Levels of reality as a fertile ontological model

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1 The levels metaphor

Speaking about levels of reality refers to the view that reality can be analyzed into various aspects, and such aspects are connected in a serial way. For example, we can think of life, matter and society as different aspects, and observe that life presupposes matter in order to exist, as no living entity is immaterial; and that society in turn presupposes life, as all social entities are living. Therefore, those three aspects are topologically related in a series: matter, life, society. The order cannot be changed, nor reverted (as matter can well exist without life, and most living species are not social).

In time, these facts have been represented by various metaphors. There are two facts to be represented: seriality and directionality. Seriality alone could be represented e.g. by the pearls of a necklace or the rings of a chain, but this would miss the other element: directionality. A more suitable metaphor has then been provided by a ladder or a stair, in which every step is higher than the previous one. Similarly, the term *levels* imply the idea of a series of layers, each resting on the lower ones, which is very appropriate to signify existential dependence: life "rests on" matter as matter is a prerequisite for the existence of life, and so on. I have thus described such metaphor elsewhere as a "gravitational" one (which should only be taken in the metaphorical sense, as levels can also exist that are prior to gravitation itself, like in the case of levels of mathematical objects).

The whole of human knowledge has often been represented by various images, including maps, trees, rhizomes, webs etc. (barsanti, 1992; santoro, 2003; weingart, 2013). Levels are one of such metaphors, that have also been expressed in the variant forms of ladders, chains, pyramids...

2 Levels in the history of knowledge

Ideas corresponding to a series of levels can traced back already to the writings of Plato, Aristotle and Plotinus (kleineberg, 2017, § 2.1). In the Middle Ages, it was

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common to refer to a "ladder of being" (*scala naturae*) where the first steps were occupied by earth, plants and animals, followed by humans and angelic creatures, with God at the top. This was also known as "the Great Chain of Being" (Lovejoy, 1927, 1936). These conceptions also had a hierarchical meaning, in the sense that the higher levels were regarded as more pure or perfect or powerful than the lower ones: one aim of human life was to free oneself from sin connected with lower-level desires, such as food, sex or wealth, and approach the higher levels through renunciation and spirituality. Clearly, such value implications are not necessarily associated with the idea of levels, which in itself is limited to a model of the world as being formed by a series of successive aspects.

Another possible interpretation of the series of levels is chronological: higher levels can be interpreted as having appeared after lower ones, which is quite reasonable if they depend on them for existence – if life depends on matter, it cannot have existed before matter, but must have appeared at the same time or, more likely, at a later time than matter. This interpretation became gradually dominant during the 19th century, with the success of the evolutionary theories of life by Jean-Baptiste de Lamarck, Charles Darwin, Ernst Haeckel etc. Organisms could be arranged in a sequential order from the most primitive, like polyps and worms, to the most evolved, like birds and mammals. While, from the scientific viewpoint, this has no necessary implication of value, anthropocentric thinking implicitly suggested that humans may be located at the top of this series, because of their special intelligence and skills (Simpson, 1950).

Philosophy in turn was inspired by the idea of evolution and extended it to the whole of reality, especially in the influential systems of Auguste Comte and of Herbert Spencer. Not just plants and animals, but the whole world can be the result of a process of cosmic evolution, starting from elementary particles through molecules, cells, organisms and minds to societies (usually including only the human ones, although even corals or ants can be social in biological senses). The idea of a cosmic evolution is of special interest to knowledge organization, as it offers a key for the arrangement of all objects of knowledge into a single system, which is an old purpose of classificationists. Indeed, Comte proposed to organize the sciences according to such a sequence, covering astronomy, physics, chemistry and biology, to end with sociology as the new science on which his philosophical system focused.

