Reviews of Concepts in Knowledge Organization

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Integrative Levels†

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Abstract: This article provides a historical overview and conceptual clarification of the idea of integrative levels as an organizing principle. It will be demonstrated that this concept has found different articulations (e.g., levels of integration, levels of organization, levels of complexity, levels of granularity, nested hierarchy, specification hierarchy, hierarchical integration, progressive integration, holarchy, superformation, self-organization cycles) and widespread applications based on various, often unrelated theoretical and disciplinary backgrounds. In order to determine its role in the field of knowledge organization, some common misconceptions and major criticisms will be reconsidered in light of a broader multidisciplinary context. In particular, it will be shown how this organizing principle has been fruitfully applied to human-related research areas such as psychology, social sciences, or humanities in terms of integrative levels of knowing.

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1.0 Introduction

In the field of knowledge organization, the organizing principle of integrative levels has a substantial though not uncontested tradition. The term "integrative levels" was first introduced in the late 1950s by the Classification Research Group (CRG) referring particularly to biochemist and sinologist Joseph Needham (1937), who invented this term, and philosopher James Feibleman (1954), who provided some generalizations or laws of the levels (Vickery 1958; Foskett 1961; 1962). Concerned with the determination of a scientifically justified sequence of main classes for a general classification scheme, Douglas Foskett (1961, 139) expressed the idea as follows: "The theory of integrative levels is that the world of things evolves from the simple towards the complex by an accumulation of properties, and that, at a succession of levels, these aggregations reach new degrees of complexity and become new wholes, with individual and unique identities." Accordingly, integrative levels can be defined as a developmental sequence in which entities at each new level integrate the essential properties and structures of the entities at the older levels, while they exhibit some emergent qualities and, therefore, more complexity than their pre-

decessors. A typical example of such a hierarchical order is presented by the sequence atoms—molecules—cells—organisms (Feibleman 1954, 62).

In more recent knowledge organization discourse, other authors emphasize other authorities who offer more or less independently developed but quite similar level conceptions. For example, Ingetraut Dahlberg (1974; 2008) as well as Claudio Gnoli and Roberto Poli (2004) rely on Nicolai Hartmann's concept of levels of reality that is based on two different kinds of hierarchical relations, namely, integrative levels called superformation and non-integrative levels called superposition, the latter without an accumulation of properties at each higher level. Furthermore, Søren Brier (2003) proposes the concept of levels of existence based on the co-evolution of matter and qualia inspired by Charles S. Peirce's evolutionary semiotics; Michael Kleineberg (2013) introduces Ken Wilber's concept of levels of being and knowing; and María López-Huertas (2013) discusses Basarab Nicolescu's concept of levels of reality and perception.

The history of the organizing principle of integrative levels, *avant la lettre*, can be traced back at least to the classifications of sciences by Herbert Spencer or Auguste Comte, which have influenced the work of many nineteenth and early twentieth century classificationists or thesaurus constructors including, among others, Charles A. Cutter's *Expansive Classification*, Ernest C. Richardson's *Order of the Sciences*, James D. Brown's *Subject Classification*, Henry E. Bliss's *Bliss Bibliographic Classification*, and Peter M. Roget's *Thesaurus of English Words and Phrases* (Dousa 2009; Gnoli 2005; 2017). Since the time of the CRG, the concept of integrative levels has been discussed extensively and in the course of a profound critique of discipline-centered approaches explicitly applied in knowledge organization systems (KOSs) that are primarily oriented on phenomena or objects of being such as *Kyle Classification* (Kyle 1969), *Information Coding Classification* (Dahlberg 2008), *Integrative Levels Classification* (Gnoli 2008), or *Basic Concepts Classification* (Szostak 2012).

The strength of the idea of integrative levels is seen in its synthesizing force that enables a non-reductionist organization of the diversity of world phenomena based on logically coherent principles and a universal scope of coverage. As suggested by Foskett (1961), it provides a helpful framework for both the specialists systematizing their own subjects and the generalists identifying the interrelations of different research areas. Therefore, it is recommended as a theoretical foundation for interdisciplinary knowledge organization (ISKO Italy 2007; Szostak, Gnoli, and López-Huertas 2016). Additionally, the idea is proposed as a disambiguation tool for different meanings of core concepts like "information," "knowledge," "cognition," or "communication" and their related theoretical and methodological approaches (Fenzl et al. 1996; Brier 2003; Wilson 2003; Bates 2005; Gnoli and Ridi 2014); or by the same token, as a comparative tool for cross-cultural studies and the organization of the epistemological dimension of human knowledge (Kleineberg 2014).

On the other hand, the idea of integrative levels is challenged by internal and external criticisms. Internal criticisms are sympathetic with the level concept but point to some inconsistencies in proposed hierarchy models such as branchings and dead ends that seem to violate the linearity of the level sequence, as noted since early discussions (Feibleman 1954; Foskett 1961; Austin 1969c; Kyle 1969; Tomlinson 1969b). For example, Tomlinson (1969b) notes that the development from the level of molecules seems to branch into non-living phenomena (e.g., minerals, rocks) and living phenomena (e.g., cells, tissues). Moreover, there is some doubt that the organizing principle of integrative levels, which might work well for a hierarchical order of phenomena investigated in the natural sciences, can be fruitfully applied to those in the social sciences or humanities (Huckaby 1972; Langridge 1976; Spiteri 1995; Poli 2001; Dousa 2009). External criticisms, however, tend to reject the idea of integrative levels as such, for example, due to the presumptions of a reductionist logical class formation and oppressive hierarchical relations, an underlying picture theory of meaning and universal claims of validity, or a hidden teleology and an implicit value ranking (Olson 1999; Svenonius 2004; García Gutiérrez 2011).

The following sections are concerned with a historical overview of the idea of integrative levels, its utilization as an organizing principle for knowledge organization systems, a reconsideration of common criticisms, and an outline of major fields of application in knowledge organization research.

2.0 A short history of an idea

2.1 The great chain of being

The idea of integrative levels has a long history. Its origins are described in Arthur Lovejoy's (1936) *The Great Chain of Being*, a study that once established the discipline known as the history of ideas by telling the story of one of the most influential ideas in Western history: the hierarchical order of reality. The genesis of this idea based on the principles of plenitude, continuity, and linear gradation, is traced back to ancient Greek philosophy, particularly to Plato's (1929, 2013) *Timaeus* and *Republic*, and its first full expression in the work of Aristotle. In *Generation of Animals*, Aristotle (1942) classifies animals according to their degree of perfection in eleven general grades from human beings at the top to so-called zoophytes at

the bottom, an idea that will later be known as a single graded "*scala naturae*" (Lovejoy 1936, 58)—from Latin *scala* "ladder" or "staircase" of nature. Even more significant, Aristotle's (1935) *On the Soul* presents a hierarchical order of all living beings according to their powers of souls ranging from plants with nutritive power to human beings with rational power to possibly another even superior kind, with "each higher order possessing all the powers of those below it in the scale and an additional differentiating one of its own" (Lovejoy 1936, 58-9). In other words, this hierarchical order presents a historical precursor to the idea of integrative levels since each higher level integrates the essential properties of the lower levels, while adding something new.

According to Lovejoy (1936), the conception of the universe as a great chain of being, exemplified in classical antiquity by Plotinus's (1992) *Enneads* and the Neoplatonist tradition taking the form of a hierarchical order from the supreme being of a godlike *ens perfectissimum* down to the most meager kind of existent, was accepted by most philosophers and scientists without question during medieval times and until the late eighteenth century. Even in non-Western cultures, particularly in the wisdom traditions of Hinduism, Judaism, Buddhism, Taoism, or Islam, ideas quite similar to the great chain of being have been articulated (Smith [1976] 1992; Wilber 1993).

Influential representatives are, for example, Augustine of Hippo and Pseudo-Dionysius the Aeropagite who both are seeking to combine Neoplatonist and Christian thought. Pseudo-Dionysius is known for inventing the term *hierarchia* "hierarchy"—a neologism from Greek *hieros* "sacred" and *arkhia* "rule"—denoting an order set out by God as the expression of divine law and will (Pseudo-Dionysius 1987, 153): "In my opinion, a hierarchy is a sacred order, a state of understanding and an activity approximating as closely as possible to the divine." He distinguishes a celestial (intelligible) and an ecclesiastical (sensible) hierarchy, each divided into a series of triads where the first member "contains the power of the lower two, and so on" (Wear and Dillon 2007, 57). In this way, the hierarchical order of the universe reflects the distinctions of powers from different ranks of angels down to rational souls to irrational souls to plants, and to soulless matter.

Within the Christian tradition represented, among others, by Albertus Magnus, Thomas Aquinas, or Baruch Spinoza, the most determinative and pervasive version of the great chain of being, according to Lovejoy (1936), is to be found in Gottfried W. Leibniz's ([1720] 2014) *Monadology*, in which he presents a hierarchical order from the divine at the top to human beings with rational souls to animals with non-rational souls down to simple substances or monads with lower perceptions. In order to solve the mind-body problem, Leibniz relies on the metaphysics of panpsychism, the assumption that all material entities have also a mind-like quality, and describes consequently his law of continuity stating that all properties attributed to a given level are integrated by each higher level in both physical and psychical terms, that is, as levels of being as well as "levels of consciousness" (Lovejoy 1936, 144).

2.2 Evolutionary order

During the eighteenth century, a "temporalizing of the Chain of Being" (Lovejoy 1936, 244) takes place as a reaction of paleontological findings and early evolutionary hypotheses that are questioning the idea of nature as a static order where every being finds its fixed and final God-given place. While the traditional order of emanationism descending from the most complex to the most simple is still to some extent echoed in the work of naturalists like Carl Linnaeus' (1758) *Systema Naturae* with its kingdoms of animals (e.g., mammals—birds—amphibians—fishes—insects—worms), plants and minerals, or Charles Bonnet's *The Contemplation of Nature* (Anderson 1976), the new temporalized chain of being or *scala naturae* follows the evolutionary order ascending from the most simple to the most complex, as stressed, among others, by Jean-Baptiste de Lamarck ([1809] 1914, 128): "I do not hesitate to say, however, that our general classifications of animals up to the present have been in the inverse order from that followed by nature when bringing her living productions successively into existence." Therefore, in his *Zoological Philosophy*, Lamarck (131) proposes six "stages of organization" according to what he considers as natural order and its progress of complexity (e.g., polyps—worms—insects—mollusks—fishes and reptiles—birds and mammals).

