

Contribution to Cross-disciplinary Lexicon

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Abstract

As the stock of human knowledge has increased, this evolution has imposed branching into disciplines which use special terminology understood “correctly” only by experts. This has raised barriers that impede communication since interpretations of terms and knowledge can vary significantly, especially in a multidisciplinary context. Misinformation is exacerbated by vague definitions including synonyms, homonyms and acronyms. This paper aspires to pinpoint the necessity of eliminating homonyms and synonyms. It attempts to illustrate the impact of misinforming that results from lexical disorder within the context of cross-disciplinary transfer of knowledge, standards setting and global business communication. The examples of homonyms and synonyms that have been observed to cause misinterpretations are presented. The genuine need for introducing a multidisciplinary transparent lexicon is advocated. A definition of a term "definition" is presented as a reference that highlights the inadequacy of homonyms and synonyms. Exemplary definitions are provided as models of transparent lexical terms. It is recommended that a hierarchy of terminology be adopted, giving the most fundamental disciplines the priority, and making sure that the other disciplines conform. A properly defined term is an information probability intensifier.

Keywords: cross-disciplinary, definition, entropy, homonym, information, lexicon, multidisciplinary, standardisation, synonym, terminology

Introduction

Intent and use of technologies can be forgotten, mind you the terms.

Communication implies that participants share and understand transferred information. Reality is that, in the middle of the Information Age, we struggle too often to understand each other due to simple, however costly, misunderstandings. Throughout history, humanity has accumulated an immense treasury of knowledge. However, even when one is aware that relevant knowledge exists in this treasury, finding the right piece of information is quite a challenge. Artificial intelligence has largely alleviated tedious searches based on keywords, yet much too frequently the keywords and terminology themselves provide still the misleading directions.

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Homonyms ? two or more words spelled (homographs) and pronounced (homophones) alike but different in meaning ? are not “protected” from misunderstanding; syntax does not prevent readers from deriving differing interpretations. For example, we use the term “paper” meaning: “a formal written composition often designed for publication and often intended to be read aloud”¹. However, this term is also a homonym as will be shown below. A “lexicon” ? a publication containing an alphabetical arrangement of the words in a language and their definitions¹ ? is another example of a homonym, as will be discussed below. Acronyms that can be decoded in differing ways can be classified as homonyms.

Still another phenomenon, called synonymy (occurrence of differing words with the same meanings), may appear at the first glance to be helpful since it provides us with several options. In fact synonyms are confusing because readers may be misled to dwell about the new term although its synonym has already been sufficiently understood. Synonyms cause further hindrance as well, namely prolixity. Thus for example, if the term “polysemy” is defined as “having several meanings”, the definition of polysemy is the same as that of homonymy, hence the terms “polysemy” and “homonymy” can cause synonymy.

Some words assume their meaning in accordance to the context, and the actual logic is governed by syntax which does not leave a margin for misunderstanding. This non-coincidental diversity should not be treated as homonymy. Definitions of this type are purposely made general and flexible, thus making it possible to be applied to a broad range of cases. Rationale for existence of such terms includes advantages of analogy and lexical economy. For example, modifier “flexible” can be applied as an adjective or an adverb and generally implies “a capability to adapt to changes”; it may mean “capability of a solid bar to be bent” or “ability of a person to adapt to diverse social influences”. This class of words will not be treated in the present paper. On the contrary, real homonyms and synonyms can cause vagueness, confusion and even misinformation which all obstruct an efficient exchange of information. Distance education, and other forms of knowledge transfer are also likely to be hindered by presence of homonyms and synonyms. Commonly accepted trends and strategies such as standardisation and globalisation require effortless and transparent cross-disciplinary communication and therefore the potential problems caused by occurrence of homonymy and synonymy deserve to be addressed.

This paper attempts to draw attention to such type of problems. Several illustrative examples of homonyms and synonyms that have been observed to cause misinterpretations will be presented within the framework of cross-disciplinary communication. This way the genuine need for introducing a multidisciplinary transparent lexicon will be promoted.