If levels are connected historically, one should wonder how the transition from one level to the next happens. At the beginning of the 20th century, this question developed into a specific philosophical movement: evolutionary emergentism (Blitz, 1992). Such authors as Samuel Alexander, Conwy Lloyd Morgan and George Conger emphasized that new levels emerge from pre-existing ones

as the result of interactions between their components, but showing at each level some new properties, so that items at the new level are "more than the sum of their parts". The movement was mainly within the context of Western science (though Alexander put "deity" at the top of his pyramid), but it opposed mere reductionism according to which everything would be but physical interactions: higher levels rather have their own properties, which are worth being investigated as such, providing a rationale for the status of such sciences as biology and psychology. "Emergence" and "supervenience" have since been discussed in philosophy of science till our time.

Of special influence on the future of knowledge organization would be Joseph Needham's (1937) lecture "Integrative levels: a revalutation of the idea of progress". The subtitle refers to a view compatible with the findings of science (Needham was a biochemist) and at the same time inspired by progressivism as theorized in historical materialism, to which some important British philosphers of science and documentalists adhered (JUSTICE, 2001). The term *integrative levels* was also adopted by psychologist James K. Feibleman (1951, § 3.3, 1954), animal psychologist T. C. Schneirla (1951) and others. A more detailed review is offered in Gnoli (2017), and Kleineberg (2017) is the author of an encylopedia entry on "Integrative levels".

Another author who has been influential in recent knowledge organization research is Nicolai Hartmann (1882-1950), a Baltic German scholar of neo-Kantianism who then developed an original philosophical system of his own. His interest was the revive of *ontology*, the philosophical branch devoted to the kinds of existing things and their description by most general categories, such as plurality, spatiality or processuality (HARTMANN, 1949). Levels are indeed found to be a main structure of Hartmann's ontology, especially in the form of the four major "strata" he identified in the "real being": matter, life, psyche and "spirit", the last covering historical-cultural phenomena. According to Hartmann, levels can be distinguished by their different sets of categories: for example, spatiality is a category possessed by matter and life but not by psyche, while life in turn has some categories not shared with matter. Hartmann's ontology is also relevant in that it covers the cultural phenomena, which are not always considered in the English-speaking tradition, leading some to claim that integrative levels are only useful for the classification of the natural sciences. Instead, Hartmann devotes much work to discuss spirit, in its three aspects of "personal spirit" i.e. an individual's culture as shaped by the views of her time, "objective spirit" i.e. socially shared culture, and "objectivated spirit" i.e. culture as instantiated in artefacts and creative works.

3 Different interpretations of levels

The case of Hartmann's ontology shows how the notion of levels has been developed in quite different philosophical movements, including both English materialism and German neo-Kantianism (GROLIER, 1971, p. 100-102). The idea obviously takes different forms according to the context in which it is considered, although a basic notion of layers dependent on other layers while showing their own original properties is always there.

Other authors also discuss levels in very different contexts. Jan Smuts, a military leader and the second prime minister of South Africa, listed the levels of material structure, living functions, animals, personality, states, and ideals as a series of "wholes in the universe". In his view, each level would be a "unity of parts which is so close and intense as to be more than the sum of its parts" and would have an increasedly centralized control (e.g. brain, government, etc.), as part of a progress by assemblage of new wholes. For this perspective, Smuts (1926) coined the term *holism*, that has encountered a new success in recent decades and is sometimes interpreted in spiritualistic senses.

Pierre Teilhard de Chardin, a Jesuit paleontologist, produced writings that depict conceptions heterodox for both Christians and biologists. He supported a view of natural and cosmical evolution through cells, increasingly conscious animals and man, that is not neutral but finalistic, as it is directed since its beginning towards a divine "omega point" (TEILHARD, 1955). Clearly, this is an interpretation of levels very different from that of the British materialists.