This kind of inversion and dynamization of the hierarchy reflects the *Zeitgeist* at the end of the eighteenth century in which various classification schemes in the natural sciences and also in academic libraries move human beings from the beginning to the end of the sequence (Šamurin [1955] 1977). Among philosophers, this turn becomes obvious if one compares, for example, Nicolas de Condorcet's essay *Example des méthodes techniques* that is concerned with classification theory and still represents more or less the old "reverse order" (Whitrow 1985, 92), with the new progressive order articulated in Johann G. Herder's *Outlines of a Philosophy of the History of Man* (1800, 108 emphasis original): "The more elaborate the organization of a creature is, *the more its structure is compounded from the inferiour kingdoms*. This complexedness begins underneath the earth, and grows up through plants and animals to the most complicated of all creatures, man." In German idealism, the idea of a hierarchical order of reality is further elaborated, again in terms of both levels of being in the philosophy of nature as

well as levels of knowing in the philosophy of mind or transcendental philosophy. In the attempt to combine both approaches, Friedrich W. J. Schelling's ([1800] 1978, 125-6) *System of Transcendental Idealism* describes the "scale of organization" simultaneously as "orders of intuition" culminating in absolute abstraction and the self-determination of intelligence. Based on the same dialectics of thesis, antithesis, and synthesis, the idea of integrative levels is foreshadowed in Georg F. Hegel's ([1830] 1970, 20 emphasis original) *Encyclopaedia of the Philosophical Sciences*: "Nature is to be regarded as a *system of stages*, one arising necessarily from the other and being the proximate truth of the stage from which it results: but it is not generated *naturally* out of the other but only in the inner Idea which constitutes the ground of Nature." This kind of speculative thought is overcome by more empirical explanations, particularly in evolutionary biology during the nineteenth century, a period known for celebrating the notions of evolution, development, and progress (Blitz 1992).

One of the most influential approaches is presented by Auguste Comte's ([1830-42] 1974) *Course in Positive Philosophy*, in which he offers a two-sided strategy for the classification of human knowledge based on the idea of both levels of being as well as levels of knowing. Comte rejects the Baconian tradition of encyclopedic ladders of knowledge that is oriented on the faculties of human mind like memory, reason, or imagination because human understanding, for him, employs all of them more or less simultaneously. Instead, he proposes a hierarchy of fundamental sciences (e.g., astronomy—physics—chemistry—physiology—sociology) corresponding to the investigated objects or phenomena that are arranged according to their affiliation (53): "The order is determined by the degree of simplicity, or what amounts to the same thing, of generality in the phenomena, resulting in successive dependencies and consequently greater or less difficulty in study." Additionally, Comte's famous law of three stages regarding the development of the human mind states that each branch of knowledge develops through a necessary order of three phases from a theological state to a metaphysical state up to a positive state, even though these developments do not need to take place synchronously and allow the coexistence of different states at the same time within a society. Moreover, Comte (21) claims that since the starting point for both individual and collective education is necessarily the same "the principal phases of the individual represent the epochs of the species."

Inspired by Comte's work and contemporary Darwinian thought, Herbert Spencer's ([1862] 1915, 246) *First Principles* presents an all-inclusive concept of evolution covering astronomical, geological, biological, psychological, and sociological phenomena in terms of a "progressive integration of Matter" (e.g., inorganic—organic—super-organic) which means an increase in structural complexity from an indefinite and incoherent homogeneity to a definite and coherent heterogeneity.

2.3 Levels of reality

In the late nineteenth and early twentieth centuries, the idea of integrative levels finds widespread application in various research fields and is often discussed under the label "levels of reality," for example, within the discourse on emergent evolution among scholars like Conwy Lloyd Morgan, Samuel Alexander, C. D. Broad, William M. Wheeler, or Roy W. Sellars (Blitz 1992). According to David Blitz, most approaches agree about at least three main levels of reality that can be summarized as matter—life—mind, whereas some argue for a preceding level of space-time and some for a succeeding level of society or even deity.

Arguably the most comprehensive and most detailed analysis of levels of reality is offered by Nicolai Hartmann's (1940) *Der Aufbau der realen Welt* (*The Structure of the Real World*) in which he introduces the hierarchical sequence of matter—life—psyche—spirit, the latter as the tripartite but inextricable unity of personal (individual), objective (collective), and objectivated (materialized in artifacts) spirit. Hartmann rejects the principle of continuity and restricts the scope of the idea of integrative levels, which he calls superformation (*Überformung*), to the levels of matter and life, while introducing the idea of superposition (*Überbauung*) where the higher level depends on the lower level but without integrating its essential properties. Most importantly, in his analysis two fundamental border lines between categorically orthogonal domains are identified, namely, a psychophysical border line between exterior life and interior psyche, and a border line between the individual personal spirit and the collective objective spirit (Kleineberg 2016).

Nevertheless, some authors defend the principle of continuity and, therefore, the integrative character of levels of reality by interpreting these border lines as boundaries between co-evolutionary correlates rather than emergent levels. For example, Lloyd Morgan (1923, 26) maintains the view that through all levels of reality from matter to life to mind both exterior physical and interior psychical dimensions develop simultaneously: "This means, for me, that there are no physical systems, of integral status, that are not also psychical systems; and no psychical systems that are not also physical systems. All systems of events are in their degree psycho-physical." Corresponding to such a panpsychism, Wheeler (1928, 39) proposes a kind of pansociality assuming different degrees of the social along all levels of reality in the sense of a co-evolution of the in-

dividual and collective dimensions: "Indeed, the correlations of the social—using the term in its most general sense—even extend down through the inorganic realm."

A further important aspect of the idea of integrative levels is stressed by Wilhelm Dilthey's ([1910] 2002) *The Formation of the Historical World in the Human Sciences*, in which he compares the natural order investigated by the sciences with a reconstructed historical order studied by the humanities with the goal to defend a nomothetic approach to the latter. Inspired by Hegel while rejecting his metaphysics, Dilthey (351, 184) is concerned with a critique of historical reason by analyzing the structure and development of human thought, for example, in terms of universal "stages of consciousness" or "stages of historical intelligibility." The importance of such an idea of integrative levels of knowing for human-related research fields is also emphasized, among others, by James M. Baldwin's (1906) *Thought and Things*, Wilhelm Wundt's ([1912] 1916) *Elements of Folk Psychology*, Ernst Cassirer's ([1923] 1955) *Philosophy of Symbolic Forms*, Max Scheler's ([1924] 1980) *Problems of a Sociology of Knowledge,* Norbert Elias's ([1939] 1994) *The Civilizing Process*, and Gaston Bachelard's ([1940] 1968) *The Philosophy of No*.

2.4 Integrative levels

To some extent independent from the sketched history, Joseph Needham invents the term "integrative levels" for an idea that is outlined in his famous Herbert Spencer lecture *Integrative Levels: A Revaluation of the Idea of Progress* in the sense of "successive forms of order in a scale of complexity and organization" (Needham 1937, 3-4) that cover the whole known universe and the way in which it has come into being from the inorganic to the biological to the social. What is a whole at the lower and older level becomes a part at the next higher and newer level (e.g., protein crystals—cells—metazoan organisms—social units). In this way and with reference to Karl Marx's and Frederick Engels's materialist version of Hegelian dialectic, he also suggests different levels of integration within the social order in terms of both productive forces (basis) as well as cultural and cognitive aspects (superstructure).

A major contribution is achieved by James Feibleman's (1954) essay "Theory of Integrative Levels" in which thoughts by Joseph Needham, Ludwig Bertalanffy, or Alex Novikoff are systemized into a dozen laws of the levels (excerpted from 1954, 59-63):

1. Each level organises the level or levels below it plus one emergent quality.
2. Complexity of the levels increases upward.
3. In any organisation the higher level depends upon the lower.
4. In any organisation, the lower level is directed by the higher.
5. For an organisation at any given level, its mechanism lies at the level below and its purpose at the level above.
6. A disturbance introduced into an organisation at any one level reverberates at all the levels it covers.
7. The time required for a change in organisation shortens as we ascend the levels.
8. The higher the level, the smaller its population of instances.
9. It is impossible to reduce the higher level to the lower.
10. An organisation at any level is a distortion of the level below.
11. Events at any given level affect organisations at other levels.
12. Whatever is affected as an organisation has some effect as an organisation.

At the same time, Feibleman argues for a revision of the linearity of the level sequence due to occurring branchings and dead ends. For example, the development from the level of molecules seems to branch into both biological phenomena with increase of complexity as well as astronomical phenomena without increase of complexity.

As already mentioned, alternatives to strict linear sequences of integrative levels are also proposed by approaches that emphasize the notion of co-evolution of different categorically orthogonal domains. Some theorists argue for a co-evolution of the physical and the psychical in the broadest sense (Lloyd Morgan 1923; Brier 2003), some others for a simultaneous emergence of the psychical and the social from the physical including the biological (Emmeche, Køppe and Stjernfelt 1997; Poli 2001), again others even for interrelated developments of the physical, the psychical, and the social (Wheeler 1928; Wilber [1995] 2000; Kleineberg 2016). In particular, there are good reasons to assume a multi-leveled co-evolution of brain, cognition, and culture (Deacon 1997; Greenberg et al. 1999; Donald 2001), of material society and immaterial culture (Habermas 1979; Dux [2000] 2011), or of microsystems (e.g., atom—molecule—cell—complex organism) and macrosystems (e.g., star—planet—ecosystem—population) (Jantsch [1979] 1980; Wilber [1995] 2000).