Definition

Polsani observed the multiple definitions and serious lack of conceptual clarity in the use of some key terms in Education, Information Management and complementary disciplines². Before presenting examples showing how homonymy and synonymy distort definitions and therefore hamper the communication, it is useful to present a workable concept for term “definition” itself.

Minimum Intent: The following definition of a term "definition" is presented as a reference, a background that will facilitate highlighting the inadequacy of homonyms and synonyms.

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"Definition" is a fixed form (an appearance of something as distinguished from the substance of which it is made; a representation, a model, an imprint, a description, a concept), of some relation(s) that significantly increases probability of realisation of an intended (premeditated) change of some relation to be achieved by an entity that is capable of utilising this definition for such a specified purpose. A definition cannot be generated or used without the existence of an entity, a materialised system, which is organised and structured above certain level of chaos. However, once it is generated, a definition can continue to exist (to be recorded) without the existence of the mentioned entity. A definition should be complemented with a minimum intent statement: a context that delimits a minimum domain of purposes for which it can be used. This statement does not exclude the possibility of using the definition correctly for some other purpose. However, this extended use must not violate (contradict to) already established meaning; e.g. this must not cause synonymy or homonymy.³

Definitions are necessary bits needed to construct and communicate the subject of knowledge. A definition is built by means of its structural components: pieces of information. Information is built by virtue of its construction elements (articulated signals of various kinds); the most frequently used include figures and words (terms).

Examples

i) Spuzic and Nouwens³ have introduced a number of illustrative examples of both homonymy and synonymy starting with the term 'figure', and basing it on definitions presented in a number of sources^{1, 7, 8, 9}:

"figure": (a) a number symbol, (b) numeral, (c) digit, (d) a geometric form (e.g. a line, triangle, or sphere) especially when considered as a set of geometric elements (e.g. points) in space of a given number of dimensions, (e) a diagram or pictorial illustration of textual matter.

The first two above definitions, (a) and (b), can themselves be taken as synonyms. The terms "figure" and "numeral" are synonyms, because both are defined in the same way as follows: "figure" ("numeral") is a conventional symbol (a figure or character) used to represent a number. The definitions given in (c), (d) and (e) above, have different meanings. Thus the term "figure", attributed to each of these three cases appears to be a homonym. Such ambiguities can be avoided as follows (the minimum intent: the following definitions are presented to provide examples how synonyms and homonyms can be avoided):

"figure": an arrangement of points made within two-dimensional space to present a visual static model of something (e.g., a figure printed on a book page, showing a front view of a home).

"digit": a figure representing a numeral

"numeral": any of the elements that can be combined to form numbers in a number system (e.g., decimal system, binary system, hexadecimal system, etc.). Examples: "0", "1", "A" ("A" is listed under an assumption that there is a convention within a non-decimal system, attributing a status of certain numeral to "A"). Different combinations of numerals provide different numbers.

The term denoting "thing itself" is here distinguished from the "model representing something": thus, "digit" is a "model representing a numeral"; and the "numeral" is the "thing itself". Furthermore, "numeral" is only an element of a more complex structure a "number": an element belonging to so-called number system; e.g. "0", "207", "0.003", "1011", "A", etc. In other words, number is a mathematical norm — a measure that can be subject to mathematical operations (e.g., succession, addition, and multiplication) following mathematical logic.³

ii) Another example is term “variance”, which is defined in literature discussing Accounting to denote the difference between the planned amount of money (the budget amount) and actual amount observed (in terms of realized revenues or costs). The act of computing and interpreting variances is called variance analysis.^{4, 5, 6}

However, another discipline, Mathematical Statistics, defines the same term as follows: the variance is a measure of how spread out a distribution is; it is computed as the average squared deviation of each number from its mean; e.g. for the numbers 1, 2, and 3, the variance is:

$$\sigma^2 = \frac{(1-2)^2 + (2-2)^2 + (3-2)^2}{3} = 0.667$$

Without entering into advanced interpretations of the term “variance” that appear in both the Accounting and Mathematical disciplines, it appears that there exists an obvious discrepancy in definitions. For example, if the budget for some unit is US\$ 107, while actual cost is US\$ 100, in terms of the Accounting definition, the variance amounts to US\$ 7. However, in terms of a Statistical definition, the variance is 12.25. The actual meaning of mathematical variance becomes more apparent when the variability is analysed in a set that consists of more than two values, and when reliability of data is taken in account as well.

