# Existential reality of information in Physical Universe

**Rajiv K Singh***

* Independent Researcher, Bangalore, India
Correspondence: rajiv.singh.21@gmail.com

## Abstract

As we look around, we observe objects and their inter-relations embedded in 4.pi steradian space; consider relations and processes as objects. We especially note that the description of objects is constructed of information. We further notice the apparent realism of the information, it is undeniable, concrete, and non-probabilistic regardless of whether or not the objects exist. Since information does not interact physically, yet undeniably apparent, the causal function in nature must be directly responsible for this reality. The constancy (uniform regularity) in causal function of physical systems dictates that a resultant state S of a system must causally depend on the reality of precursor states of interacting systems within limits of causal function. Therefore, S intrinsically must correlate with the information of relation among precursor states, which is in general expressible as -- disjunction of conjunctions of values (primitive semantics) of states within limits of reality (Singh, 2018) that may result in S. For the same causal dependence, S must also correlate with the same expression on the values of correlation of respective states in each configuration. This second order correlation is organizable in modular hierarchy to give rise to arbitrary structured and abstract semantics. Conjunction creates a configuration within limits of specificity, whereas disjunction of such conjunctions gives rise to abstraction of structure and relation. Hence, we have a quantitative mechanism of information processing applicable to neural systems in addition to its ontological basis. As the brain processes semantic values of information, the mechanism must be formally laid down.



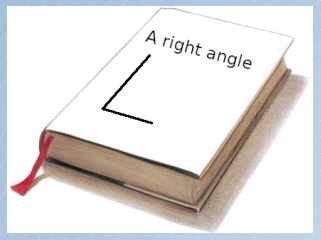
Keywords: reality of information ; information processing via physical interaction ; representation of semantic values ; mechanism of abstraction

Rajiv K Singh. Fundamentals of Natural Representation, Information. 9(7), 2018. https://doi.org/10.3390/info9070168

# The problem of missing formalism for semantic values

Shannon information or other considerations of information in physical sciences do not deal with the semantic content of information. Consider the object of a reference:

Open a **book**.
Pick a **ball**.
Semantics →




Looking at the book or the balls we know what semantic values of information we have about them; no need of a language. Brain processes semantics of information, there must exist a formally describable mechanism to represent and process information. What have we missed in our description of nature that has left us with such a void?

# The central ideas

- To establish the ontological reality of information. Must all elements of reality be measurable? Are superposition and entanglement a measurable reality?
- To formulate a general mechanism of information processing at each interaction applicable to neural systems.
- To establish formal mechanism of processing the semantic content of information rather than the quantity of information or the values assigned to bits / qbits.
- To lay down the mechanism of abstraction or emergence.
- To develop a sense or notion of difference between first person and third person perspective of information.

# Terms, definitions, and scope

Since the description of all objects is constructed of semantic values, here, the domain of discourse covers the space of all objects including elements of physical reality, relations, processes – structured or abstract.

- Object refers to all that is referable. An object has a specification as structural relation among its components and functional relations with other objects in a context or frame of reference.
- When referring to identity, we use the term ‘object’, and when referring to the description, we use the term ‘semantics’.
- An element of information necessarily expresses or qualifies a distinction in terms of implicit or explicit relation among objects. The value expressed is the semantic content.
- The term ‘causal function’ is used here to refer to the function of an object or a state, physical or representational, to effect a regular change within limits, in the respective domains, by which the object or the state is designatable or identifiable.

# Constancy of relation

A relation among objects is an expression of constancy that holds over the objects even when objects transform or undergo change. The term ‘constancy of relation’ refers to this expression.

If the number of possible values (states) for an object A is $N_A$ and for B, $N_B$ , yet if the number of possible combinations is less than their Cartesian product $N_A \times N_B$ , then there exists a relation between them, even though, for a given value of A, B can have a range of values. In this case, the constancy of relation is defined by the limits, where for a given value of A, the value of B is limited within a class, and vice versa.

# Natural causation or causal dependence

The natural universe, as observed from within, undergoes change. The changes follow certain uniformity and regularity (constancy), such that an observable state, S, of a physical entity, P, bears dependence on certain other states { Sx } within specific limits, where { Sx } may include relative static or dynamic quantities in conjunction and/or in disjunction. That is, if { Sx } were not to form a part of contextual reality within the limits, the state S of P could not have an existential reality either. Therefore, S of P intrinsically and causally must correlate with the semantic value of information about { Sx }.