After all, there seems to be no consensus on the idea of integrative levels, neither on the conceptual definition and theoretical foundation nor on the sequence and architecture of level models (Wheeler 1928; Greenberg and Kenyon 1987; Poli 2001). As a matter of fact, its utilization as organizing principle often reveals inconsistencies or exceptions for practical reasons (Spiteri 1995; Dousa 2009). Nevertheless, the theoretical interest in the idea of

integrative levels continues until today, even though many domain-specific discourses appear to be isolated from each other using different terminologies within different more or less restricted fields of research (Yao 2009). These include, without claiming comprehensiveness, biology (Kummer 1987; Lobo 2008), ecology (Rowe 1961; Esbjörn-Hargens and Zimmerman 2009), comparative psychology (Tobach 1987; Campbell 1990; Pisula 2009; Tomasello 2014), developmental psychology (Campbell and Bickhard 1986; Overton 2006; Commons 2008; Lourenço 2016), neuropsychology (Feinberg 2011), neuroanthropology (Deacon 1997; Donald 2001), social anthropology (Hallpike 2008), cognitive archaeology (Mithen 1996; Trigger 2003), macrosociology (Steward 1972; Nolan and Lenski 2015), sociocultural evolution (Sahlins and Service [1960] 1988; Habermas 1979; Dux [2000] 2011), general systems theory (Bertalanffy 1968), self-organization (Jantsch [1979] 1980; Fenzl et al. 1996), emergentism (Blitz 1992; Pettersson 1996; Bunge 2003), and hierarchy theory (Koestler 1967; Salthe 2009).

3.0 Integrative levels as organizing principle

3.1 Principles of organization

Knowledge organization systems require organizing principles. Mathematician and library scientist Shiyali R. Ranganathan (1967, 83) specifies the following eight principles of organization for helpful sequences: later-in-time, later-in-evolution, spatial contiguity, quantitative measure, increasing complexity, canonical sequence, literary warrant, and alphabetical sequence. One advantage of the idea of integrative levels might be seen in its ability to combine several of these principles, namely, the relations of later-in-time, later-in-evolution, and increasing complexity (cf. Gnoli 2017).

The principle of increasing complexity is reflected by Feibleman's (1954) first and second laws of the levels stating that integrative levels are cumulative upward in terms of both properties and structures, while adding an emergent quality at each higher level. In the case of cumulative properties, this principle is compatible, as suggested by Broughton (2008, 49), with Bliss's principle of gradation by specialty that following Comte describes a sequence from the most general to the most specific, also known as genus-species relation. In cases of cumulative structures, however, one might speak of the principle of successive parthood that describes an "organisation as itself a part of some higher and more complex organisation" (Feibleman 1954, 61), also known as part-whole relation. A corollary of the principle of increasing complexity is expressed in Feibleman's third law stating that each higher level depends upon the lower level(s) but not vice versa, a relation that could be labeled in Comtean terms as the principle of successive dependence (cp. Gnoli, Bosch, and Mazzocchi 2007). Furthermore, Feibleman's eighth law stating that the population of instances decreases with each higher level (e.g., there exist fewer molecules than atoms, and fewer cells than molecules) could be termed the principle of decreasing span in correspondence with the principle of increasing depth, adopting Arthur Koestler's (1967, 342) terminology of "depth" (here a synonym for height or altitude) as the number of levels that an entity comprises and "span" as the number of entities at a given level. Since levels of integration are supposed to constitute evolutionary or developmental stages (Needham 1937; Feibleman 1954; Aronson 1987; Salthe 1991), it follows that they are also in line with Ranganathan's principle of later-in-evolution which in turn implies the principle of later-in-time, also expressed by Austin's (1969b, 114) "principle of consecutiveness."

Note that the two main principles of increasing complexity and later-in-evolution seem not to be reducible to each other. On one hand, not every order of complexity presents an evolutionary or diachronic sequence of entities but sometimes a rather synchronic one (e.g., tissue—organ—organism) that comes into being concurrently. For that reason, Austin (1969c, 88) rephrases Feibleman's fifth law: "For an organisation at any given sublevel [for Austin a "sublevel" means a part of a whole but not itself a whole, M.K.], its mechanism lies at the level below the whole of which it is a part, and its purpose is defined by a need of the whole of which it is a part." On the other hand, not every evolutionary or developmental change means a change toward increasing complexity (e.g., a new species of bacteria). This is why Wilber (2000, 66) emphasizes the distinction between "translation" and "transformation" echoed by Overton's (2006, 25) distinction between "variational change" and "transformational change," according to which only the latter leads to an emergence of novelty and increasing complexity.

There might be other principles of organization that are compatible with the idea of integrative levels but one should carefully analyze to what extent these are constitutive. For example, Jolley (1973, 72) speaks of a "dimensional fallacy" for the tendency to consider aggregates like gross material bodies with an increase in the spatial dimension as increasingly higher levels of integration. Not to mention that the spatial dimension applies exclusively to material structures but not at all to mental structures (Richmond 1965; Kyle 1969). Another popular candidate is a sequence of increasing value (cf. Gnoli 2015), as exemplified by the historical idea of the great chain of being in terms of an approximation to God stating that an increasing height of levels reflects an increasing god-

likeness and value (Scrivner 1980). Such value rankings, however, appear to be rather accidental since integrative levels can be equally described in non-evaluative terms. For example, one can acknowledge that human beings are more complex and belong to a higher level than other life-forms without claiming that they are normatively superior or have more intrinsic value (Conger 1925; Aronson 1987).

In short, the organizing principle of integrative levels in a proper sense can be expressed in terms of evolutionary order based on the combined principles of gradation by specialty (genus-species relation), successive parthood (part-whole relation), and later-in-evolution (developmental relation) presenting "a conceptual progress from the general to the specific, the simple to the complex, and the past to the present" (Dousa 2009, 76).

In order to illustrate these inherent relations, various diagrammatic models and metaphors are in use evoking notions like "lower" and "higher", or "deeper" and "shallower" such as a nest or a spiral, a pyramid or a staircase, a chain or a ladder, each emphasizing certain aspects at the expense of some others (see Figure 1).

For example, similar to Russian dolls or Chinese boxes, a nesting of concentric circles depicts levels of integration in a way that each level as a whole is included as a part in the next more complex level, just as atoms are included in molecules which in turn are included in cells. This two-faced aspect of a given level has been aptly called "holon"—from Greek *holos* "whole" and the suffix *–on* suggesting a part or particle like in proton or neutron—meaning a simultaneous whole and part relative to the view along the level hierarchy or "holarchy" (Koestler 1967, 48, 103).

In contrast, the same sequence of integrative levels can be illustrated by a pyramid where each higher level rests and depends on the more fundamental lower level(s), while the population of instances or the span decreases at each higher level, just as there are fewer molecules than atoms and fewer cells than molecules (cf. Feibleman 1954; Blitz 1992).

Another way to represent the same sequence of integrative levels is a simple chain that can be depicted horizontally or vertically with an increasing or decreasing sequence. In Figure 1, the chain is reproduced vertically as inverse sequence of the pyramid beginning with the most fundamental and most general level at the top in order to illustrate that it constitutes the root class of a "specification hierarchy" (Salthe 2009, 87) in which each sub-class presents a specification of the preceding more general class, just as the physical level (e.g., atomic matter) is specified by the chemical level (e.g., molecular matter) which in turn is specified by the biological level (e.g., cellular matter) without claiming that one of them can be reduced to any other.

While it seems to be true that the idea of integrative levels is compatible with a broad range of well-known principles of organization, it appears to be equally true that different aspects are often combined without sufficient qualification which might lead to serious inconsistencies in modeling hierarchical sequences of integrative levels.

3.2 Hierarchies and order relations

The idea of integrative levels is the idea of a hierarchy. In the field of knowledge organization, hierarchies are considered to be one of the most informationally rich and most effective semantic relations for the development of knowledge organization systems like classifications, thesauri, or formal ontologies (Svenonius 2000; Stock and

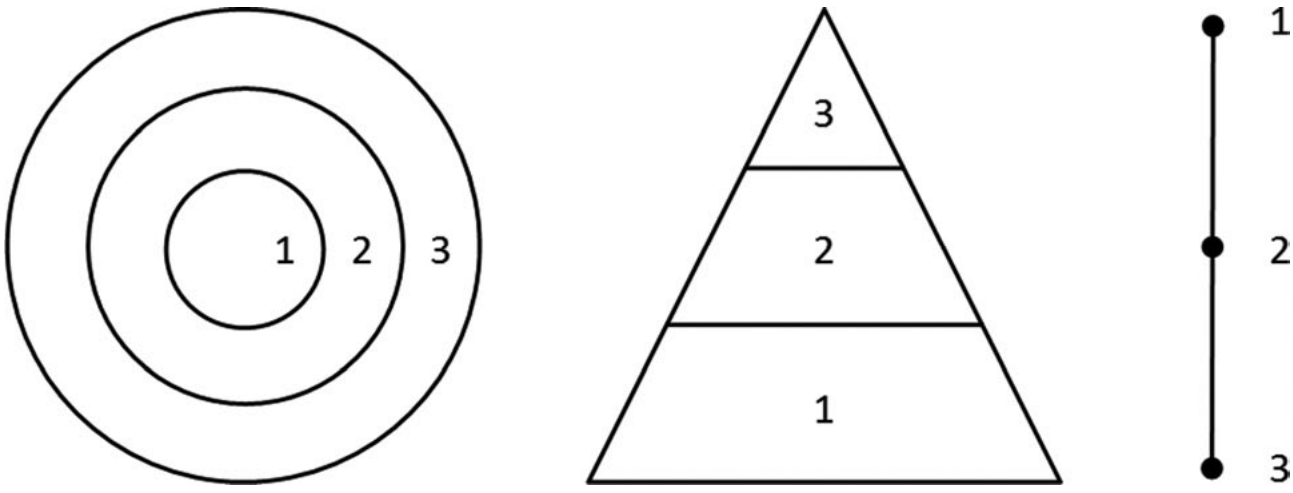

Figure 1. Metaphors for integrative levels as nest, pyramid, and chain.

Stock 2013; Frické 2016; Gnoli 2017). Most importantly, hierarchical relations, in opposition to equivalence relations or association relations, are able to represent an order in the mathematical sense (Stock and Stock 2013).

Order theory is the branch of mathematics that is concerned with the formalization of the intuitive notion of ranking using binary relations for a comparison of pairs of objects. Order relations rest on the properties of transitivity and antisymmetry, while they can be strict or non-strict (Davey and Priestley 2008). A non-strict order (or non-strict partial order) on a set is a binary relation $\leq$ on this set such that, for all its elements x, y, z:

(a) $x \leq x$ (reflexivity),
(b) $x \leq y$ and $y \leq x$ imply $x = y$ (antisymmetry),
(c) $x \leq y$ and $y \leq z$ imply $x \leq z$ (transitivity).