The purpose of this paper is not to argue which definition is more useful, for there is no doubt that each has its well established use. The point is that, if the statistical methods of analysis of variance are applied to some accounting problems, the conflict of terminology may cause significant confusion.

iii) The term 'failure mode' has been used by different authors to denote differing meanings, therefore this term is a homonym.

In an Engineering field, so called Reliability-Centered Maintenance, the term 'failure mode' is frequently used to denote a single event that causes a functional failure. For example an electrical short circuit can cause a pump supplying 300 litres of oil per minute to fail.

However, in Failure Modes and Effects Analysis, the term 'failure mode' is often used to denote a functional failure, i.e. in the above example the actual failure of a pump to supply 300 litres per minute, is in fact the failure mode.

The use of term 'failure mode' can also be related to differing statistical distributions of failure probability. Thus the occurrence of some types of failures is found to be correlated to Normal (Gaussian) Distribution, to Hypergeometric Distribution, etc.^{10, 11}

Yet further sources [8](#), [12](#), [13](#) define ‘failure mode’ as a process of physical and/or chemical deterioration of a solid item. Such processes include fatigue, corrosion, erosion, abrasion etc.

Dellarocas and Klein¹⁴ use the term ‘failure modes’ to address a variety of socio-psychological exceptions – unexpected deviations from an ideal sequence of events caused by design errors, resource failures and requirement changes – in conflict management.

If the term ‘failure mode’ is used as a generic term encompassing all the above meanings, then each particular sub-set of failure modes should be designated a special name. For example ‘failure processes’ belong to a broader class of ‘failure modes’; failure process is a physiochemical, social, psychological or physiological transformation leading to deterioration of attributes of a physical item – an asset, a team, a person – thus rendering it inappropriate for denominated purposes. A classification of failure modes should be introduced to improve both understanding of this concept and understanding of the variety of included phenomena.

iv) Further example of a homonym is the term “paper”: material in the form of thin sheets, manufactured by the webbing of vegetable cellulose fibers. Paper is used for writing and printing, for packaging, and for a variety of other special purposes. [1](#), [15](#)

However this term may have a number of differing meanings:

- a) (n) a piece of paper containing a written or printed statement (document)
- b) (n) a formal written composition often designed for publication or intended to be read aloud
- c) (n) newspaper
- d) (v) to fold or enclose in paper. [1](#), [8](#), [9](#), [16](#), [17](#)

How are we supposed to understand the sentence: “The paper used to paper the paper 'Dilemmas in Using the Recycled Paper' is not recycled”?

v) The term “phase” is another homonym that causes significant hindrance to cross-disciplinary communication. The following definitions can be found in “chemical”, “physical”, “computing”, “general” and other dictionaries and publications:

a) “phase” (in chemistry): Any of the forms or states, solid, liquid, gas, or plasma, in which matter can exist, depending on temperature and pressure¹⁷. This meaning could be represented using the phrase "physical state of matter", not merely the word "phase".

b) “phase” (in chemistry and physics): ‘A homogeneous part of a heterogeneous system that is separated from other parts by a distinguishable boundary. A distinct state of matter in a material system that is identical in chemical composition and physical state and can be mechanically separated from other material, as is ice from water. A mixture of oil and water is a two-phase system.’ [17](#), [18](#), [19](#) This meaning could be represented by using a newly invented non-homonymic term, rather than using term "phase".

c) The Dictionary of Astronomy in Physical Sciences & Mathematics¹⁸ provides yet another definition: “phase” (in astronomy): ‘The proportion of the visible disk of the Moon or a planet that is illuminated as seen from Earth.’

