Exploring the use of metaphor in communication of contemporary physics

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Abstract

The paper deals with the role of analogical and metaphorical thinking in the public communication of contemporary physics. We focus on the cognitive aspects: how to disseminate complicated formal physical concepts to a non-professional public maintaining the 'correct' disciplinary meaning (communication of 'good physics'). To face the issue from the perspective of cognitive linguistics, we analyze the characterization of the generative aspect of 'new' meanings in the analogical and metaphorical use in order to evaluate the construction of 'actual' physical meaning. We investigate the research problem by analyzing a set of 'relevant' analogies and metaphors taken from popular science literature within the framework of conceptual metaphor. A case study is presented: Schrödinger's analogy for *'elementary particle'*. The results of the analysis suggest that the conceptual metaphor perspective might be a potential tool both to assess the quality of analogical forms used in dissemination of physics and to design new and 'better' analogies and metaphors. Besides, in a recursive process this analysis could help to focus on those meaningful cognitive aspects that characterize, and refine, a 'complete' and 'correct' physical concept. We think that fruitful results of inquiry might come from a deeper interdisciplinary approach between linguistics and physics.

Keywords: Contemporary Physics communication; cognitive linguistics; conceptual metaphor; analogy;

1. Introduction: Problem statement and purpose of study

The research proposal is framed within the general problem of the public communication of contemporary physics. Results in physics education research emphasize the difficulties involved in the explanation of complex disciplinary topics when a formal background in physics and mathematics cannot be assumed to be mastered by the audience (Jones, 1991).

We must refer to ordinary language and ordinary conceptual system in order to generate new meanings accessible to the audience, as Schrödinger underlines in the text analysed below in this paper:

> 'Physics takes it starts from everyday experience, which it continues by more subtle means (…) We have taken over from previous theory the idea of a particle and all the technical language concerning it .This idea is inadequate. It constantly drives our mind to ask information which has obviously no significance' (Schrödinger, 1950, p.111)

The physicists themselves cannot avoid *talking* and *thinking* in terms of ordinary language:

> 'Physicists who deal with the quantum theory are also compelled to use a language taken from ordinary life (…) they could no longer express their thoughts, they could no longer speak, they would be completely sterile. I consequently believe that it is necessary to take up certain *a priori* forms of classical language, even though their value has perhaps somewhat changed. (Heisenberg, 1961, p.34)

We shall focus on the linguistic aspects in order to face our core research problem: how to disseminate advanced physical concepts to a non-professional public, communicating the 'correct' disciplinary meanings (Kapon, Ganiel, and Eylon, 2010), that is aiming at 'communication of good physics'.

For this purpose, we have looked for formal tools apt at analyzing the linguistic features of dissemination texts and tested them through evaluation of the effectiveness of texts in communicating 'good physics' and in pointing out the implicit obstacles to the 'sense of understanding'.

We have drawn our attention to the role of analogical and metaphorical forms in the construction of 'actual' physical meanings because they obviously play an important role in introducing new concepts from previous ones when dealing with contemporary physics phenomena that are far from the ordinary perceptive domain (Fauconnier & Turner, 1994, 2002, Gentner & Holyoak, 1997).

Research on the role of analogy and metaphor in communication has been carried out from several disciplinary perspectives, from poetry, literary critics, archaeology, philosophy to semiology, cognitive linguistic, psychology of language and, more in general, to the cognitive science domain (Ghiazza, 2005; Hellsten & Nerlich, 2008).

The role of analogy and metaphor in scientific knowledge development has been underlined both in the constitutive (Black, 1962; Hesse, 1966; Boyd, 1979) and in the explanatory (Ogborn, Kress, Martins & McGillicuddy, 1996) functions.

For the purpose of our investigation the Conceptual Metaphor perspective, within the framework of cognitive linguistics, appeared to be the most promising analytical tool. Lakoff and Johnson, who first developed the theory, argue that our ordinary conceptual system is largely metaphorical (Lakoff & Johnson, 1980a, 1980b, 1999). All our thought and knowledge either emerge directly from our sensory experience or is understood and structured in terms of other concepts:

> 'Our ordinary conceptual system, in terms of which we both think and act, is fundamentally metaphorical in nature' .. 'The essence of metaphor is under-standing and experiencing one kind of thing in terms of another' (Lakoff & Johnson, 1980b, p.4-6)

The metaphorical forms might not be interpreted as isolated instances of colorful language, they are instead used in everyday language with a great deal of systematicity, structuring our ordinary experience by a complex system of mappings between conceptual domains ('cross-domain mappings').