Every relation $\leq$ induces a relation $<$ of strict inequality in the way that $x < y$ if and only if $x \leq y$ and $x \neq y$. Therefore, it is possible to restate the conditions (a) – (c) in terms of a strict order (or strict partial order) on a set which is a binary relation $<$ on this set such that, for all its elements x, y, z:

(i) $x < x$ does not hold (irreflexivity),
(ii) if $x < y$ then $y < x$ does not hold (asymmetry),
(iii) $x < y$ and $y < z$ imply $x < z$ (transitivity).

Note that irreflexivity and transitivity combined already imply asymmetry which in turn is defined by antisymmetry and irreflexivity.

While mathematicians usually allow equality as it is implicit in the non-strict order relation less-than-or-equal-to or its opposite greater-than-or-equal-to, outside mathematics the strict order relation less-than or its opposite greater-than is much more common and can be regarded as equally fundamental (Davey and Priestley 2008). In knowledge organization literature, hierarchical relations are described in terms of both non-strict orders (Jolley 1973; Svenonius 2000) and strict orders (Jolley 1973; Stock and Stock 2013; Gnoli 2017), depending on the interpretation of the condition of reflexivity or irreflexivity.

However, this distinction becomes crucial for the concept of levels of integration that is based on two main assumptions. First, there are qualitatively distinct levels that can be ranked in a linear developmental sequence from the less complex to the more complex. Second, there are hierarchical integrations in the way that each more complex level includes the essential structures and properties of its predecessors. In connection with conceptual ordering systems like knowledge organization systems, the question arises whether or not hierarchical relations are non-strict orders that hold reflexivity, meaning that a given set (e.g., a class, a concept, a term, a level) would include itself as its own subset (e.g., a subclass, a subordinate concept, a narrower term, a lower level). According to the idea of integrative levels this seems not to be the case since a given level integrates a lower level while adding something new (Feibleman's first law). This process is often described in terms of differentiation and integration, or transcendence and inclusion (Spencer [1862] 1915; Salthe 1991; Wilber [1995] 2000; Lourenço 2016). Hence a level and its next lower level cannot be identical and their relation of inclusion is an irreflexive one. This leads to the conclusion that the hierarchical relation of integrative levels is a strict linear order exhibiting the properties of irreflexivity, asymmetry, and transitivity.

3.3 The problem of transitivity

While it appears to be quite obvious that the modeling of integrative levels requires an asymmetric relation, because if one level is integrated by another, then the opposite cannot be true (e.g., atoms are integrated by molecules, but molecules are not integrated by atoms), it seems to be much more difficult to meet the condition of a transitive relation. It goes without saying that the principles of organization identified above as being constitutive for integrative levels (i.e., increasing complexity, gradation by specialty, successive parthood, successive dependence, decreasing span, increasing depth, later-in-evolution, later-in-time) are supposed to be transitive relations. But as often noted, transitivity requires a homogeneous way of subdivision along the hierarchy, a requirement that seems to be frequently violated at the price of inconsistent relations of inclusion (Beghtol 2000; Svenonius 2000; Guizzardi 2009; Stock and Stock 2013; Almeida and Baracho 2014). Therefore, it is of utmost importance for the idea of integrative levels to qualify different types of subdivisions.

In this regard, a first basic distinction is usually made between genus-species relations based on logical division and part-whole relations based on structural or partitive division (Frické 2016), also known by the following terminological distinctions: is-a-kind-of relation vs. is-a-part-of relation (Stock and Stock 2013, 554, 555), generic relation vs. partitive relation (Broughton et al. 2005, 144), class inclusion vs. merological inclusion (Winston, Chaffin, and Herrmann 1987, 435), hyponym-hyperonym relation vs. meronym-holonym relation (Stock and Stock2013, 552, 555), specification hierarchy vs. scale hierarchy (Salthe 1991, 260), subsumptive hierarchy vs. compositional hierarchy (Salthe 2009, 88), or taxonomy vs. partonomy (Beghtol 2000, 315). On one hand, a genus-species relation can be defined by a concept and its subordinated concept that inherits all properties attribut-

ed to its superordinated concept. On the other hand, a part-whole relation can be defined by an item and its superordinated item that integrates the structure or organization of its subordinated item as an integral part (Stock and Stock 2013; Frické 2016). As stressed by Beghtol (2000), both types of subdivision are often combined within the same KOS and the failure to distinguish them encourages ambiguity since the same set of foci (e.g., heart, liver, lungs) can be interpreted in terms of both a genus-species facet (e.g., kind of organs) or a part-whole facet (e.g., parts of bodies).

Since for the idea of integrative levels both genus-species relations and part-whole relations are constitutive, it follows that both types of hierarchical subdivision need to be applied simultaneously and each one of them must exhibit transitivity. For example, the sequence atom—molecule—cell can be interpreted at the same time as both a genus-species hierarchy (e.g., kinds of matter) and a part-whole hierarchy (e.g., parts of organisms).

Moreover, there exist different types of subdivisions within each of these two main hierarchical relations. On one hand, the genus-species relation can be qualified in the following way (based on Chaffin and Hermann cited in Beghtol 2000, 314):

> Perceptual subordination (e.g., animal—horse)
> Functional subordination (e.g., furniture—chair)
> State subordination (e.g., disease—polio)
> Activity subordination (e.g., game—chess)
> Geographic subordination (e.g., state—New Jersey).

As noted by Stock and Stock (2013), it is important for an is-a-kind-of relation that the subordinated concept (hyponym) and the superordinated concept (hyperonym) are regarded from the same perspective and that not every is-a relation (simple hyponomy) is necessarily an is-a-kind-of relation (taxonomy) which *per definitionem* entails a transitive sequence. For example, it appears to be inappropriate to say that a stallion is-a-kind-of instead of is-a horse because a stallion is regarded from the perspective of gender and a horse is not (Cruse 2002).

From a logical point of view, it must also be emphasized that even if nearly all definitions in natural-language dictionaries refer to a genus-species relation (Svenonius 2000), the order-theoretical property of transitivity does not necessarily apply in ordinary language contexts that rely on less formal principles, like Ludwig Wittgenstein's family resemblance stating that not all but only a few properties attributed to a class need to be inherited by its subclass, or Eleanor Rosch's prototype theory stating that categorization is graded and some subclasses are more central than others (Stock and Stock 2013; Frické 2016; Hjørland 2017).

On the other hand, the part-whole relation can be qualified as follows (based on Winston, Chaffin, and Herrmann 1987, 420; see also Stock and Stock 2013; Almeida and Baracho 2014):

> Component—integral object (e.g., pedal—bike)
> Member—collection (e.g., ship—fleet)
> Portion—mass (e.g., slice—pie)
> Stuff—object (e.g., steel—car)
> Feature—activity (e.g., paying—shopping)
> Place—area (e.g., Everglades—Florida).

Again, the problem of transitivity occurs if different types of subdivision are combined within the same hierarchical sequence or stated in the premises of a syllogism (Cruse 1979; Winston, Chaffin, and Herrmann 1987; Guizzardi 2009; Almeida and Baracho 2014). This seems to be of particular importance for KOSs like formal ontologies that enable automated reasoning in order to enhance information retrieval. The following example presents an intransitive part-whole relation and, therefore, an invalid conclusion (based on Winston, Chaffin, and Herrmann 1987, 431-32):

> Premises:
> Simpson's arm is part (component) of Simpson.
> Simpson is part (member) of the Philosophy department.
> Conclusion:
> Simpson's arm is part (?) of the Philosophy department.

In other words, for modeling integrative levels the condition of transitivity is by far the most important challenge and, at the same time, the most important evaluation criterion for the consistency of proposed hierarchical sequences.

3.4 Evaluation of level sequences

In this section, some exemplary sequences based on the idea of integrative levels will be reconsidered in light of the transitivity condition in order to identify typical cases of inconsistency (see also Appendix):

> (I) Atoms—molecules—cells—organisms—human beings—human societies (Coates 1969, 21).

As noted by Austin (1969c, 88), some authors add an "aggregative or societal level" beyond man, ignoring the fact that this violates the principle of later-in-evolution since collective human societies emerge concurrently with individual human beings. Furthermore, different part-

whole relations seem to be confused since atoms, molecules, and cells are components of organisms, whereas human beings are members of human societies, just as all individual life-forms are members of their collective population or species. In general, Austin (1969c) concludes that such collective phenomena spring from that individual entity along the integrative levels sequence that forms the parts of the aggregate. Therefore, such alleged branchings are derived from the confusion of integration and aggregation leading to what one might call the individual/collective inconsistency.

(II) Atom—molecule—molecular assemblage—physical structure—planet—collection of planets—universe (Tomlinson 1969b, 30).

This level sequence presents a further version of the individual/collective inconsistency at the inorganic level. In contrast to the integrative relation between atom and molecule, the aggregative relations between molecule and molecular assemblage or between planet and a collection of planets do not present an increase in complexity but rather what Jolley (1973, 72) calls the spatial version of the "dimensional fallacy" (cf. Jantsch [1979] 1980; Wilber [1995] 2000).

Note that the entity "universe" at the end of the sequence in example (II) also violates the principle of later-in-evolution and should be replaced to the beginning since the existence of the universe starts from the Big Bang and does not depend on the emergence of the other mentioned entities. The same misconception, which one might call the consecutiveness inconsistency, holds if ecosystems or the biosphere are considered to be the highest and most complex level of living entities, as suggested by Rowe (1961) or Lobo (2008). Instead, it should be recognized that the biosphere comes into being concurrently with the first forms of life.

For the same reason, the anthroposphere or noosphere referring to human-related phenomena should not be considered to be integrated by a spatially greater biosphere but quite the opposite: the noosphere is a specification of the biosphere, while the biosphere is an integral part of the noosphere (Wilber [1995] 2000; Esbjörn-Hargens and Zimmerman 2009).

(III) Physical entities—chemical entities—heterogenous non-living entities—artefacts—biological entities—man—mentefacts (CRG quoted in Austin 1969b, 112-13).

Another version of the consecutiveness inconsistency occurs if non-living human artifacts are placed before living entities since they depend on the emergence of human beings, as stressed by Austin (1969b) or Dahlberg (1974) relying on Feibleman's (1954, 64) rule that the "reference of any organisation must be to the highest level which its explanation requires."

(IV) Physical—chemical—biological—psychological—cultural (Feibleman 1954, 63).