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d) “phase” is a measure of position along a cyclically varying quantity, such as a wave or a periodic vibration. Phase is measured as an angle with respect to a fixed datum point; one complete cycle is equivalent to a phase of 360° , or occasionally as a number between 0.0 and 1.0.’ [18](#), [20](#) This meaning can be introduced by the phrase: “cyclic periodic phase measured in radians or other angular norms...” if a general definition of term “phase” is adopted as follows:

e) “phase” (generic term): Any stage in a series of events or in a process of development. Any one aspect of a thing of varying aspects; a state or stage of change or development; e.g. in phrase: "Phase one (or two, etc.): the first (or second, etc.) stage of a process, series of events, etc.” [8](#), [16](#)

If the above definition listed under (e) is adopted, the word “phase” can be efficiently used as a generic term when explaining the other meanings listed under (a), (b) and (c) above, rather than causing confusion in cross-disciplinary communication.

vi) According to a number of sources [1](#), [8](#), [16](#), [17](#), [21](#) term “lexicon” can have the following meanings:

- a) (n) alphabetical arrangement of the words in a language and their definitions,
- b) (n) dictionary, thesaurus,
- c) (n) the vocabulary of a language, an individual speaker or group of speakers, or a subject,
- d) (n) glossary, terminology – a list of terms in a specialized field of knowledge.

In fact, each of the above terms can have a specific definition, for example:

- “terminology” may be used as a general term encompassing all the above meanings
- “dictionary”: alphabetical arrangement of the words giving equivalent meanings in 2 languages
- “lexicon”: alphabetical arrangement of the words in a single language and their definitions
- “glossary”: a list of selected terms frequently used in particular discipline (e.g. in medicine)
- “vocabulary”: terminology used in particular domain or social group.
- “thesaurus”: alphabetical arrangement of synonyms or the words with similar meanings.

It is also important to distinguish the meaning of terms “lexicon” or “dictionary” as defined above, from the recording media used for storage and retrieving, i.e. physical materials that hold information, such as a Book, Compact Disk Read-Only Memory, and Digital Versatile Disk

Analysis

The purpose of science is to make knowledge explicit, public and testable, a clear object of critical review so that members of the whole community can use and build upon it. The translation of thoughts in language is perhaps one of the most challenging aspects of the transfer of knowledge. Control of language will become more important as science and technology address more complex problems in our dynamic and global environment. [22](#), [23](#), [24](#), [25](#), [26](#)

Scientific language should be composed of unchanging terms with "permanent" definitions that cannot be changed dynamically, at the same rate that characterises improvement of our knowledge. Indeed, there is a need for logical milestones, for definitions that serve as norms of progress, as the reference points. We need a mathematically deterministic, rigid structure of language, in order to evaluate our hypotheses and establish the foundation of knowledge. New terms should be introduced in the language, rather than continuously modifying the established

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existing terms that are logically linked to fragments of our current knowledge. Homonyms, synonyms and excessive use of acronyms should be avoided, at least within one language.³

The analogies between English grammar and mathematics have frequently been cited²⁷. However, in mathematics there is no room for dual meaning of terms. "Naturally" developed structures that appear within the language are certainly valuable phenomena that deserve detailed study. Nonetheless, there are both means, and the efforts seeking for improvement. Numerous attempts to produce specialised thesauri, each being limited to a confined domain of knowledge, present the evidence of an urging need for improving the scientific language. A comparison with mathematical structures suggests a useful strategy in resolving the problems of synonyms and homonyms. A given presentation of a group is said to have a solvable word problem if there exists a method enabling one to decide for each pair of words whether or not they represent the same element. The word problem can be solved for some simple classes of groups encountered in practice. Therefore, if the rules of algebra are applied to one explicit language, it is possible to define it in such a way that only the presentations with solvable word problem do appear. However, at the same time one cannot ignore the fact that another, more general, algebra (language) will continue to exist, where the unsolvable word problems will remain.^{3, 27}