This relation of the 'present to the precursor' or 'posterior to the prior', is referred to here as 'natural causal dependence'. It is referred to as 'natural' to imply the independence of this relation from any model or interpretation to mean what really exists, an ontological connotation.

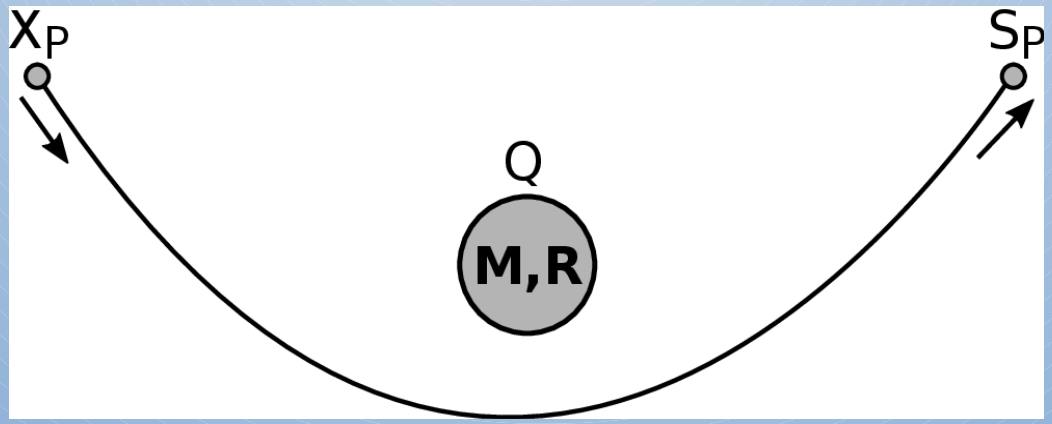
It is noteworthy that an element of { Sx } is not said to cause the state S of P, but the state S of P bears a causal dependence on elements of { Sx } in conjunction and/or disjunction. This is how the term causality must be referred to.

# Information as causal correlate of a state

Mass state of a physical system Q is a relatable quality or characteristic, for it conveys Q's causal function in an interaction, which constitutes a basis of Q's relation with other objects. Hence, the information of 'mass state' of Q forms a primitive of semantic value, a meaningful object grounded in reality without a qualifying label. An interacting system P responds to the relative measure of this quality that reflects in proportionate or relative transition in P's state. Similarly, spatial placement of system Q relative to P is a semantic value of consequence to P. As P undergoes a transition in its trajectory due to the causal function of mass M and relative placement R of Q, as shown in figure, the resultant state S of P must 'correlate with' (symbol ⇒ ) the information of mass and relative placement of Q, symbolically denoted as

$$S_P \Rightarrow (M,R)_Q$$

Here, LHS is a physically observable state and RHS is information of its partial causal correlation.



# Information as causal correlation of a state [Cont.]

$$S_P \Rightarrow (M,R)_Q$$

This information includes positive correlation with causally permissible limits of (M,R) in reality and negative correlation with the rest of space. A positive correlation indicates a possible range of values for precursor states in reality that may result in S of P, a negative correlation indicates forbidden values for precursor states, and a null correlation denotes independence. $S_P$ may causally correlate with other values in conjunction or disjunction, but the mechanism of computing advanced here may filter that out.

# The law of natural correlation

Post-interaction, the observable resultant state S of a physical system P represents a definite semantic value C that is derived from all causally equivalent configurations of reality, describable in terms of precursor states of interacting systems, that result in the state S of system P. The components of semantic value C are given by the following expressions:
( i) disjunction of conjunctions of values of respective states in each configuration;
(ii) disjunction of conjunctions of semantic values of correlation of respective states in each configuration.

We introduce A and O as infix binary operators for conjunction and disjunction respectively, with A having a higher precedence.

$$S_P \Rightarrow (v_1^1 \ A \ v_2^1 \ A \ v_3^1 \ A \ ...) \ O \ (v_1^2 \ A \ v_2^2 \ A \ v_3^2 \ A \ ...) \ O \ ...$$

Here, $v^i_j$ specifies $j^{th}$ value in conjunction of $i^{th}$ term in disjunction. $v^i_j$ is a value in arbitrary space of semantics specified with positive and negative limits, which could be a state value itself as per (i), or a value represented by it as per (ii) above. For instance, a line segment may be specified as a conjunction of values with limits in the spaces of length, width, orientation, etc., and a right angle with limits on relative orientation between two lines.