In the literature the conceptual metaphor approach has been already applied to physics knowledge, in particular in the research field of physics education, concerning topics like thermodynamics (Amin, 2009; Amin, Haglund, Jepsson & Strömadahl 2010; Haglund, Jepsson and Strömadahl, 2010), quantum mechanics (Brookes, 2006; Brookes & Etkina, 2007), scientific explanation of complex topics (Kapon, Ganiel, and Eylon, 2007, 2010) and primary school physics education (Fuchs, 2011).

In this paper the following research questions will be addressed from this perspective: Can the conceptual metaphor be a powerful and reliable tool to analyse and assess the quality of analogical forms from the point of view of the dissemination of 'good physics'? Can this approach, through

some kind of recursive process, lead us to focus on those meaningful cognitive aspects that characterize, and refine such a 'good physics', as 'complete' and 'correct' physical concept?

We shall try to answer these questions by presenting a case study where the proposed analysis is applied to an excerpt of the famous text of communication of quantum physics 'What is an elementary particle?' (Schrödinger, 1950).

2. Case Study: 'What is an elementary particle?' (E. Schrödinger, 1950)

The article was first published in the review *Endeavour* in several languages. In the paper we analyse the English version. The text was addressed to a public of 'non-specialists'. The essay deals with the peculiar nature of 'elementary particles' in quantum mechanics.

We focus our attention on the part of the text where the author introduces and discusses an analogy (p.114-115) *'I shall use an instance from everyday life'* (p.113) in order to illustrate the *'the meaning of new statistics'*[†]. Schrödinger's purpose is to give the reasons, for a '*change of attitude*' from classical to quantum physics: the loss of 'individual identity'.

> 'No doubt the notion of individuality of pieces of matter dates from time immemorial (…) In the new turn of atomism that began with the papers of Heisenberg and de Broglie in 1925 such an attitude has to be abandoned. (…) If we wish to retain atomism we are forced by observed facts to deny the ultimate constituents of matter the character of identifiable individuals (…) Yet we must deny the particle the dignity of being an absolutely identifiable individual' (p.113)

At first Schrödinger puts forward the conceptual aspects of the analogical system (source domain), that can be projected onto the representation of the physical system (target domain), that are common to all the three statistics:

the classical or Boltzmann statistics and the two quantum Bose-Einstein and Fermi-Dirac statistics. 'Three schoolboys, Tom, Dick, and Harry, deserve a reward. The teacher has two rewards to distribute among them. Before doing so, he wishes to realize for himself how many different distributions are at all possible. There is only a question to investigate (we are not interested in his eventual decision). It is a statistical question: to count the number of different distributions. The point is that the answer depends on the nature of the rewards. Three different kinds of reward will illustrate the three kinds of statistics.'

Then the author specializes the analogy for the three cases. He 'manipulates' the nature of a specific element of the source domain ('the reward') modifying some relevant conceptual aspects of the cognitive representation of the physical system by the analogical correspondence. In the three cases the 'rewards' are represented respectively by 'memorial coins', 'shilling-pieces', 'memberships' (p.114):

a) The two rewards are two memorial coins with portraits of Newton and Shakespeare respectively.

b) The two rewards are two shilling-pieces (which, for our purpose, we must regard as indivisible quantities).

c) The two rewards are two vacancies in the football team that is to play for the school'

Schrödinger then communicates explicitly his proposal of analogical correspondence between the elements of the source and target domain: 'rewards' are projected onto 'particles' and 'boys' onto 'physical states'.

‘Let me mention right away: the rewards represent the particles, two of the same kind in every case; the boys represent states the particle can assume. Thus, ’Newton is given to Dick’ means: the particle Newton takes on
the state Dick’

In the following paragraphs the author analyses in details the elements that characterize the specialized analogical sub-domains emphasizing the specific conceptual categories introduced by the different typology of ‘reward’ that can characterize the relevant physical properties of the system as ‘the counting of the different distributions’. ‘Notice that the counting is natural logical, and indisputable in every case. It is uniquely determined by the nature of the objects: memorial coins, shillings, memberships’

He shows that the ‘individual identity’ of the ‘memorial coins’ represents the properties of the classical statistics.