Although anthropocentric views that see humans and civilization as a culmination of evolution are a common temptation, standard biology considers evolution as a neutral process: organisms evolve from some forms to others in response to environmental pressures, but the forms that prove to be better adapted to a given environment will not be adapted anymore as the environment changes. Therefore, a primitive life form has no less value than an evolved one. More sophisticated forms, like humans, are just one attempt among the experimentations of evolution, but coexist with such simpler forms as bacteria, which are still dominant in quantitative terms. Also notice that not always are evolved organisms more complex than primitive ones: for example, animal species that became specialized for life in caves have lost pigmentation or even eyes, as these characters are not useful anymore in the new environment.

A slightly different, though still scientifically-oriented, view was proposed by Julian Huxley to account for some remarkable differences among the results of evolution. While humans are just one among many primate lineages in terms of standard taxonomy, they clearly have very special characters that have caused a

revolution in the Earth ecosystems. Huxley thus proposes to classify humans in a separate realm, "Psychozoa", that has indeed evolved from apes but should be distinguished from them by its novel characters (HUXLEY, 1955). In Huxley's terms, humans are a new "grade" of evolution, that is a new advancement in terms of general anatomical organization.

The notion of grade much reminds that of level, as it describes entities that have novel properties though being derived from pre-existing entities. Its relevance can be appreciated by comparing two competing approaches to biological taxonomy: phenetic and cladistic. Phenetic taxonomy only accounts for the morphological differences between organisms, in an attempt to be objective and not influenced by theories. In principle, this could even lump organisms of different origin together in case they show similar structures, like eyes or wings that have evolved along independent linages. Contemporary biology, however, is based on the evolutionary view, so that similarities that turn out to be originated from a common descent (homologous characters) are considered to be more important for classification than similarities originated by convergent evolution along different lineages (analogous characters). This principle is brought to an extreme in the cladistic school of taxonomy, according to which only common descent matters: which brings some unexpected results like having to classify birds within reptiles, because the lineage of birds originated from reptiles later than the separations between other kinds of reptiles. Such a choice does not take in account the great morphological differentiation of birds, with their development of feathers, wings and empty bones adapted to flight; that is, it provides information on descent but not on morphology. On the other hand, Huxley's notion of grade would be useful to produce classification systems that account for both descent and morphology. The same principle implicitly guides general classifications of phenomena: the whole class of life is indeed derived from that of matter, which is why life is listed after matter, but at the same time shows very important novel properties, which is why life is considered as a class separate from matter.

These examples show how levels can be interpreted in non-reductionistic ways: indeed, claiming that higher levels are derived from lower ones does not mean that only lower ones are relevant – for example, that physics is the only relevant science as all further sciences just describe superficial properties, as in the view of emergence as just "supervenience" (MCLAUGHLIN; BENNETT, 2021). A counterargument to such reductionist views is that higher levels can have causal powers upon lower levels. This has been described as *downward causation* by Donald Campbell (1974; 1990). A clear case of downward causation can be observed during the covid-19 pandemic, which clearly involves several levels of organization: to simplify, let us

consider only the level of living beings, covering viruses, humans and their biological interaction, and the level of political institutions such as governments. The latter is a level higher than the former, as it is derived from it – institutions are formed by human beings – but also has such original properties as representativeness or authoritarianism. In managing the pandemic, some governments privileged public health over economical systems, thus succeeding in limiting the contagion rate, while others like those of Bolsonaro and Trump privileged economy and imposed less restrictions, resulting in an increasing rate of deaths. It was widely acknowledged that the higher level of political institutions (together with other factors) had causal effects on the lower level of viruses and humans.

Until now, we have mainly discussed applications of the idea of levels to the objects of knowledge, that is to ontology. Some authors have also considered levels in the ways of knowing, that is in epistemology. Kleineberg (2018; 2020; 2021) reviews authors, like Piaget or Kohlberg, that have identified series of "levels of knowing", meant as degrees of awareness and integration in cognitive processes; he proposes that levels of knowing can also applied to knowledge organization systems (KOS) much as levels of known objects are: the subject of a document could thus be indexed by both the level of the studied phenomena, e.g. material, living, social etc., and the level of their study, e.g. preoperational, concrete operational, formal operational etc. This is related to Gnoli's (2020, p. 28-29) model of the dimensions involved in KOSs, which include phenomena (the objects of knowledge), perspectives (the ways of knowing), documents (the carriers of knowledge), collections, information needs, people and cognitive skills. Levels can be applied to one or more of these dimensions.

