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On Novelty*.

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ABSTRACT

It is shown that a previous elucidation of novelty is not fully correct. An alternative procedure to detect quantitative and qualitative novelty and emergent properties is proposed.
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INTRODUCTION

The elucidation of terms is strictly necessary for their rigorous and clear use in the scientific discourse [1]. This process was applied to the concept of novelty by Bunge [2]. He distinguished two kinds of novelty: quantitative novelty (or superficial novelty), happening when one or more properties of a thing vary in intensity or degree, and qualitative novelty (or radical novelty), when a thing gains or loses new properties. At this respect, Bunge proposed the following definition.

Def. Let x be a thing, P(x) the set of all properties of thing x, P(x, t) the set of properties of x at time t and P(x,t') the same set but at a later instant t'. Then:

a. The *total novelty* occurring in thing x during the time interval [t, t'] is given by:

$$n_x(t,t')=\left[P(x,t')\cap\overline{P}(x,t)\right]\cup\left[\overline{P}(x,t')\cap P(x,t)\right] \quad (1)$$

where $\overline{P}$ is the complement of P. $n_x(t, t')$ is therefore the set of properties of thing x that between t and t' appeared or disappeared.

b. The *emergent properties* appearing in x during interval [t, t'] are given by:

$$e_x(t,t') = P(x,t')\cap\overline{P}(x,t) \quad (2)$$

$e_x(t,t')$ is then the set of all properties of x at time t' that did not exist at time t.

Finally, Bunge asseverates that the concept of qualitative novelty can be represented by the state space of x, $S^Q(x)$, where Q denotes the dimensionality of the space.

Here we show that points a and b above are quite erroneous and that the state space could be at most a representation of quantitative novelty.

If we argue that at a later instant t' thing x presents a property that does not belong to P(x, t), we have two possible explanations for this fact:

1. The property existed at time t but went unnoticed. Possible reasons are a lack of awareness of it (if the property can be directly observed through our senses), or that it was not measured because we do not know that it existed. This case is relevant only for opening a discussion about a possible intensional vagueness in the description of thing x.
2. The property did not exist at time t. In other words, the property really appeared. This seems to be contradictory with an exact definition of thing x because it demands that thing x remains the same after a new property appears. The only way to keep the discourse logically coherent is to accept that after time t thing x underwent a process of change leading to the appearance at time t' of a new thing, say x', having one or more new properties (i.e., thing x was transformed into thing x', $x \neq x'$).

From this brief analysis, we may conclude that Bunge defined the concept of emergent property quite erroneously [2]. If we remember that an emergent property of a thing is the one that is unpredictable on the basis of the information concerning the constituent parts of thing x [3, 4], then we cannot hold the idea that thing x will suddenly present an emergent property and will continue to be x. For these reasons the concept of novelty must be elucidated again.

Emergent properties.

Let x be a thing formed by the association of n parts y^k (k=1, 2, … ,n). Denoting by $\oplus$ the physical operation by which the n parts assemble to form thing x (for example, the formation of bonds between atoms to constitute a molecular system), we have:

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$$x = \bigoplus_{k=1}^{n} y^k \qquad (3)$$

Now, we form the set of all properties of the components of thing x, $P(y^1, y^2, \ldots, y_n)$, as:

$$P(y^1, y^2, \ldots, y^n) = p(y^1) \cup p(y^2) \cup \ldots \cup p(y^n) \qquad (4)$$

where $p(y^j)$ is the set of all properties of the j-th part. The universe set, U, includes all possible properties of physical things at a given level of description. With these definitions we may calculate:

1. The total qualitative novelty, i.e., the set of all emergent properties of thing x, plus the properties that the constituent parts have but x does not:

$$n_x = \left[P(x) \cap \overline{P}(y^1, y^2, \ldots, y^n \right] \cup \left[\overline{P}(x) \cap P(y^1, y^2, \ldots, y^n \right] \qquad (5)$$

2. The emergent properties of thing x:

$$e_x = P(x) \cap \overline{P}(y^1, y^2, \ldots, y^n), \quad e_x \subseteq n_x \qquad (6)$$

Calling the set of positive integers N and using the cardinality concept [5], we obtain from 5 and 6:

3. The number of emergent properties of thing x plus the number of properties disappearing in the y^k's when they assemble to form thing x:

$$a = \text{card } n_x, \quad a \in N \qquad (7)$$

4. The number of emergent properties of thing x, b:

$$b = \text{card } e_x, \quad b \in N \qquad (8)$$

Another aspect that can be formalized is the change of the value of a property within the time interval [t, t']. If we assign a real number or an integer to each property, we say that a property of thing x changed its value in the time interval [t, t'] if:

$$\left| l_i(x,t) - l_i(x,t') \right| \neq 0 \qquad (9)$$

where $l_x(x,t)$ is the numerical value of the i-th property at time t.

The change of numerical value of the several properties of thing x (i.e., quantitative novelty) can be represented through the state space formalism. The state space of system x is just a Q-dimensional linear space, $S^Q(x)$, in which a state of the system is represented by a point whose coordinates are given by the values of Q selected state variables. The evolution in time of the system (i.e., the change of numerical value of one or more variables), will be represented by a curve in $S^Q(x)$. There remains the problem of which state variables to include. From a formal point of view, it would be desirable to select the most "fundamental" state variables, in the sense of including those belonging to the core intension of thing x [6]. For example, if thing x has only three properties we may employ the Cartesian axes u, v and w. Let us consider now the movement of the point in the u-v plane. This only means that the property represented in axis v has a constant value, and not that it does not exist. In fact, as our starting point was that thing x has three properties we cannot claim that a movement in any of the three planes defined by two axes implies that the third property does not exist! If we add a new axis to represent the appearance of a new property we are changing the dimensionality of the space $S^Q(x)$ and we must also say that we are dealing now with thing x' and not with thing x. Therefore, the state space formalism represents quantitative novelty only.

If we denote the states of thing x in space $S^Q(x)$ at times t and t' by $S_1(u_1, v_1, w_1, t)$ and $S_2(u_2, v_2, w_2, t')$ respectively, the phase state formalism allows the extent of the change from the original situation to be obtained as:

$$D = \left[(u_2 - u_1)^2 + (v_2 - v_1)^2 + (w_2 - w_1)^2\right]^{1/2} \quad (10)$$

The path followed during the time interval [t, t'] is given by the equations of movement of thing x.

In this way, the concepts of qualitative and quantitative novelty are well elucidated and can now be applied to any level of physical reality.

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