# Conjunction and disjunction as computable binary operators

Conjunction and Disjunction are not logical operators to accept True or False as their operands referring to arbitrary propositions. These operators accept three values of correlation, Positive (Pos), Negative (Neg), and Null (Nul), as operands referring to positive, negative, and null correlation with limits of semantic values. A binary representation of {Pos, Neg, Nul} as {01, 00, 11} maps conjunction and disjunction to binary operations of AND and inclusive OR respectively. The set of values {Pos, Neg, Nul} together with conjunction and disjunction operators forms a mathematical structure, a new kind of comprehensive mechanism of information processing (Singh,2018).

- On two's complement platform, binary AND and OR correspond to conjunction and disjunction respectively.
- No need for an Unary Negation operator. Negation is equivalent to default Null AND the Negative correlation.

| Corr1 | Corr2 | Conjunction | Disjunction |
|---|---|---|---|
| 01:Pos | 01:Pos | 01:Pos | 01:Pos |
| 01:Pos | 00:Neg | 00:Neg | 01:Pos |
| 01:Pos | 11:Nul | 01:Pos | 11:Nul |
| 00:Neg | 00:Neg | 00:Neg | 00:Neg |
| 00:Neg | 11:Nul | 00:Neg | 11:Nul |
| 11:Nul | 11:Nul | 11:Nul | 11:Nul |

# Conjunction and disjunction as computable binary operators

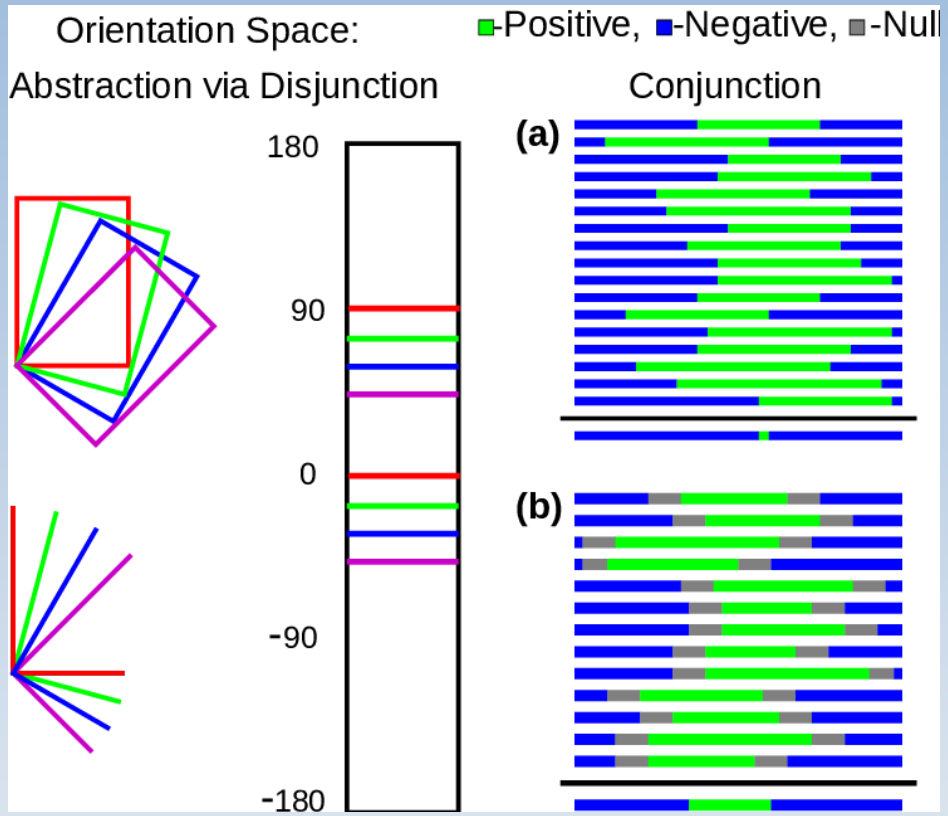
A conjunction of semantic values evaluates to greater specificity with narrower positive correlation when the values overlap in an object space, or to a specific composition when the values come from non-overlapping spaces, e.g., two specific line segments at right angle is one such composition. Disjunction functions as a mechanism of generalization giving rise to abstract semantics of a class, relation, or structure, e.g., semantics of 'right angle' from instances of right angle, as shown in the next slide. A class object encapsulates a relation that holds on the instances (members) of the class. Hence, the disjunction causes the emergence of an irreducible abstract semantics, making available a reference to a class object without referring to an instance.

$$p\ A\ q_1\ A\ q_2\ O\ p\ A\ q_3\ A\ q_4\ O\ p\ A\ q_5\ A\ q_6\ O\ \ldots = p\ A\ (q_1\ A\ q_2\ O\ q_3\ A\ q_4\ O\ q_5\ A\ q_6\ O\ \ldots)$$

Here, if $q_{2*i+1}$ and $q_{2*(i+1)}$ represented instances of two lines having common relation of right angle, p, then a disjunction of all such conjunctions represents the abstract semantics of right angle, p, without any particular dependence on a given instance. This is presented on the left in the figure on next slide, where any set of two lines in same color maps to the same value. That is, if two active agents representing the specific orientation of lines in same color activates the same recipient agent A, then the active state of A correlates with the abstract semantic value of right angle.