4 Levels in knowledge organization systems

As analysis by levels arranges entities in classes and establishes a sequence between them, it is very suitable to be used as a principle of knowledge organization. The lists of levels identified by ontologists and philosophers of science, that we have briefly discussed above, already are KOSs in a broad sense. Grolier (1974) offers many examples of them within the history of knowledge. Here we will now focus on KOSs meant as tools for ordering and retrieving bibliographical items, especially during the 20th century, although the history of bibliographic classifications is much older.

Levels cannot be found to be a prior structuring principle in those KOSs that reflect traditional arrangements of disciplines as they were grouped in 19th-century universities or in Francis Bacon's work: for example, the main classes of Dewey Decimal Classification (DDC) start with philosophy, religion and sciences, meant

as the products of "reason", then have arts and literature as the products of "imagination", and end with geography and history as the products of "memory". However, levels can be found within some DDC classes, for example *500* pure sciences are divided into mathematics, astronomy, physics, chemistry, geology, palaeontology, biology, botany and zoology, in an order clearly reflecting levels of natural objects.

Orders based on levels of knowledge objects become predominant in the works of some classificationists at the beginning of the next century, like Ernest Cushing Richardson who, in his 1901 treatise *Classification: theorical and practical*, claims that "the order of the sciences is the order of things" and "the order of things is lifeless, living, human, superhuman" (RICHARDSON, 1930), although systems devised by him for actual library collections show less interesting orders. An innovative bibliographical system, the Subject Classification, was devised by James Duff Brown, who explained that "[m]atter, force, motion and their applications are assumed to precede life and mind, and for that reason the material side of science, with its applications, has been selected as a foundation main class on which to construct the system. Life and its forms, arising out of matters, occupy the second place among the main classes [...] Human life, its varieties, physical history, disorders and recreations, follows naturally as a higher development; and so on" (BROWN, 1906, p. 12). This was based on philosophical references, where Brown "identified the four recurrent categories (guiding principles) in the classifications by some thinkers: Matter, Life, Mind, and Record" (SALES *et al.*, 2020, § 6).

An explicit reference to philosophical systems of knowledge, including that of Comte, was also made by Henry Evelyn Bliss in his books on "the system of the sciences" (BROUGHTON, 2020, § 3.3). He compared many such similar systems that show similar orders of the sciences, and found that these have to be only slightly adapted for the needs of education and of librarianship. Consistently, he built his Bibliographic Classification (BC) on such an order of main classes, starting with philosophy and mathematics, continuing with physics and the other natural sciences, then the social sciences and the humanities. This sequence is described by him as a "gradation in speciality", meaning that the first listed disciplines like philosophy and mathematics can deal with any subject, while the next ones cover increasingly special subjects – material phenomena only, then living phenomena only, etc. The other great general classification of this time, Ranganathan's Colon Classification, starts with a similar order for the natural sciences, which is described as "increasing concreteness" by the author; but it differs from the previously mentioned systems in that these disciplines are followed by the humanities and then the social sciences, in an order reversed as compared to that of levels, ending with political sciences, economics, sociology and law, listed in an order of

"increasing artificiality" of their principles (satija, 2017). Between natural and human sciences is placed class delta of spiritual experience and mysticism, suggesting an original triangular pattern that can also be found in such other ideas of this author as "APUPA" and "anteriorizing/posteriorizing common isolates". One could say that Ranganathan conceived the world not as a vertical series of levels but as a horizontal series of subjects gradually departing in both directions from the user's spirit in the centre.