Whereas in the case of Bose-Einstein the ‘numerical quantity’ is the relevant concept. In the Fermi-Dirac case

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† The author refers to the quantum Bose-Einstein and Fermi-Dirac statistics in opposition to the classical Boltzmann statistics.

Schrödinger stresses the deeply abstract nature of this kind of ‘rewards‘, that in addition to the loss of character of ‘individuality’ expresses a binary attribute of possession:

‘With membership neither has a meaning. You can either belong to a team or not. You cannot belong to it twice over’…

‘According to Pauli’s exclusion principle, there can never be more than one electron in a particular state. Our simile renders this by declaring double membership meaningless’

Schrödinger then focuses on the Fermi-Dirac case. He explicitly emphasizes how the analogical choice can cause a feeling of ‘*oddness*’ and ‘*inversion*’ for the reader. He seems to suggest that this feeling is the salient point that introduces the peculiar characters of the new statistics in terms of our ordinary conceptual systems: the impossibility to conceptualize the ‘elementary particles as identifiable objects’.

‘The example may seem odd and inverted. One might think, “Why cannot the people be the electrons and various clubs their states? That would be so much natural”. The physicist regrets, but he cannot oblige. And this is just the salient point: the actual statistical behavior of electrons cannot be illustrated by any simile that represents them as identifiable things’

The author seems to explicitly disclose the linguistic and cognitive operation he is carrying on in the text by the use of the concept of ‘reward’ in the analogy: an adequate representation in ordinary conceptual system of the Fermi-Dirac physical system requires an ‘inversion’ of roles between ‘particle’ and ‘state’ as ‘subject’ and ‘predicate’ of the discourse and of the ‘thought’ in order to avoid individuality of the particles.

We can find a confirmation in the words of Bitbol (1996) who writes about this text:

‘With this illustration, one understands that quantum mechanics strongly suggests a kind of ontological inversion. In classical paradigm, the particles were ascribed the grammatical status of subjects of propositions and states as predicates of the particles; but in the quantum paradigm, it is much more natural to consider states as subjects and the numbers of each

variety of quanta in these states (or statistical distributions) as predicates, in good agreement with the Fock-space second-quantized representation' (p.109).

2.1. Data analysis

We have already noticed that some communicative difficulties might emerge from the mentioned 'oddness' and 'inversion' in the reader's conceptualization of the physical entities. Applying the conceptual metaphor approach, we will show in a more formal and structured way that the emerging 'oddness' on one side helps us to focus on the relevant trait of 'lack of individuality' of the elementary particle, but on the other, it potentially introduces aspects of contradiction and incoherence in the conceptualization of the physical system in terms of ordinary conceptual system. In particularly we will put forward the hypothesis that in this text the analogical form can be considered in some ways 'incomplete' causing a lack of 'sense of understanding' in the reader.

For the purpose of the analysis, we found a useful theoretical reference in the conceptual metaphors that are involved in the conceptualization of events and states (Lakoff & Johnson, 1980b, 1999):

> 'Event-structure concepts, for example, state, action, and cause, are conceptualized metaphorically in terms of more "specialized" notions (e.g.: self-propelled motion and force). Metaphor is, in a significant way, constitutive of all event-structure concepts. Moreover, we reason about event and causes using these metaphors. In addition, these metaphors emerge from everyday bodily experience. Patterns of body-based inference are the source of abstract inference patterns characterizing how we reason using such event structure concepts' (Lakoff & Johnson, 1999, p.171)

The authors find out for events two dual metaphorical structures which are linked by a figure-ground shift:

> 'Our most fundamental understanding of what events and causes are comes from two fundamental metaphors, which we shall call the Location and Object Event-Structure Metaphors. Both make use of primary metaphors Causes Are Forces and Changes are Movements. They differ, however, in that one conceptualizes events in terms of locations, in other in terms of objects '. (Lakoff & Johnson, 1999, p.179) In the analysis we shall refer to the Object Event-Structure Metaphor to point out the conceptual structures involved in the representation of the physical system. The Location Event-Structure has been applied to the analysis of the Italian version of the Schrödinger's text, that will be not mentioned in this paper. The Object Event-Structure Metaphor can be characterized by three submappings:

'Attributes or States Are Possessions' e.g. 'I *have* a headache. (The headache is a possession).
'Changes Are Movements Of Possessions (acquisitions or losses)' à e.g. I *got* a headache. (Change is acquisition-motion to)

'Causation Is Transfer Of Possessions (giving or taking)' e.g. .The noise *gave* me a headache (Causation is giving-motion to.) (Lakoff & Johnson, 1999, p.196)

In order to focus on the potential elements of coherence/incoherence between the different analogy levels and the dynamic of the fundamental concepts of the physical system, we shall deal

separately with the general descriptions of both the analogy and the physical system and those parts of the text referring to the peculiarities of the three statistics.