This level sequence seems to be challenged by Hartmann's (1940) psychophysical border line between the biological and the psychological that violates both the principle of gradation by specialty and the principle of successive parthood since biological properties or structures (e.g., spatial exteriority, cellular structure) are not integrated by the psychological level (e.g., non-spatial interiority, cognitive structure).

One way to avoid such a categorical mistake, which one might call the exterior/interior inconsistency, is to adopt a pure materialist approach, as preferred by Austin (1969c, 88) who restricts the number of levels to not more than four "truly integrative" ones: fundamental particles—elements—compounds—living compounds. In fact, there is a long tradition of materialism which appears to be strongly reductionist in that it does not take psychical or cultural phenomena into account (Novikoff 1945; Rowe 1961; Jolley 1973; Pettersson 1996; Bunge 2003; Vickery 2005).

Any non-reductionist approach, however, needs to consider some categorically orthogonal domains that cannot be arranged linearly as a transitive sequence due to the lack of hierarchical inclusions, as indicated by Poli's (2001) three domains of the material, the mental, and the social; or Wilber's ([1995] 2000) four domains of the objective, the subjective, the intersubjective, and the interobjective (Kleineberg 2016). In principle, there seem to be two different strategies to deal with that challenge: either the linearity of the level sequence will be defended at the price of hierarchical inclusions or the hierarchical inclusions of the level sequence will be defended at the price of linearity.

The first strategy is adopted, to some extent, by Hartmann's (1940) conception of levels of reality. In this tradition, the idea of levels of integration is replaced by the more general notion of "level of organization" (Gnoli 2017, 40) stating that each higher level depends historically and logically on the next lower level but without a mandatory integration of its essential structures and properties. In other words, while the principle of later-in-evolution still holds, the principles of successive parthood and gradation by specialty do not.

Integrative levels	Correlates				Examples
	Exterior-individual (objective)	Interior-individual (subjective)	Exterior-collective (interobjective)	Interior-collective (intersubjective)	
1.	Matter	?	?	?	Atom
2.	Complex matter	?	?	?	Molecule
3.	Life	?	?	?	Cell
4.	Complex life	Proto-mind	Proto-society	Proto-culture	Organism
5.	Most complex life	Mind	Society	Culture	Human being

Table 1. Emergent integrative levels and co-evolutionary correlates.

Order relation	Integrative levels (superformation)	Non-integrative levels (superposition)	Correlates (co-evolution)
Increasing complexity	Yes	?	?
Gradation by specialty	Yes	No	No
Successive parthood	Yes	No	No
Successive dependence	Yes	Yes	Interdependence
Decreasing span	Yes	Yes	No
Increasing depth	Yes	Yes	No
Later-in-time	Yes	Yes	No
Later-in-evolution	Yes	Yes	No

Table 2. Principles of organization.

The second strategy is mostly elaborated by Wilber's ([1995] 2000) conception of co-evolutionary holons. In this school of thought, the idea of integrative levels is maintained but the linear sequence is modified in the way that categorically orthogonal domains are related as interdependent and co-evolutionary correlates (see Table 1).

In order to compare and evaluate proposed sequences of integrative levels, Table 1 presents a framework that avoids both the individual/collective and the exterior/interior inconsistencies by distinguishing emergent integrative levels and co-evolutionary correlates with regard to a widely agreed-upon example sequence. Transitivity of integrative levels applies within each column, even though the origins of the evolutionary proto-forms for the anthropocentric phenomena of mind, society, and culture might be located differently and must, for the time being, remain open questions (Kleineberg 2016).

From that perspective, a last level sequence that is quite typical for the field of knowledge organization, taken from the research project Integrative Levels Classification, will be reconsidered:

(V) Forms—matter—life—mind—society—culture (Gnoli 2017, 46).

Although inspired by the idea of integrative levels, this hierarchical sequence relies much more on Hartmann's notion of superposition without mandatory hierarchical inclusions. Leaving aside the domain of forms whose ontological status seems to be controversial, as the author admits, this linear sequence can easily be mapped onto the emergent-correlate framework. In this way, it might become more evident to what extent relations between entities or concepts constitute integrative levels or superformation within a column (e.g., matter—life), non-integrative levels or superposition across columns (e.g., life—mind), or co-evolutionary correlates within a row (e.g., mind—society—culture) (see also Table 2).

4.0 Common criticisms

4.1 Hierarchy and formal logic

The idea of integrative levels as an organizing principle is criticized on many grounds and is still a matter of controversial debates. Most importantly, the limitations and shortcomings of the notion of hierarchy for conceptual ordering systems are emphasized, no matter whether hierarchical relations are taking generic, partitive, or developmental forms (Olson 1999; García Gutiérrez 2011; Mai 2011; De Beer 2015). According to Olson (1999), the predominant classificatory thought and practice is based on classical formal logic rooting in the Aristotelean tradition with the underlying and interrelated presumptions of disjoint class formation (exclusivity), a linear progression towards a goal (teleology), and a rigid subordination through logical division and the dominance of some classes over others (hierarchy). It is argued that this kind of classification presents a culture-specific construction and tends to oppress and marginalize alternative kinds of organizing knowledge (Olson 1999; Jacob 2000; García Gutiérrez 2011).

Therefore, the idea of a hierarchical order of reality is questioned with regard to its theoretical and metatheoreti-

cal assumptions, while often a change in metaphors is proposed from tree-like hierarchies to rhizome-like webs, that is, a shift in emphasis from hierarchical relations to associative relations (Robinson and Maguire 2010; López-Huertas 2013; De Beer 2015). In this regard, the traditional classification based on formal logic is often contrasted with conceptual ordering systems that are more in line with Wittgenstein's notion of family resemblance or Rosch's prototype theory, which allow overlapping classes without essential properties and, therefore, the formation of intransitive hierarchical relations (Jacob 2004; Hjørland 2017). Some authors consider these approaches as "two complementary forms of representation" (Priss 2001, 53) and argue to overcome the reductionism of formal logic by means of a "wider and inclusive cognitive matrix" (García Gutiérrez 2011, 9) that does not deny the formal-logical way of thinking but seeks to integrate it into a logical pluralism.

From a developmental perspective, however, it should be noted that such a logical pluralism can itself be organized according to the principle of integrative levels in terms of "levels of knowing" (Wilber 1999, 451), "levels of consciousness" (Overton 2006, 53), "stages of thought" (Commons 2008, 305), or "levels of perception" (Nicolescu 2010, 25), while offering a clearer distinction between dominator hierarchies and growth hierarchies. For example, the Model of Hierarchical Complexity proposed by cognitive psychologist Michael Commons (1998, 2008) presents an invariant sequence of task performances understood as the activity of organizing information in which actions at a higher level coordinate and transform the lower-level actions. According to that framework, the use of classical formal logic is represented by four distinct levels from simple deductions to a full-fledged system of formal operations including Boolean operators, while seven preceding preformal levels and four succeeding postformal levels are distinguished. The latter metasystematic or metalogical kind of reasoning that integrates its precursors is also reflected, for example, by Wilber's ([1995] 2000, 266) "vision-logic," Overton's (2006, 32) "relational metatheory," and Nicolescu's (2010) "logic of the included middle."

4.2 Picture theory of meaning and universality claim

Another criticism is concerned with the underlying epistemology of the classical theory of integrative levels. As Svenonius (2004) points out, Feibleman's approach seems to be based on a correspondence theory of truth in the way that his description of the level sequence is supposed to mirror the actual structure of external reality. This kind of a picture theory of meaning is criticized by context-sensitive instrumental or use theories of meaning for being objectivist, positivistic, and reductionist, while claiming universal validity regardless of alternative constructions of reality (Jacob 2000; Svenonius 2004; Mai 2011; Hjørland 2017).

However, several approaches demonstrate that an acknowledgement of the context-dependent nature of human knowledge does not necessarily mean to give up the possibility of universal validity claims (for example, the claim that all human knowledge is context-dependent), and even less that a rejection of the picture theory of meaning implies a rejection of the idea of integrative levels (Bertalanffy 1968; Habermas 1979; Wilber [1995] 2000; Fenzl et al. 1996; Brier 2003; Overton 2006; Kleineberg 2013).

4.3 Teleology and value ranking

According to Olson's (1999) critique, teleology within classification is illustrated by a linear progression of main classes from basic to more developed phenomena that is oriented toward a goal and implies a value ranking, as exemplified by Aristotle's hierarchical order of animals with human beings at the top level. Indeed, historical ideas like the great chain of being clearly present hierarchies of value and many progress theories since the eighteenth century tend to make unjustified teleological assumptions, as prominently presented in the work of Teilhard de Chardin (1959). But while recent theories of evolution commonly reject the idea of a "scala naturae," some authors argue for a modified version that avoids both teleology and value ranking (Greenberg 1995; Donald 2001).

As stressed by theories of self-organization, transformational change in evolution or development presents directionality without a telos, that is, increasing complexity without a final goal (Jantsch [1979] 1980; Aronson 1987; Wilber [1995] 2000; Brier 2003). Therefore, an adequate explanation requires a reconstruction after the fact and a clearer distinction between the dynamics and the logic of development (Habermas 1990).

With regard to integrative levels of knowing, there is a strong emphasis on the dialectics of progress that includes both a growth of learning abilities but also new problem situations and possible pathologies (Habermas 1979; Wilber 1999). Furthermore, it is underlined that normative approaches claiming a hierarchy of justification are able to avoid the naturalistic fallacy by taking recourse to philosophical arguments (Kohlberg and Hersh 1977; Habermas 1990; King and Kitchener 1994).

5.0 Fields of application

5.1 Interdisciplinary knowledge organization

Since at least Comte's and Spencer's classifications of the sciences, the main motivation for the elaboration on the

idea of integrative levels is to interrelate different domains of human knowledge according to a hierarchical order in terms of either discipline-centered fields of research or phenomena-centered objects under investigation, or even a combination of both within the same KOS such as the *Bliss Bibliographic Classification, Second Edition* (Gnoli 2005). According to Needham (1937), such a big picture is important as soon as researchers take the broader context of their special fields into account, while Feibleman (1954, 59) even speaks of a kind of "superscience" that is particularly concerned with the interrelations among disciplines like physics, chemistry, biology, psychology, and anthropology. Some theorists consider the idea of integrative levels promising for a defense of the unity of science (Oppenheimer and Putnam 1958; Reiser 1958; Bertalanffy 1968), while others argue for a transdisciplinary approach beyond disciplinary borders since "levels of organization offer the possibility of a new taxonomy of the more than 8000 academic disciplines existing today" (Nicolescu 2010, 27).