A special place in the application of levels to KO have the members of the Classification Research Group, who regularly met in London for many years in the second half of the century. After having acknowledged Ranganathan's facet analysis as the basic method to develop KOSs, and produced several faceted classification schemes for special domains, they embarked in the 1960s in a big project of a new general classification system. Its main innovation would be that it would not list classes of disciplines, as was usual in bibliographic classifications, but classes of phenomena, activities and properties. In order to establish a general order of phenomena, the Group referred to the theory of integrative levels as formulated some years before by Needham and Feibleman. Although several works are signed collectively by the Group (particularly relevant to us being classification research group, 1969), members especially associated with the idea of levels since the beginning appear to be Douglas Foskett, Leo Jolley and Barbara Kyle. Brian Vickery also discussed levels as a principle for knowledge organization in his book Classification and indexing in science (vickery, 1958), but he soon moved from London to Oxford and did not take part in the works of the Group for a general classification (vickery, pers. comm.). The CRG project produced a very interesting draft, of which the main classes were:

A general systems
B phenomena and energy
C matter
D mineral systems
E life support systems
G astronomical universe
H Earth as an environment
J atmosphere
K liquid layers
L land forms
M geo-centred living systems
N viruses
P organisms sharing characteristics of plants and animals

Q plants
R animals
S man

However, the NATO grant for this research was not renewed and unfortunately the project was not completed. Its principles were described by Derek Austin in some remarkable articles (austin, 1969, 1976). Austin later applied some of these ideas, especially related to systems theory and citation order, to another important KOS, the Preserved Context Index System (PRECIS), though in a verbal system levels are less relevant because no systematic order is required. His approach was also received by the Italian Gruppo di ricerca sull'indicizzazione per soggetto (GRIS) and affected the structure of Nuovo Soggettario.

In the meantime, other classification systems have been published which mostly follow the classical series of levels, although they have not been applied as widely as BC2: these include Eric Coates' Broad System of Ordering, Ejnar Wåhlin's Universal System, Martin Scheele's Universal Facet Classification, Ingetraut Dahlberg's Information Coding Classification (ICC) and the 21st-century editions of Library-Bibliographical Classification. Interestingly, Dahlberg's system is inspired to the theories of levels of both Feibleman and Hartmann, according to which are arranged the ten main classes of "object areas of being": shapes and structures, energy and matter, Cosmos and Earth, organic area, human-sphere animated being, social area, economics and technology, science and information, cultural area. However, instead of further specifying subclasses of such objects, these are divided according to ten epistemic categories, thus producing subclasses of knowledge fields, which are not particularly relevant to the ontology of phenomena.

In the 2000s, I have resumed research on the lines of CRG's original project and, with help from other researchers, have started developing the Integrative Levels Classification (ILC), which refers to levels in its very name (preferred to the earlier version Naturalistic Classification because this could erroneously be associated to the natural sciences only, as remarked by Lorena Zuccolo). ILC too is inspired to 20th-century emergentists, as it is to Hartmann thanks to collaboration with ontologist Roberto Poli; Hartmann's ontology helps in the identification of the levels of human phenomena, which were not developed enough in the CRG draft system. A workshop on "Levels of reality as a KO paradigm" was organized at the International ISKO Conference 2010, with talks by Poli, Gnoli and philosopher Carlo Scognamiglio. In my talk (gnoli, 2010) I discuss how levels can be combined with two other structuring principles, types and facets, to produce different KOSs according to which principle is given priority over the others in the division of knowledge.

The ILC lists phenomena grouped in 25 main classes represented by small caps, from *a* "forms" to *y* "knowledge" according to a logic similar to that of the CRG. These are divided into subclasses (types) of phenomena represented by additional small caps, and can be specified by facets introduced by digits. Facets are distinguished into bound, parallel and free. Free facets allow to connect any two phenomena from different levels, e.g. "governments, affecting viruses". The standard citation order for such combinations is that the higher level precedes the lower one; however, in case the lower level is the most focal in the indexed document, e.g. in a virology article discussing the influence of governments, it should be considered the *base theme* so that the citation order changes to "viruses, affected by governments" and the item is grouped together with those focusing on viruses. The notion of base theme is contributed by GRIS member Alberto Cheti.