About the general description of the analogy (‘*The three schoolboys, Tom, Dick and Harry, deserve a reward*’), we can observe that, from the first proposition, the entities ‘boys-states’, by being the grammatical subjects, are moved to the centre of communicative and cognitive attention. We further observe how the use of proper nouns (‘*Tom, Dick, and Harry*’) realizes a linguistic ‘definiteness’ that introduces the cognitive attribute of ‘individuality’. ‘Individuality’ then provides the basis thanks to the analogical correspondence for the representation of disciplinary ‘distinguishability’ in terms of ordinary conceptual system.

Through the analysis the presence of a metaphorical conceptual structure of the analogical source domain can be detected: the Object Event-Structure Metaphor. First of all, we notice that ‘boys’, who are the subjects of the cognitive attention, represent the entity characterized by the discourse. The use of terms like ‘deserve’ and ‘distribute’ suggests the presence of a possession schema according to the first submapping of the Object Event Structure Metaphor: ‘The schoolboys have rewards’ ‘Attributes Are Possessions’ (Rewards Are Possessions)

The ‘boys’ are the entities whose ‘attributes’ are specified as ‘possession’ of the objects ‘rewards’. Furthermore, if the ‘rewards’ are ‘distributed’ to the ‘boys’, then the ‘boys’ will ‘acquire’ the ‘rewards’ by a ‘movement’ of the rewards toward them. The second submapping of the Object Event-Structure Metaphor emerges here:

‘Schoolboys get rewards’ ‘Changes Are Movements Of Possessions’ (Change Is Acquisition Of Rewards – motion to)

The ‘teacher’ is an external ‘force’ that ‘causes’ a change of the attributes (change of possession of ‘rewards’) of the entities ‘boys’ by the ‘forced movement’ (‘distribute’) of the entities ‘rewards’. This is the third kind of submapping:

> ‘The teacher gives rewards to the schoolboys’ à ‘Causation Is Transfer of Possessions’ (Causation is giving of Rewards – motion to)

Therefore, the emerging conceptual structure, thanks to the analogical correspondence, provides a basis for the conceptual representation of the physical system in terms of ordinary conceptual system. The ‘states-boys’ are the entities whose ‘attributes’ are specified as ‘possession’ of the objects ‘particles-rewards’. The proposed schema is:

‘The states have particles’ ‘Attributes Are Possessions’ (Particles Are Possession)

‘The states get particles’ ‘Changes Are Movements Of Possessions’ (Change Is Acquisition Of Particles – motion to) ‘Particles are given to states’ ‘Causation Is Transfer of Possessions’ (Causation is giving of Particles – motion to)

The author explicitly applies the analogy to each of the three statistics by the dynamics of the concepts of ‘reward’. In doing so the presence of the conceptual structure in terms of Object Event-Structure Metaphor and of the ‘individuality’ of the ‘boys-states’ are confirmed by the text. In the Boltzmann analogy the ‘memorial coins’ are the rewards:

> ‘The two rewards are two memorial coins with portraits of Newton and Shakespeare respectively. The teacher may give Newton either to Tom or to Dick or to Harry, and Shakespeare either to Tom or to Dick or to Harry’

The ‘definiteness’ emerging from the use of the proper nouns ‘Newton and Shakespeare’ introduces the conceptual attribute of ‘individuality’ to the entities ‘rewards-particles’. The use

of a term like ‘give’ reinforces the possession metaphorical structure detected in the common part of the analogy.

In the Bose-Einstein case the rewards are ‘shilling-pieces’:

> ‘The two rewards are two shilling-pieces (which, for our purpose, we must regard as indivisible quantities). They can be given to two different boys, the third going without. In addition to these three possibilities there are three more: either Tom or Dick or Harry receives two shillings’.