In the field of knowledge organization, this synthesizing aspect of the idea of integrative levels is recognized by the CRG and exploited for the development of a basic scheme of a new general classification that is based directly on phenomena maintaining a universal scope of coverage (Classification Research Group 1969; Foskett 1978). As noted by Austin (1969a), due to academic overspecialization discipline-centered knowledge organization systems are challenged by the problems of keeping the scheme up to date (currency), inserting new subjects (hospitality), or avoiding multiple entries (cross-classification). In order to meet James E. Farradane's condition of a "place of unique definition" (Austin 1969b, 111), the CRG's new general classification adopts the organizing principle of integrative levels as a non-arbitrary linear order of phenomena or main classes which in turn can be combined by using the analytico-synthetic technique of faceted classification with fundamental categories or facets that indicate different kinds of relationships or particular semantic contexts (Gnoli 2008). Although the CRG's proposal never reached the status of practical application, similar approaches elaborated further such an interdisciplinary approach to knowledge organization. For example, Dahlberg's (2008) Information Coding Classification, developed in the 1970s, seeks to combine nine integrative levels of objects of being with nine facets in order to define a comprehensive matrix of discrete fields of knowledge or subject groups.

During the last decade, theorizing about phenomena-centered faceted classifications based on the organizing principle of integrative levels has been intensified and practically applied in KOSs like Basic Concepts Classification or Integrative Levels Classification (ISKO Italy 2007; Gnoli 2008; 2017; Szostak 2012; Kleineberg 2013). In particular, the monograph *Interdisciplinary Knowledge Organization* (Szostak, Gnoli, and López-Huertas 2016) summarizes its potential benefits and expands the scope from classification to further types of KOSs like thesauri or formal ontologies.

5.3 Semantic information retrieval

Knowledge organization systems serve information retrieval of relevant documents and in cases where documentary languages are machine-readable vocabularies, such as XML (Extensible Markup Language) based on RDF (Resource Description Framework) and formal ontologies (e.g., Suggested Upper Merged Ontology, General Formal Ontology), one is concerned with semantic information retrieval (Rajasurya et al. 2012). An advantage of such semantic web technologies is to enable automated reasoning based on a structured database of facts or RDF statements combined with documentary languages exhibiting transitive semantic relations (Guizzardi 2009; Herre 2013; Almeida and Baracho 2014; Santis and Gnoli 2016). As argued by D. Grant Campbell (2002), the framework of integrative levels could play a significant role in the integration of RDF statements into formal ontologies. Furthermore, information retrieval often uses automated query expansion by moving upwards in transitive concept ladders (Gnoli, Santis, and Pusterla 2015), for example, from the smallest geographical unit to larger ones in order to detect the nearest location of interest (Stock and Stock 2013). In this regard, sequences of integrative levels due to their inherent multiple transitive order relations appear to be promising informationally rich tools.

5.3 Comparative method

The idea of integrative levels offers a framework that allows comparison of different degrees of complexity within a given developmental sequence. In the broader inter- or transdisciplinary field of information research, the comparative method has been applied to disambiguate some basic concepts like "information," "knowledge," "cognition," or "communication" in order to interrelate different theoretical and methodological approaches (Fenzl et al. 1996; Hjørland 2002; Brier 2003; Wilson 2003; Bates 2005; Yao 2009; Gnoli and Ridi 2014). For example, Fenzl et al. (1996) propose a multi-level model of information based on a combined layer-theoretical (dialectic of whole and part) and phase-theoretical (dialectic of old and new) concept expressed as a hierarchical sequence from physico-chemical systems (dissipation) to biotic systems (autopoiesis) to socio-cultural systems (recreation). Aiming toward a unified information theory, their hierarchy of cognition and communication is able to

identify and delimitate the particular ontological level a given approach (e.g., Claude Shannon's theory of communication) is actually concerned with. One of the most comprehensive comparative frameworks, the model of hierarchical complexity developed by Commons (2008) within the intersection of information science and developmental psychology, presents integrative levels of behavioral tasks accounting for both performances of machines and human action.

As noted by Wilson (2003), the idea of integrative levels is today widely employed in fields like biology, biochemistry, comparative psychology, and environmental science, and these already existing hierarchical sequences might provide useful semantic relations for the development of domain-specific KOSs (see Appendix). In this regard, a major contribution is made by "incorporating the levels of consciousness into the framework of the integrative levels theory" (Pisula 2016, 51) since it offers comparative tools with regard to the evolution and development of human consciousness and the cognitive aspects of cultural artifacts and documents (Werner and Kaplan 1956; Haaften, Korthals, and Wren 1997; Greenberg et al. 1999; Quilley 2010; Oesterdiekhoff 2013). This seems to be of particular importance since in knowledge organization discourse, the concept of "mentefacts" (Kyle 1969, 14), that is, intellectual concepts and systems, appears to be theoretically underdeveloped and, therefore, fails in applying the organizing principle of integrative levels for the social sciences and humanities (Huckaby 1972; Langridge 1976; Spiteri 1995; Poli 2001; Dousa 2009).

5.4 Viewpoint analysis and indexing

As argued by Kleineberg (2013; 2014), the application of the idea of integrative levels to the epistemological dimension of human knowledge offers an organizing principle for the plurality of different perspectives or viewpoints in terms of integrative levels of knowing. According to developmental psychologist Orlando M. Lorenço (2016, 123 emphases orignal), this concept can be characterized by the following main criteria: "(a) *Hierarchy*: stages appear in an invariant, hierarchical order; (b) *integration*: a given stage integrates, albeit overcomes or transcends its predecessor." In the field of knowledge organization, this principle has been utilized for classifying the epistemic outlook of both creators and users of documents. On one hand, Jason Farradane's (1963) relational indexing is an early attempt to incorporate cognitive-developmental aspects, as analyzed by Jean Piaget and others, in order to indicate the degree of conceptual clarity that is represented in documents (see also Foskett 1980). On the other hand, Jihee Beak's (2014) child-driven metadata scheme uses such developmental level models of cognition for the analysis of particular user groups and the development of user-centered indexing languages.

In many other human-related research areas, the idea of integrative levels of knowing serves also as an organizing principle for a classification of the epistemological dimension in order to describe the "conceptual profiles" (Mortimer et al. 2014) that are embedded in artifacts or documents of the cultural and scientific heritage (Thompson 1996; Haaften, Korthals, and Wren 1997; Barnes 2000; Bammé 2011). This includes various domain-specific lines of cognitive development such as spatial representation in pictorial art (Gablik 1979), Paleolithic stone tool technology (Wynn 1985), narrative structures in English literature (LePan 1989), ethics in classical Chinese literature (Roetz 1993), symbolization in ancient Egyptian artifacts (Brunner-Traut 1992), arithmetic in ancient Sumerian-Babylonian texts (Damerow 1996), and religious systems in mythological and theological writings (Bellah 2011).

6.0 Conclusion

Although not uncontested, the idea of integrative levels presents one of the most informationally rich organizing principles for conceptual ordering systems that combines several order relations, most importantly, gradation by specialty (genus-species hierarchy), successive parthood (part-whole hierarchy) and later-in-evolution (developmental hierarchy), even though these order relations are rarely made explicit but rather remain implicit assumptions.

In the field of knowledge organization, the idea of integrative levels has been applied either discipline-centered or phenomena-centered in both domain-specific and interdisciplinary knowledge organization systems including formal ontologies for semantic information retrieval. In this regard, the most important challenge is the condition of transitivity for its hierarchical relations that seems to be frequently violated not least due to a lack of conceptual consensus. Indeed, it would appear misleading to speak of "the" theory of integrative levels since there are various and often unrelated approaches grounded in different paradigms or disciplinary contexts. Knowledge organization research, however, might benefit from classification schemes based on the idea of integrative levels that already exist in other fields, in particular, from largely neglected developmental sequences reconstructed by psychology, social sciences and humanities.

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Appendix:
Sample of Sequences Based on the Idea of Integrative Levels

(Excerpts are in chronological order of original publication. Numbering is added, M.K.)

Comte, Auguste ([1830-42] 1974, 55):
Phenomena
1. Physical
2. Chemical
3. Physiological
4. Social

Comte, Auguste ([1830-42] 1974, 20):
Human mind
1. Theological or fictitious
2. Metaphysical or abstract
3. Scientific or positive

Spencer, Herbert (1883, 3):
Phenomena
1. Inorganic
2. Organic
3. Super-organic

Hobhouse, Leonard T. (1901, 359–68):
Human mind
1. Pre-intelligence
2. Unconscious readjustment
3. Concrete experience and the practical judgment
4. Conceptual thinking and will
5. Rational system

Richardson, Ernest C. (1901, 30):
Things
1. Lifeless
2. Living
3. Human
4. Superhuman

Baldwin, James M. (1906, 33):
Cognition
1. Pre-logical
2. Quasi-logical
3. Logical
4. Hyper-logical
5. Extra-logical

Alexander, Samuel ([1920] 1950, Vol. II: 52, 345):
Entities
1. Space-time
2. Matter
3. Life
4. Mind
5. Deity

Lloyd Morgan, Conwy (1923, 27):
Events
1. Matter (with psychical correlates)
2. Life (with psychical correlates)
3. Mind (with physical correlates)

Conger, George P. (1925, 312–113):
Material realm
1. Energies
2. Electrons
3. Atoms
4. Molecules
5. Astronomical masses, or bodies
6. Solar systems
7. Star clusters
8. Galaxies
9. Universes

Conger, George P. (1925, 313):
Biological realm
1. Organic compounds
2. Infra-cellular organisms
3. Unicellular organisms
4. Multicellular organisms
5. Plant-and-animal groups
6. Families or tribes
7. Nations
8. "The Great Society"

Conger, George P. (1925, 313):
Neuropsychological realm
1. Specialized cells
2. Nervous areas
3. Reflex arcs
4. Complex reflexes
5. Instinctive emotional complexes
6. Sentiments
7. Values
8. Personalities

Wheeler, William M. (1928, 74):
Phenomena
1. Physical
2. Chemical
3. Psychological
4. Social

