. While he argued for causality, his maladroit wording argued against it.

In the following section we try to clarify the still ambiguous concept of locality and its relation to causality.

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## Extended Locality

In its habitual usage and even in Einstein's formulations locality appears confused and incompatible with interaction of spatially separated events. We shall try to repair it by expansion to "Extended Locality" (e-locality), defined as follows:

Two events are said to be e-locally related (in a Model) when their Model's representations are connected by a geodesic of model's SPACE Continuum to the same "location" or point of this Continuum. E-locality is clearly Model dependent.

E-locality clarifies the confusion of "locality" with a single point of SPACE. Even such distant bodies as Earth and Moon are e-locally related via the SPACE-equivalent gravity field continuum.

In order to conform with the usual terminology, we shall further use the term 'locality', meaning by it the e-locality, unless differently defined, in which case we shall mark it with inverted commas, as "locality".

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## Causality and implication

Given locally related Events A,B we shall say that they appear respectively as "Cause" and "Effect" if:

-A precedes B in time,

-B has never been observed without A, while A might have been observed without B.

Thus force appears as cause of acceleration as the latter has never been observed without the former, while force is often observed without acceleration.

Eventual causality relation maps into model's abstract implication relation. Thus, we consider causality as equivalent with implication: to say "A is cause of B" is equivalent with "A implies B".

Weak verifiability and strong falsifiability of Implication corresponds to the uncertainty of Causality which is hypothetical, never verified, but at best not (yet) falsified by eventual observation of effect lacking its alleged cause. Taking into account the fundamental fuzziness of events ("NATURAL MODEL") we can conclude:

**CAUSALITY IS HYPOTHETICAL, FALSIFIABLE AND FUZZY.**

As a necessary foundation of implicative scientific Models, it extends over them these characteristics.

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## Reified causality, or "determinism"

In "STRUCTURES OF MIND" we asserted that sensations trigger ordered "physical reality" of images and that mind's faculty of (re)cognition guides us through their labyrinth.

"Physical bodies" have been constructed by collecting some repeatedly occurring patterns of sensations into secondary images, apparently more "real" than their originations.

Similarly, one selects some pattern of event-images apparently always followed by another one and under names respectively "cause"/"effect" collects them into the secondary image under the symbolic name "causality". Like in the case of "physical body", one attributes to this secondary construct "causality" the unshakable "physical reality" and certainty, unlike to its "cause/effect" instances. And, having constructed the "physical world" by populating it with "physical bodies", one orders it with the principal orderer "causality".

However, this "physical world" appears as a map of some hypothetical territory-"Transcendancy". And temptation arises to regress it to this transcendental territory and to posit thus called forth transcendancy as the "real world out there". Yet, no matter how tenacious and persistent this temptation may be, the transcendental "reality" of regressed mental constructs is nothing, but a "transcendental illusion".

One may give in to the temptation and fall prey to the transcendental illusion by regressing mental secondary constructs - the "physical bodies" to "real objects" of transcendancy.

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To use the fashionable philosophical term, the transcendental illusion is tantamount to reification.

Like the e-locality, causality is an abstract construct pertinent exclusively to abstract models. Reified causality, illusorily ordering phantasmal "real objects" of transcendency is known as "determinism".

Thus, "determinism" is irrational and void of any rational meaning. Qualifying a physical approach as "deterministic", or, for that matter, "indeterministic", falls to the province of pseudo-philosophy and not physics.

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## Extrinsic logic

Mind's faculty to support inference's ERN structures and functions may be called intrinsic or natural "Logic". It is the subconscious Mind's system used instinctively as support of daily behavior. Irreplaceable as pilot of simple activities, it may nevertheless be misleading owing to its inadequacy to handle complex cases due to mind's limited working memory and its incapacity to concentrate simultaneously on numerous issues, as well as to the fuzziness of induction.

Facing shortcomings of their natural faculties, humans usually produced compensating tools: hammer to assist striking and extrinsic "Logical Systems" to assist intrinsic mind's inference. Such extrinsic systems may be justified exclusively by their capacity to extend and simulate mind's intrinsic, ERN logic. In the chapter "ERN LOGIC" we present a properly justified extrinsic logical system, whose applications so far stood the verification test, i.e., which, as yet, has not been falsified. It replaces consistently and simply the ill founded established systems.