Awareness of the problem of managing the scientific lexicon is not new. In the 18th Century, Carolus Linnaeus originated the modern binomial nomenclature system for classifying and giving distinct names to organisms to promote effective communication, investigation and development of knowledge in this field of science.²⁸ From the distant 19th Century, the words of Rudolph Clausius come to us as an inspiration, an example how new terms can be introduced: "I propose... to call S the entropy of a body, after the Greek word 'transformation'. I have designedly coined the word 'entropy' to be similar to 'energy', for these two quantities are analogous... that an analogy of denomination seems to be helpful". Helpful for what, if not helpful for the transfer of knowledge.³

Let us use information entropy for the sake of simple demonstration of the effect of homonyms on indeterminacy. We shall use formula proposed by Shannon²⁹:

$$H = - \sum_{i=1}^n p(i) \cdot \log_2 p(i)$$

H = information entropy

p(i) = probability of knowing the presented term

n = number of possible interpretations of the presented term.

Let it then be assumed that the p(i) = 0.9 and there are no homonyms. Then, the above equation gives information entropy H = 0.137. However, if there are two equally possible interpretations due to homonymy, p(i) becomes 0.45 and H = 1.04 (indeterminacy is nearly 8 times greater).

Information Science has long recognised the lexicon as a critical system resource. For example, in a heavy-equipment lexicon, there are a few hundred terms found out of 60,000 which have more than one sense per term. It is important to make publicly available large-scale lexical resources, with broad coverage and basic types of information, generic enough to be reusable in different application frameworks, e.g., with application-specific lexicons built on top of them.

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This need for shareable resources, possibly built in a cooperative way, brings in the issue of standardization. [30](#), [31](#), [32](#)

Snowden³³ suggests that recent developments in knowledge management have drawn attention to the cost of converting personal scientific knowledge to explicit, documented knowledge that can be disseminated with various technologies. One element in this cost must be attributed to ambiguities and misrepresentations that arise because of inconsistencies in the way we use words. Management of the scientific lexicon is becoming an important issue. There is a need to develop a rule-based scientific lexicon to reduce costs by making what Snowden calls the domain of 'known' knowledge more accessible.

In an earlier paper-sheet based economy in which authoritative scientific knowledge was disseminated through physical artifacts that moved slowly in response to requests, it was difficult to implement a responsive, rule-based scientific lexicon. However, in this 'digital age' tools are available to construct and maintain such a lexicon, and to provide convenient access to it. The need exists, and the means are available. [34](#)

Conclusions

Transparency of terminology is critical for achieving objectives in any socioeconomic system. Organisational structures (academe, marketing, operations) impose branching and hierarchy on information, and much knowledge is categorised into sub-domains understood only by "experts". This has raised barriers to multidisciplinary communication. Globalisation trends favour the de-specialisation of knowledge and collaborative communication between initially separated disciplines. However, these trends have uncovered hindrances such as prolixity, superficiality, ambiguity and the creation of narrow specialised terminology (jargon).

The examples of especially inconvenient and confusing terms should be exposed. In addition a trend of using more constructive, cross-disciplinary and transparent terminology should be established and fostered. It is recommended that a hierarchy of terminology be adopted, giving the fundamental disciplines (mathematics, physics, chemistry) priority, and ensuring that other disciplines conform thus eliminating homonymic or synonymic terminology. Scientific lexicon should attribute to each definition a unique set of words devoid of homonyms and synonyms. A lexicon devoid of homonyms and synonyms will improve information entropy.

The comprehensive review and "cleaning" of scientific terminology is certainly an immense task that demands the gathering together of competent institutions. Nonetheless the need to expunge scientific and technical language of ambiguity is urgent and becoming increasingly so.

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