5 Jacob's law and levels of information

Emergence of one level from pre-existing ones always look like an ashtonishing fact, that can hardly be explained beyond simple observation. Indeed, most philosophers who discuss levels aim at providing an *account* of how the world is, rather than an explanation of it, unless they resort to finalistic ideas like in the case of Teilhard. This is especially true as for what is called "strong emergence", that is appearance of radically new forms. How could life emerge from matter? How could minds emerge from life?...

Hartmann distinguishes two kinds of relationships between levels. Some minor levels, or "layers", such as atoms and molecules, are related in such a way that the higher one depends on the lower one for being composed of parts from the lower levels: molecules are made out of atoms, though also showing such novel properties as bonds or folding. Such material dependence is called "overforming" by Hartmann, and contrasted with "overbuilding" which occurs between two major levels or "strata" (POLI, 2001). For example, the dependence of minds over living entities is not compositional, as mental entities such as thoughts or memories are not "made of" living parts. It could rather be described, in terms of classical philosophy, as a formal dependence.

If the relationship is not compositional, what is it? Some hints suggest that it could be informational. A powerful clue comes from a passage of Nobel Prize geneticist François Jacob (1975): "As a matter of fact, the two breaking moments in evolution, the appearance of life, then that of thought and language, each correspond to the formation of a memory system, heredity and nervous system".

In recent decades, information has become an increasingly central notion in science. The term *information* is not meant just as an exchange of knowledge be-

tween humans anymore, but as a fundamental quantity in physics. John A. Wheeler even proposed that information is more fundamental than matter, which would thus be (in our terms) a level derived from information: "it from bit". Paul Davies (2020) explicitly claims that "the bottom of what we might call the Great Chain of Being is information". One can compare this idea with the place of logical and mathematical entities in KOSs based on levels: indeed, these entities are often listed at the beginning of schemes (e.g. in BC2 *A*, just after philosophy; in ICC *o*; in ILC *a*). While some can interpret the position of these classes as a kind of epistemological prolegomena, similar to class *ooo* for reference works in DDC, a platonist interpretation of it is also possible: formal entities are at the beginning because they are a fundamental level of reality, prior to those of matter, life, mind and culture. Hartmann's ontology can also be compatible with this view: indeed, it includes logico-mathematical entities in "ideal being", a realm separated from that of "real being" that comprises matter, life, psyche and spirit. In some passages Hartmann (1931, § 15) even describes this as a level more basic than the material one.

If the nature of all reality is fundamentally informational, information as a common ground can also provide links between subsequent levels. Jacob's "memory systems" can be configurations of entities at a given level that are formally, though not materially, similar to those of other levels. This is quite familiar to us in the case of human culture, which reproduces the connections among entities at other levels by its new medium of language. Things that are connected in lower levels, like pandas and bamboos, are also connected in such linguistic propositions as *pandas eat bamboo*, despite the absence of any particle of panda or bamboo when the proposition is produced.

Jacob mentions "thought and language" as a single memory system, which would give an ontology of only three levels – matter, life, and thought – emerging through two breaks. However, "thought and language" seem to be different memory systems, as subjective cognition was also there in many animals before language developed in humans. So we can consider at least four informational levels: matter, life, cognition and culture. In cognition, configurations of nervous systems represent connections in other levels, both lower (matter and life) and higher (culture).

The formal correspondence between life and other levels is less obvious, but can indeed be found in the other memory system mentioned by Jacob: genomes. These, indeed, store information as sequences of nucleotides that ultimately trigger the production of certain proteins; structural and enzyme proteins are the main determinants of, respectively, the anatomy and functionalities of organisms. Thus, the characters of organisms are indirectly stored in genomes, and these can be seen as a memory system representing the features of the organisms environment. Indeed,

as pointed out by Konrad Lorenz, such characters as a fish shape are a model of the physical properties of water, where it has to live.