Vygotsky, Lev S. ([1934] 1986, 140):
Concept formation
1. Syncretic
2. Complex (pseudoconcept)
3. Potential concept
4. True concept

Needham, Joseph (1937, 6):
Phenomena
1. Inorganic
2. Biological
3. Social

Bachelard, Gaston ([1940] 1968, 15):
Philosophical explanation
1. Animism
2. Realism
3. Positivism
4. Rationalism
5. Complex rationalism
6. Dialectical rationalism

Hartmann, Nicolai (1940, 498):
Nature
1. Matter
2. Life

Hartmann, Nicolai ([1942] 1953, 46):
Consciousness
1. Spiritless (psyche)
2. Spiritual (personal spirit)

Novikoff, Alex B. (1945, 209):
Matter
1. Physical
2. Chemical
3. Biological
4. Sociological

Novikoff, Alex B. (1945, 211):
Biological matter
1. Cells
2. Tissues
3. Organs
4. Organ-systems
5. Organisms
6. Populations

Gebser, Jean ([1949] 1985, 42):
Consciousness
1. Archaic
2. Magical
3. Mythical
4. Mental
5. Integral

Neumann, Erich ([1949] 1975, 264):
Collective consciousness (mythology)
1. Uroboros
2. Great Mother
3. Dragon fight

Piaget, Jean ([1952] 1977, 456–61):
Cognition
1. Sensorimotor
2. Preoperational
3. Concrete operational
4. Formal operational

Feibleman, James K. (1954, 60–62):
Organizations
1. Electrons, protons, neutrons
2. Atoms
3. Molecules
4. Cells
5. Organisms
6. Human cultures

Feibleman, James K. (1954, 63):
Properties (behavior)
1. Physical (cause-and-effect)
2. Chemical (combination-rearrangement)
3. Biological (sensitivity-reactivity)
4. Psychological (stimulus-response)
5. Cultural (contact-adaptation)

Steward, Julian H. ([1955] 1972, 190):
Societies
1. Hunting and gathering
2. Incipient agriculture
3. Formative
4. Regional florescent
5. Initial empire

Oppenheim, Paul and Putnam, Hilary (1958, 9):
Things
1. Elementary particles
2. Atoms
3. Molecules
4. Cells
5. Multicellular living things
6. Social groups

Sahlin, Marshall D. and Service, Elman R. ([1960] 1988, 37):
Social systems
1. Unsegmented and chiefless bands (preagricultural)
2. Segmented and chiefless tribes (agricultural)
3. Segmented chiefdoms
4. Archaic civilizations
5. Nation states (industrial technology)

Rowe, J. Stan (1961, 422):
Objects
1. Cell
2. Organ
3. Organism
4. Ecosystem (single organism-habitat)
5. Local Ecosystem
6. Regional Ecosystem
7. Ecosphere
8. Universe

Forsche, Joachim (1965, 124; my translation, M.K.):
Material structures
1. Elementary particles
2. Atoms
3. Molecules
4. Polymeres
5. Macromolecules
6. Viruses
7. Cells
8. Organisms
9. Organisms with central nervous system
10. Specific human structure

Richmond, Phyllis (1965, 43):
Mentefacts
1. An observation
2. A group of observations
3. 1st level generalization
4. 2nd level generalization
5. A law

Bertalanffy, Ludwig (1968, 27):
Organized entities
1. Elementary particles
2. Atomic nuclei
3. Atoms
4. Molecules
5. High-molecular compounds
6. Structures between molecules and cells
7. Cells
8. Organisms
9. Supra-individual organizations

Bertalanffy, Ludwig (1968, 87):
Systems
1. Physical
2. Chemical
3. Biological
4. Sociological

Bertalanffy, Ludwig (1968, 214):
Mental systems
1. Instincts, drives, emotions
2. Perception, voluntary action
3. Symbolic activities

Perry, William G. (1968 [folded chart]):
Intelligence and ethics
1. Simple dualism
2. Complex dualism
3. Relativism
4. Commitment in relativism

Austin, Derek (1969c, 88):
Entities
1. Fundamental particles
2. Elements
3. Compounds
4. Living Compounds

Kyle, Barabara (1969, 14):
Entities
1. Inorganic
2. Vegetable
3. Animal
4. Man
5. Groups
6. Formal groups
7. Government local
8. Government central
9. Intergovernmental

Coates, Edwards J. (1969, 21):
Organized wholes
1. Fundamental particles
2. Nuclei
3. Atoms
4. Molecules
5. Molecular assemblages (natural objects and artifacts)
6. Cells
7. Organisms
8. Human beings
9. Human societies

Tomlinson, Helen (1969b, 30):
Physical entities
1. Fundamental particle
2. Atom
3. Molecule
4. Molecule assemblage
5. Physical structure
6. Physiographic feature
7. Planet
8. Collection of Planets
9. Universe

Tomlinson, Helen (1969b, 30):
Chemical entities
1. Element
2. Radical
3. Compound
4. Complex
5. Aggregate

Tomlinson, Helen (1969b, 30):
Artefacts
1. Raw material
2. Worked substance
3. Compound
4. Assemblage of compounds
5. Finished complex article

Tomlinson, Helen (1969b, 30):
Biological entities
1. Crystal complex
2. Organelle
3. Cell
4. Tissue
5. Organ
6. Organ system
7. Whole organism
8. Community

Tomlinson, Helen (1969b, 33):
Man
1. Individual
2. Families
3. Urban communities
4. Groups of towns
5. States
6. Intergovernmental units

Tomlinson, Helen (1969a, 79):
Mentefacts
1. Word
2. Sentence
3. Paragraph
4. Complete work

Jolley, John L. (1973, 30):
Ideas
1. Set-theoretic (e.g., members of sets, full sets)
2. Spatial (e.g., points, lines and linear spaces)
3. Subatomic (e.g., photons, electrons)
4. Molecular (e.g., atoms, molecules)
5. Cytomechanic (e.g., organelles, cells)
6. Biomorphic (e.g., organs, plants and animals, machines)
7. Communal (e.g., departments, organizations)
8. National (e.g., local goverments, nations)

Smith, Huston ([1976] 1992, 62):
Selfhood (traditional great chain of being)
1. Body
2. Mind
3. Soul
4. Spirit

Kohlberg, Lawrence and Hersh, Richard H. (1977, 54–55):
Moral judgment
1. Punishment-and-obedience (preconventional)
2. Instrumental-relativist
3. Interpersonal concordance (conventional)
4. Law and order
5. Social-contract, legalistic (postconventional)
6. Universal-ethical-principle

Apel, Karl-Otto (1978, 9):
Paradigms of First Philosophy
1. General metaphysics (ontology)
2. Transcendental philosophy (consciousness)
3. Transcendental semiotics (language)

Habermas, Jürgen (1979, 83):
Communicative action
1. Incomplete interaction (natural identity, consequences of actions)
2. Complete interaction (role identity, systems of norms)
3. Communicative action and discourse (ego identity, principles)

Habermas, Jürgen (1979, 100–101):
Ego identity
1. Symbiotic
2. Egocentric
3. Sociocentric-objectivistic
4. Universalistic

Habermas, Jürgen (1979, 104–5):
Worldview
1. Magical-animistic
2. Early mythological
3. Late mythological
4. Rationalized
5. Reflexive

Habermas, Jürgen (1979, 157–58):
Social integration
1. Neolithic societies
2. Early civilizations
3. Developed civilizations
4. The modern age

Jantsch, Erich ([1979] 1980, 132):
Self-organizing microsystems
1. Dissipative structures
2. Prokaryotes
3. Eukaryotes
4. Multicellular organisms
5. Complex animals

Jantsch, Erich ([1979] 1980, 132):
Self-organizing macrosystems
1. Planetary chemodynamics
2. Gaia system
3. Heterotrophic ecosystems
4. Societies with division of labor
5. Groups, families

Jantsch, Erich ([1979] 1980, 240):
Self-organizing mind (mentation)
1. Dissipative structures (intracellular processes)
2. Organelles (prokaryotes)
3. Cells (eukaryotes)
4. Organism/organismic mentation
5. Reflexive mentation (gestalt perception)
6. Self-reflexive mentation (sociocultural dimension)
7. Self-image

Schluchter, Wolfgang ([1979] 1981, 102):
Ethics and law
1. Magic ethics and revealed law
2. Law ethics and traditional law
3. Ethics of conviction and deduced law
4. Ethics of responsibility and positive law

Fischer, Kurt (1980, 522):
Skills
1. Single sensory-motor sets
2. Sensory-motor mappings
3. Sensory-motor systems
4. System of sensory-motor systems (single representational sets)
5. Representational mappings
6. Representational systems
7. Systems of representational systems (single abstract sets)
8. Abstract mappings
9. Abstract systems
10. Systems of abstract systems

Selman, Robert L. (1980, 37–40):
Interpersonal understanding
1. Undifferentiated, egocentric
2. Differentiated, subjective
3. Self-reflective, second-person, reciprocal
4. Third-person, mutual
5. In-depth, societal-symbolic

Fowler, James W. (1981, 113):
Faith
1. Undifferentiated
2. Intuitive-projective
3. Mythic-literal
4. Synthetic-conventional
5. Individualistic-reflective
6. Conjunctive
7. Universalizing

Leontiev, Alexei N. ([1981] quoted in Tolman 1987, 199):
Activity
1. Irritability
2. Sensitivity
3. Perceptivity
4. Animal intellect
5. Human consciousness

Turiel, Elliot (1983, 106–11):
Social-conventional concepts
1. Descriptive of uniformity
2. Related to rule and authority system
3. Mediated by societal standards
4. Functional

Stern, Daniel N. ([1985] 1998, 32):
Sense of self
1. Emergent
2. Core
3. Subjective
4. Verbal

Parsons, Michel J. (1987, 22–25):
Aesthetic experience
1. Favoritism

2. Beauty and realism
3. Expressiveness
4. Style and form
5. Autonomy

Damon, William and Hart, Daniel (1988, 56):
Self-understanding
1. Categorical identifications
2. Comparative assessments
3. Inter-personal implications
4. Systematic beliefs and plans

Kramer, Deidre A. (1989, 153):
Social cognition
1. Undifferentiation
2. Pre-formism
3. Formism, mechanism
4. Static relativism
5. Static systems
6. Dynamic relativism
7. Dynamic dialecticism