The ‘nature’ of the rewards and the ‘indefiniteness’ introduced by the use of plural forms suggest the ‘lack of individuality’ in the conceptualization of the ‘rewards-particles’ in this specific analogy.

Terms like ‘given’ and ‘receive’ confirm the Object Event-Structure Metaphor. But we must notice that the possession does not refer to the individual ‘shilling-pieces’ but to the abstract notion of ‘quantity’ as a discrete number, that we could implicitly express by the proposition below:

The boys possess an amount (quantity) of money (a number of shilling-pieces)

The abstract notion of ‘numerical quantity’ represents the attribute that characterizes the ‘boys-states’ by possession.

> ‘Shillings (…) are still capable of being owned in the plural. It makes a difference whether you have one shilling, or two, or three’

In these propositions we can find out the presence of another relevant structure from the conceptual metaphor theory linked to numerical quantities (‘Arithmetic is Object Construction Metaphor’) proposed by Lakoff and Núñez (2000) (Amin, Haglund, Jepsson & Strömadahl 2010). The authors argue that numerical quantities (numbers) are metaphorical conceptualized ‘as wholes made up of parts’ and ‘the parts are other numbers’ (Lakoff and Núñez, 2000, p.65).

For the Fermi-Dirac analogy Schrödinger proposes ‘membership’ as ‘reward’:

> 'The two rewards are two vacancies in the football team… In this case two boys can join the team, and one of the three is left out’
>
> ‘Such particles, electrons for instance, correspond to membership in a club; I mean to the abstract notion of membership’

The presence of the Object Event-Structure metaphor is confirmed in this case too, but we notice that the conceptualization of the notion of ‘reward-particle’ loses any material or concrete property becoming a pure abstract binary attribute.

In the Fermi-Dirac analogy therefore it makes no sense to *talk* or to *think* in terms of ‘individual identity’ and ‘quantity’ when referring to ‘rewards-particles’. These two concepts of lack of individuality and lack of quantity are the basis for the representation in terms of ordinary conceptual system of both the disciplinary concepts of ‘indistinguishability’ and Pauli’s exclusion principle.

Going from the classical to the quantum representation of the world we progressively lose ‘information’ in the analogy. We could say that instead of introducing ‘new’ elements in the conceptualization of the physical entities, we are taking semantic traits away from the concepts. In a previous paragraph Schrödinger himself observes that ‘*According to the new theory less is required, and less is obtainable*’ (p.110).

After the analysis of the description of the 'pure' analogical domain, we have drawn our attention to the literal ('proper') description of the physical system. Some propositions refer to the common description of the three statistics, i.e.:

> 'Let me mention right away: the rewards represent the particles, two of the same kind in every case; the boys represent states the particle can assume. Thus, 'Newton is given to Dick' means: the particle Newton takes on the state Dick'

Others are present in the discussion of the Fermi-Dirac statistics, on which the author particularly draws his attention:

> 'Any person eligible to membership in that club represents a well-defined state an electron can take on.'

Using the conceptual metaphor approach, we have tried to point out the implicit cognitive aspects involved in the conceptual structure of the physical system in the 'proper' discourses that the author uses in the text after presenting the analogical domain in order to discuss the analogies themselves.

We suggest that even from the 'proper' discourses about the physical system description an implicit conceptual structure in terms of Object Event-Structure Metaphor emerges both for the general physical system and for the specific statistics. The use of terms such as 'take on' and 'assume' confirms the hypothesis. The relevant point here is that the metaphorical schema of possession seems here to be inverted if compared to the conceptual structure proposed by the analogical domains. The roles of 'particle' and 'state' are inverted The 'particle', that is the 'possessed attribute' in the conceptual representation of the analogical system, becomes the entity characterized by the 'possession' in the conceptual representation of the proper system, and vice versa for the entity 'state'.

2.2. Findings and Results

The data analysis seems to confirm our hypothesis that conceptual metaphor approach, by the identification of the potential aspect of contradiction and incoherence between the analogical and the proper descriptions, can provide us with a reliable formal tool to deal with the difficulties in text comprehension detected at intuitive level.