In all these cases, the link between different levels consists in a topological *isomorphism* in the connections between elements of the system and the connections of the modeled entities. Organism characters model the environment where they live; neural networks model external objects; and linguistic statements model the objects of cultural knowledge. All this suggests that theories of levels can nowadays be reformulated in informational terms.

6 An ontology of informational systems

We will conclude this paper by sketching a new ontology of levels in informational terms, which is capable of accounting for the level-based ontologies discussed previously, and at the same time connects levels through links of an informational nature. I discuss it in more detail in some Italian notes (Gnoli, 2021) and envisage to develop it in the future.

A starting notion, already connected to theories of levels by the Classification Research Group, is that of system. In general systems theory, a system is any organized entity composed of interacting connected parts. Bunge (1979) formalizes systems as sets of a composition *C*, a structure *S* and their environment *E*.

We define a particular kind of systems that we call *informational systems*, as those systems that are composed (*C*) by sets of elements (*modules*) taken from a limited repertoire, like the twenty aminoacids forming proteins or the twenty-six letters forming sentences. Modules can be arranged in combinatorial sequences along one dimension (strings) or along more dimensions (matrices, vectors), subject to certain syntactical rules (*S*), so to produce a very large number of possible combinations, like in proteins or texts. A familiar example of syntactical rule is that consonants can be adjacent only in groups of 2 or 3, after which a vowel is required.

An informational system is *semantic* if its combinations are affected by its environments ($S \leftarrow E$), which means that in some way they represent it. Examples are a footprint on the sand or the shape of a valley modelled by the erosion of an old glacier.

Semantic systems can stand for a shorter or longer time, but will eventually be destroyed, unless they are preserved through some copying system. This becomes possible if the informational system gets structured into several subsystems, which acquire separate functions. One subsystem, the *memory*, is made independent from direct interaction with the environment (e.g. by developing a cell membrane or by storage in a library) and only keeps the syntactic function of being copied and informing the central semantic component, called the *model*. The model is semantic

in that it reflects the forms of the environment, like in fish shape or in knowledge contained in books; though fitting its environment, it interacts with it only passively. A third subsystem, the *effector*, interacts with the environment both passively and actively, by modifying and being modified by it: this is the pragmatic subsystem, like animal behaviour or a device built according to instructions in a book. The syntactic, semantic and pragmatic subsystems all form a complex informational system that may be called a *semiotic* system, in the same way as the field of semiotics, devoted to the study of signs, is composed of syntax, semantics and pragmatics.

The appearance of a new major level, being a "memory system" in Jacob's terms, can now be seen as the transformation of some semantic system, e.g. certain macro-molecular compounds which are just models at the material level, into the memories of a new kind of entities, e.g. nucleic acids, whose combinatorial explosion triggers the production of a whole new kind of entities, e.g. organisms made of proteins.

In light of this model, we can now describe in informational terms the major classes identified in level theories. Our approach leads to acknowledge many common entities as being informational systems composed by combinations of modules, and to find out their syntactic, semantic or pragmatic nature. A provisional scheme of major informational levels is given in Table 1.

Table 1 - Informational levels.

	Memories	Models	Effectors
FORMS	Dispositions	Algebraic structures	Results
MATTER	Layouts	Compounds	Forces
LIFE	Genomes	Phenotypes	Life functions
COGNITION	Nervous systems	Consciousness	Behaviour
HERITAGE **- Artefacts** **- Mentefacts**	 - Plans - Languages	Works - Architectures - Contents	 - Devices - Messages

Source: Developed by the author

We have included the early levels of forms and matter for the sake of completeness, although these have not been studied much in these informational terms yet: in particular, it is not clear which "memories" can reproduce their semantic models. Still, such entities as algebras, atomic structures, molecular compounds or mineral compositions of rocks clearly are the results of combinatorial dispositions of their elements, which give rise to different properties in each case.