# A graphical illustration of mechanism of population coding with conjunction and disjunction

Each horizontal color bar under Conjunction represents a correlation profile of an active agent (a neuron) in arbitrary space of semantics. For example, an active state of a neuron may correlate positively (green) with a range of orientation value of a line segment, and negatively (blue) with the rest of space. The actual data for the figure is taken from a simulation. The result of conjunction on columns of values is displayed below the black line which shows a sharp correlation, which, in figure (a), is same as the orientation value presented for simulation. Therefore, when a set of these neurons together activate another neuron, active state of the recipient neuron represents the value below the black line.



# Basis of representing arbitrary semantics

The general mechanics of representing arbitrary semantics is based on the following observations that constitute first principles. The term object is used here to refer to all that is referable, including relations and processes.

- An object description is constructible in two fundamental ways, one, a bottom-up structural relation that includes components and their inter-relations, and another, a top-down functional relation with objects in encapsulating context. That is, an object description is always constructed of relations.

- An object is referable or has an identity by virtue of certain constancy in its structural and / or functional relations. Without such constancy in structure or function there is no definable characteristics, no objectivity, and no referability, hence no existential reality even in the domain of representation.

- A relation among objects is expressible as a map, which is also expressible as a disjunction of all possible conjunctions as shown below.

$$F : \{A, B, ...\} \mapsto \{X\}$$
$$F : \{A, B, ..., X\} \mapsto \{X\}$$

# Population coding of causal relation as a map

$$F : \{A, B, ...\} \mapsto \{X\}$$
$$F : \{A, B, ..., X\} \mapsto \{X\}$$

Map F defines a relation as a function, where specific conjunctions of values from parametric spaces of A, B, ... map to specific values in X, where X is an arbitrary space of semantics, including disjunctive many-to-one and one-to-many mapping. In terms of sets, morphism F is a selection of a subset of A×B×...×X. A disjunction of such conjunctions of elements in the subset represents the function / relation F itself as shown below. Extensions to the usual interpretation of a map include non-discrete values that may overlap, spaces that may not be independent of each other, and non-exclusive mapping from domain to codomain, as the conjunction and disjunction operators are independent of such requirements.

$$F_{ref} : \{\{A, B, ...\} \mapsto \{X\}\} \mapsto \{F\}$$
$$F_{ref} : \{\{A, B, ...\}(t-1), \{X\}(t)\} \mapsto \{F_{causal}\}$$
$$F_{pred} : \{\{A, B, ..., X\}(t), F_{causal}\} \mapsto \{\{A, B, ...\}(t+1)\}$$

In a re-entrant system, the representation of current value in space X can be looped back to form a conjunction with new values in A, B, ... forming a temporal process. A disjunction of conjunctions of values in temporal sequence maps to the causal relation. A causal relation, learned from observation and represented in a population coding system, can be used in conjunction with the current values to predict the values at the next moment. One may note that this mapping scheme to represent arbitrary relations bears direct correspondence to the neural function.

# Summary and Inferences

- Natural causal correlation of an observable state is shown to be the foundation of existential reality of information. Semantic content of information is grounded in causal function.
- A fundamental law is advanced to formalize this reality symbolically and to create a mechanism to compute the semantic content of information.
- Conjunction and disjunction are introduced as generic operators for semantic processing enabling expressions of structured and abstract semantics organizable in modular hierarchy. The method is directly applicable to neural systems.
- A principle based on constancy of relations is introduced as a uniform mechanism to construct object description via structural and functional relations.
- Abstraction via disjunction causes emergence of a class or relation, which enables a mechanism of referencing such objects.
- The mechanics of population coding of semantic values is expressed quantitatively.
- Objective basis of subjectivity is derived from causal function in nature.
- This work deals with the directly accessible reality of nature, whereas, all physically observable properties are subject to interpretation and modification. Information serves as a medium to all knowability; information itself does not require any medium.