We have observed that the conceptual representation of the analogical domain evolves by the change of the 'nature' of the 'rewards', but the Object Event-Structure Metaphor and the role of the entities in the schema of possession must not change. It may be useful for the discussion to introduce three propositions that can express the evolution of the conceptual structures of possession through to the dynamics of 'the rewards' and the corresponding propositions that could be used in a coherent description of the physical system in proper terms**.**

CLASSICAL: 'The boys possesses **the** reward' 'The state possesses **the** particle'
BOSE-EINTEIN: 'The boys possesses **some** reward' 'The state possesses **some** particles'
FERMI-DIRAC: 'The boys possesses **a** reward' 'The state possesses **a** particle'

On the contrary the conceptual representation of the physical system described in 'proper' terms does not evolve in the text. The related specific forms of the Object Event-Structure Metaphor do not adapt themselves to the different statistics representing only the classical or spontaneous conceptualization of the system 'elementary particle'.

We have shown in the previous paragraph that there is an 'inversion' of roles between 'particle' and 'state' in the Object Event-Structure Metaphors of the analogy if compared to the proper description of the system. The inversion of the schema of possession is not semantically neutral: the subject of the discourse, the entity that 'possesses' the attribute, assume implicitly traits of 'individuality'. So the conceptualization of the proper system can be compatible only with the conceptualization proposed by the classical analogy because of the 'individual identity' of the 'reward particle' entity. But in the cognitive representation of the quantum statistics the analogical and the proper conceptualizations are incompatible.

Therefore, we argue that, in the Fermi-Dirac case, the inversion of the schema of possession generates some sense of 'oddness' because of the emerging 'incompatibility' in the conceptualization of the 'elementary particle'. 'Oddness' that the author mentions in order to draw the attention of the reader to the lack of 'individual identity' of the Fermi-Dirac 'elementary particle'. However, the 'inversion' of the schema of possession introduces potential aspects of contradiction and incoherence in the conceptualization of the physical system in terms of the ordinary conceptual system. In fact, in the Fermi-Dirac case the analogy could be interpreted as a 'negative analogy' (Hesse, 1966; Kapon, Ganiel, and Eylon, 2010): it emphasizes only the differences between the analogical source domain ('boys-membership') and the classical system described in proper terms. But the main result of our analysis is that the analogy appears to be 'incomplete': the text does not provide a direct description in 'proper' terms of the physical system onto which the systematic conceptualization explicitly proposed by the two quantum analogies can be projected in a coherent way.

We argue that the analogical 'incompleteness' can induce in the reader a 'sense of *not* understanding' related to meaning construction (conceptualization) of the quantum objects, since the 'lack of individuality' does not match with a coherent unconscious representation of the physical system in terms of ordinary conceptual system.

3. Final Remarks

Through the analysis of the case study we have checked the hypothesis that the conceptual metaphor approach can help us to make the specific communicative intentions of the author explicit from a disciplinary point of view, that is to identify the specific physical concepts he wants to communicate.

We have also shown that the approach has effectively helped us to focus on the relevant cognitive aspects in terms of ordinary conceptual system that are coherent with the disciplinary view and that are good candidates for the construction of meanings for the general audience. In other terms the analysis has pointed out, through an iterative process, which concepts potentially constitute the 'good physics' that can be communicated.

We have seen that the conceptual metaphor perspective gave us a reliable tool to assess the quality of the analogy from the point of view of the communication of 'good physics'. In fact, we have detected the presence not only of a productive sense of 'oddness', but even of aspects of incoherence between the analogical and the proper domain. We infer that the presence of a potential 'incompleteness' of the analogy can have a negative impact on the 'sense of understanding' of the audience.

Finally, we think that our results can suggest a more general issue, that could be the object of further research. The idea is that the difficulties connected to the presence of the dualism 'oddness-contradiction' may be an intrinsic aspect of dissemination of contemporary physics. As

we observed, the analogical forms play a fundamental role in the dissemination of contemporary physics, in particular they must deal with 'unfamiliar' aspects of the phenomena in terms of ordinary experience and knowledge, introducing concepts that may generate forms of 'oddness'. It can be argued that the analogy is bound to introduce some kind of 'oddness' in order to stress the peculiarities of the disciplinary concepts that are 'unfamiliar' for the general audience. On the ground of our study, the research hypothesis can be put forward that the difficulties may appear when communication fails to move the attention from the 'negative' (differences) aspects of the analogy, that are pointed out by the 'oddness', to the 'new' 'positive' ones, that make the analogy complete by providing a description in 'proper' terms of the physical system onto which the systematic conceptualization explicitly proposed by the analogy can be coherently projected.

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