As these examples show, many informational levels can be divided into subclasses, like the level of matter can be subdivided into atomical structures, molec-

ular structures, mineral structures etc. In the same way, life includes the subclasses of prokaryote cells, eukaryote organisms, populations etc.; cognition can be distinguished into the sublevels of instincts, learned experience and socially-acquired habits; cultural heritage includes both artefacts, that is technological products, and mentefacts, that is knowledge products based on symbolic languages such as artworks and scholarly contents.

Only the subclasses of heritage have been shown in the table, as they are especially relevant to assess the ontological place of the phenomena studied in library and information science and in knowledge organization. These belong to the level of mentefacts, despite frequent confusion in the use of such words as "information", "knowledge", "concepts" that also occur in previous levels – just because all levels are informational in the most general sense. Particularly, the disciplines of psychology and sociology are concerned with the earlier level of cognition, which is an obvious pre-requisite for the existence of cultural heritage, but is separate from it. This suggests that LIS, KO and such other domains as heritage science and history of science should look for principles autonomous from those of psychology and sociology, rather focusing on such properties specific of cultural heritage as the topology and evolution of KOSs.

7 Conclusions

Our survey of levels as a way of looking at the whole of knowledge, in order to identify some structure in it, has shown that they are a very old idea. Indeed, similar metaphors such as those of "nature ladder" or "chain of being" were present already in ancient or medieval thought. In the modern centuries, these have evolved to lose a religious sense which placed God on the top of them and get associated to a temporal, evolutionary view.

Such new perspective often keeps an implicit idea that the higher levels have greater value than the lower ones, although this is not contained in, e.g., Darwin's theory of biological evolution. Higher levels can be taken as more valuable just in the sense that they have required a longer evolutionary path to be achieved (have greater "logical depth" in the terms of information theorist Charles H. Bennett), so are a kind of informational heritage.

In KO literature, "integrative levels" have usually been associated with specific periods in KO literature (e.g. 19th-century positivism or 20th-century materialism), which would imply that they are now an outdated model in the current postmodern context. However, our review has shown that the history of this idea covers many different times in the history of knowledge, as well as very different world views. Levels were also studied by Christian authors like Teilhard de Char-

din, holist ones like Smuts, and neo-Kantian ones like Hartmann, who has devoted a great effort to discuss the macro-level of "spirit". This allows for their application not just in the natural and social sciences, but also in the humanities; not just in the ontological dimension, but also in the epistemological one, in the version of levels of knowing.

In other words, levels go beyond any specific philosophical movement. This makes them suitable to inform the development of contemporary, general knowledge organization systems, such as the Integrative Levels Classification, which are not "born old" because of their application of levels, bur rather are exploring new developments of the idea.

Among such developments, those associated with the contemporary idea of information as a fundamental entity look especially promising. While the past systems have mostly identified levels of material things, the new informational paradigm can be fruitfully related to the idea of levels, leading to the notion of a series of informational levels. This can have consequences for general knowledge organization systems, as shown in our draft table, and is especially interesting for the characterization of the mentefacts that are the object of, among other fields, library and information science.

As a more general conclusion, we can observe that metaphysical ideas, such as that of levels, have indeed much to do with knowledge organization. That is, knowledge organization is not just a practical task of arranging information resources in some practical way, but ultimately depends on different philosophical views, as is shown for example in the evolution (actually, a revolution) of the Library-Bibliographical Classification (SUKIASYAN, 2017). Those interested in knowledge organization cannot avoid to include some metaphysics in the range of their reference sources.

Acknowledgments

I am grateful to the editors for inviting me to speak at the SEMOC conference and contribute this collection. Michael Kleineberg and Nina G. S. Barcellos d'Almeida provided useful comments to a first version. Patrícia de Almeida kindly translated the title, keywords and abstract into Portuguese.

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