Atran, Scott (1990, 79):
Human cognition
1. First-order concepts (common-sense)
2. Second-order concepts (science)

Campbell, Donald T. (1990, 11):
Knowledge processes
1. Nonmnemonic problem solving
2. Vicarious locomotor devices (distance receptors)
3. Habit
4. Instinct
5. Visually supported thought
6. Mnemonically supported thought (including computer problem solving)
7. Social vicarious exploration
8. Language
9. Cultural cumulation
10. Science

Blitz, David (1992, 181):
Material or physical-chemical entities
1. Subatomic particles
2. Atoms
3. Molecules
4. Macromolecules

Blitz, David (1992, 181–82):
Biological or cellular-organismic entities
1. Cell-components
2. Prokaryotic cells
3. Eukaryotic cells
4. Multi-celled organisms (e.g., fungi, plants animals)

Blitz, David (1992, 182):
Social or populational entities
1. Social insects (fixed)
2. Higher primates (greater variability)
3. Humans (greatest variability)

Blitz, David (1992, 182):
Mental or perceptual-conceptual entities
1. Sensation
2. Perception
3. Cognition
4. Intelligence
5. Consciousness

Blitz, David (1992, 183):
Entities
1. Matter
2. Life
3. Society
4. Mind

Wilber, Ken (1993, 53):
Being and knowing (traditional Great Chain of Being)
1. Matter
2. Body
3. Mind
4. Soul
5. Spirit

Kegan, Robert (1994, 314–15):
Consciousness
1. Immediate, atomistic
2. Durable category
3. Cross-categorical, trans-categorical (e.g., traditionalism)
4. System, complex (e.g., modernism)
5. Trans-system, trans-complex (e.g., post-modernism)

King, Patricia M. and Kitchener, Karen S. (1994, 14–15):
Reflective judgment
1. Pre-reflective
2. Quasi-reflective
3. Reflective

Wilber, Ken ([1995] 2000, 15):
Phenomena
1. Physiosphere
2. Biosphere
3. Noosphere

Wilber, Ken ([1995] 2000, 198):
Exterior-individual holons (behavioral)
1. Atoms
2. Molecules
3. Prokaryotes
4. Eukaryotes
5. Neural organisms
6. Neural cord organisms
7. Reptilian brain stem organisms
8. Limbic system organisms
9. Neo-cortex organisms
10. Complex neo-cortex organisms

Wilber, Ken ([1995] 2000, 198):
Exterior-collective holons (social)
1. Galaxies
2. Planets
3. Gaia system
4. Heterotrophic ecosystems
5. Societies with division of labor
6. Groups/families
7. Tribes (foraging)
8. Tribal/village (horticultural)
9. Early state/empire (agrarian)
10. Nation/state (industrial)
11. Planetary (informational)

Wilber, Ken ([1995] 2000, 198):
Interior-individual holons (intentional)
1. Prehension
2. Irritability
3. Sensation
4. Perception
5. Impulse
6. Emotion
7. Symbols
8. Concepts
9. Concrete operations
10. Formal operations
11. Vision-logic

Wilber, Ken ([1995] 2000, 198):
Interior-collective holons (cultural)
1. Physical-pleromatic
2. Protoplasmic
3. Vegetative
4. Locomotive
5. Uroboic
6. Typhonic
7. Archaic
8. Magic
9. Mythic
10. Rational
11. Centauric

Fenzl, Norbert et al. (1996, 275):
Systems
1. Physical and chemical (dissipative)
2. Biotic (autopoietic)
3. Socio-cultural (re-creational)

Mithen, Steven (1996, 69):
Mind
1. General intelligence
2. General intelligence supplemented by isolated multiple specialized intelligences
3. General intelligence supplemented by connected multiple specialized intelligences

Parker, Sue T. and Russon, Anne E. (1996, 438):
Culture and cognition
1. Preculture (e.g., social mammals, monkeys)
2. Protoculture (e.g., chimpaneezes)
3. Ur-culture (e.g., Middle Pleistocene hominids)
4. Eu-culture (modern humans)

Pettersson, Max (Pettersson 1996, 91):
Entities
1. Fundamental particles
2. Atoms
3. Molecules
4. One-chromosome cells, and other intermediate entities
5. Cells with nuclei
6. Multicellular organisms
7. One-mother family societies, etc.
8. Multifamily society
9. Society of sovereign states

Deacon, Terrance (1997, 449):
Consciousness
1. Iconic representation
2. Indexical representation
3. Symbolic representation

Emmeche, Claus; Køppe, Simo and Frederick Stjernfelt (1997, 112–13):
Phenomena
1. Physical
2. Biological
3. Psycho-social

Damerow, Peter (1998, 10):
Prehistoric cognition
1. Sensorimotor or practical intelligence
2. Preoperational or symbolic intelligence (Middle to Upper Paleolithic transition)

3. Operational or reflective intelligence (e.g., urban revolution)

Commons, Michael L. et al. (1998, 247):
Tasks
1. Computory
2. Sensory and motor
3. Circular sensory-motor
4. Sensory-motor
5. Nominal
6. Sentential
7. Preoperational
8. Primary
9. Concrete
10. Abstract
11. Formal
12. Systematic
13. Metasystematic
14. Paradigmatic
15. Cross-prardigmatic

Cook-Greuter, Susanne R. ([1999] 2010, 197–203):
Ego
1. Symbiotic
2. Impulsive
3. Self-protective
4. Rule-oriented
5. Conformist
6. Self-aware
7. Conscientious
8. Individualist
9. Autonomous
10. Construct-aware
11. Unitive

Greenberg, Gary et al. (1999, 177):
Language and culture
1. Simple communication (monkey social group, low neocortical ratio)
2. Proto-language use (ape social group, intermediate neocortical ratio)
3. Language use (human culture, high neocortical ratio)

Donald, Merlin (2001, 260):
Cognition and culture
1. Episodic (primate)
2. Mimetic (early hominids, peaking in *Homo erectus*)
3. Mythic (sapient humans, peaking in *Homo sapiens sapiens*)
4. Theoretic (modern culture)

Donald, Merlin (2001, 325):
Conscious capacity
1. Pre-conscious (very simple perceptual objects, automatically bound, transient)
2. Level-1 basic (simple perceptual events, integrated across time but ephemeral)
3. Level-2 basic (complex events that can be held in short-term memory briefly)
4. Level-3 basic (complex social world-models held in extended working memory)
5. 1st-order hybrid (shared mimetic world-models that incorporate the physical self)
6. 2nd-order hybrid (shared narrative world-models, autobiographical self-awareness)
7. 3rd-order hybrid (shared theoretical world-models, external symbolic networks)

Brier, Søren (2003, 88, 96):
Matter and qualia
1. Quantum vacuum fields (Peirce's Firstness)
2. Physical (Peirce's Secondness)
3. Informational-chemical (Peirce's Thirdness)
4. Biological-semiotic (sign games)
5. Social-linguistic (language games)

Bunge, Mario (2003, 147):
Material things
1. Physical
2. Chemical
3. Biological
4. Social
5. Technical

Torbert, William R. (2003, 126–27):
Action-logics
1. Impulsive (conception)
2. Opportunist (investment)
3. Diplomat (incorporation)
4. Expert (experiment)
5. Achiever (systematic)
6. Individualist (social network)
7. Strategist (collaborative inquiry)
8. Alchemist (foundational community of inquiry)

Bates, Marcia J. (2005, 13):
Information
1. Physical (information 1)
2. Biological (information 2)
3. Anthropological (knowledge)

Vickery, Brian (2005, no paging):
Material organization
1. Elementary particles

2. Atoms
3. Molecules
4. Cells
5. Animals
6. Humans

Overton, Willis F. (2006, 20):
Discourse
1. Observational (common sense)
2. Theoretical (reflective)
3. Metatheoretical (metatheories)
4. Metatheoretical (ontological-epistemological groundings)

Overton, Willis F. (2006, 23):
Psychological subject
1. Practical (action systems)
2. Symbolic (representational action systems)
3. Reflective (2nd order representational action systems)
4. Trans-reflective (3rd order representational systems)

Dahlberg, Ingetraut (2008, 163):
Objects
1. General forms and structures
2. Matter and energy
3. Aggregated matter (cosmos and earth)
4. Biological objects (micro-organisms, plants, animals)
5. Human beings
6. Societal beings
7. Material products of mankind (products of economy and technology)
8. Intellectual products (scientific, information and communication products)
9. Spiritual products (language, literature, music, arts, etc.)

Lobo, Ingrid (2008, 141):
Biological matter
1. Macromolecule
2. Cell
3. Tissue
4. Organ and organ systems
5. Organism
6. Population
7. Communities and ecosystems
8. Biosphere

Pisula, Wojciech (2009, 123):
Exploratory behavior
1. Taxis
2. Orienting response
3. Locomotor exploration
4. Perceptual exploration
5. Investigatory responses
6. Cognitive curiosity

Salthe, Stanley (2009, 89):
Physical world
1. Physical dynamics
2. Material connectivity
3. Biological form
4. Social organization

Salthe, Stanley (2009, 97):
Physical entropy
1. Entropy production
2. Free energy expenditure
3. Metabolism
4. Cognition

Yao, Yiyu (2009, 1):
Information-processing
1. Numeric
2. Larger information granules
3. Symbol-based

Feinberg, Todd (2011, 4):
Neural self system
1. Interoself
2. Integrative
3. Exterosensorimotor

Feinberg, Todd (2011, 14):
Consciousness
1. Consciousness
2. Self
3. Self awareness

Tomasello, Michael (2014, 140):
Thinking
1. Individual intentionality (nonhuman great apes)
2. Joint intentionality (genus *Homo*, culminating in *Homo heidelbergensis*)
3. Collective intentionality (modern humans)

Nolan, Patrick and Lenski, Gerhard (2015, 6):
Things
1. Subatomic particles
2. Atoms
3. Molecules
4. Cells
5. Multicellular organisms
6. Societies
7. Species
8. Ecological communities
9. The global ecosystem

Nolan, Patrick and Lenski, Gerhard (2015, 64):
Societies
1. Hunting and gathering
2. Horticultural
3. Agrarian
4. Industrial

Gnoli, Claudio (2017, 46):
Phenomena
1. Forms
2. Matter
3. Life
4. Mind
5. Society
6. Culture