Systems for Integrating and Creating Knowledge

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ABSTRACT

This paper presents the *I*^{5} *System* or the *Knowledge Pentagram System* for knowledge integration and creation and its relation to the new concept of the *Creative Space*. The five ontological elements of *Pentagram System* are *Intelligence, Involvement, Imagination, Intervention, Integration* correspond to five diverse dimensions of the *Creative Space.* We discuss the meanings and functions of these dimensions in knowledge integration and creation. We also discuss the relation of the *I*^{5} *System* to Far East philosophy and to *Shinayakana Systems Approach*. *Shinayakana* means soft and hard together – elastic like a willow and sharp as a sword, implying a synthesis between soft and hard systemic approaches.

However, there are also other dimensions of *Creative Space,* not included in the *Knowledge Pentagram.* The concept of the *Creative Space* can be used to represent spirals of diverse processes of knowledge creation – beside *SECI Spiral* of organizational knowledge creation, also *ARME Spiral* of revolutionary knowledge creation, *DCCV Spiral* of brainstorming processes, three spirals of normal academic knowledge creation: *Hermeneutic EAIR Spiral, Experimental EEIS Spiral, Intersubjective EDIS Spiral,* and others. All these representation help in a better understanding of knowledge creation processes and in constructing software for creativity support systems.

Keywords: knowledge integration, knowledge creation, systems approach, processes and spirals of knowledge creation.

1. INTRODUCTION: THE *SECI SPIRAL*, THE *CREATIVE SPACE* AND THE KNOWLEDGE PENTAGRAM

We have shown in [1] how we can fruitfully generalize the *SECI Spiral* from [2] by adding more nodes in the basic dimensions of the spiral, thus obtaining the concept of *Creative Space;* this is illustrated in Fig. 1 and 2. Essentially, the epistemological dimension of *SECI Spiral* is enriched by splitting *tacit knowledge* into its two specific parts: *emotive knowledge* and *intuitive knowledge,* and the other dimension (called *ontological* in [2] and more precisely *social* in [1]) is enriched by adding the third level of *humanity heritage* to the levels of *individual* and *group.* This way, a three-by-three matrix is distinguished, indicating *nine nodes of Creative Space* shown by ovals in Fig. 2; there are also diverse *transitions* between these nodes (called in [2] *knowledge conversions*).

While, for example, the nodes of *individual emotions* and *individual intuition* just show more specifically which parts constitute *individual tacit knowledge,* the consideration of the three nodes of *humanity emotive, intuitive,* and *rational heritage* is a very important addition to *SECI Spiral:* every process of knowledge creation is in fact based on humanity intellectual heritage, called *the third world* by Popper [3] but including rational, intuitive and emotive parts.

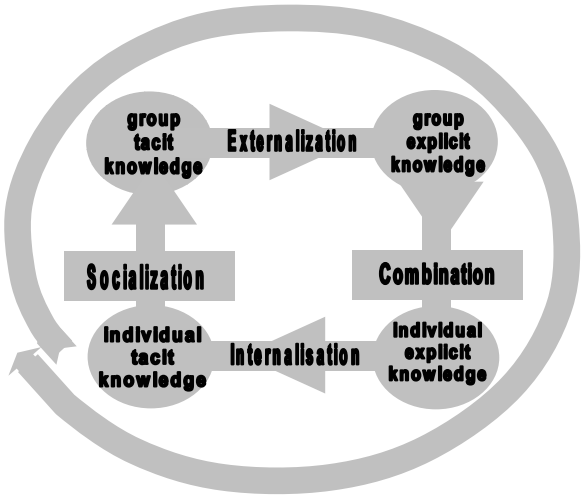

Fig. 1. The *SECI Spiral* (Nonaka and Takeuchi [2])

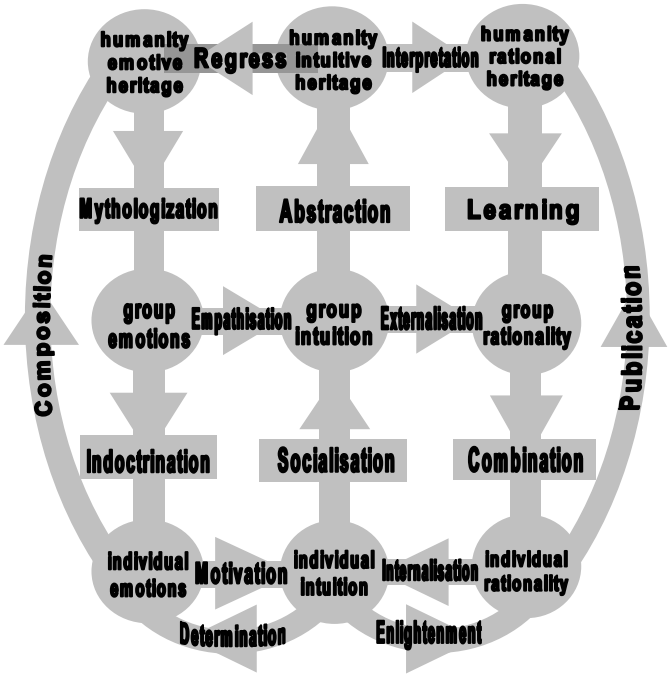

Fig. 2. The basic dimensions of *Creative Space* [1]

In this way new descriptions of creative processes can be obtained. For example, while the four nodes in the lower right-hand corner of Fig. 2 represent the known *SECI Spiral,* the four nodes in the upper left-hand corner of Fig. 2 represent another theory of knowledge creation, *the Theory of Regress* of Motycka [4], describing the processes of basic knowledge creation in time of a scientific revolution, such as during the creation of quantum theory; this theory can be also represented as a spiral which consists of transitions *Abstraction – Regress – Mythologization –Empathisation,* hence *ARME Spiral;* for more detailed description and analysis, see [1] and [5].

However, the *Creative Space* has certainly more dimensions than just the *epistemological* and *social* dimensions used in Fig. 1 and 2. This is stressed, for example, by Nakamori's I^5 *System* (or *Knowledge Pentagram System*)– see [6]; its five ontological elements are *Intelligence, Involvement, Imagination, Intervention,* and *Integration* and they might correspond actually to five diverse dimensions of *Creative Space;* thus, they stress the need to move freely between more dimensions of this space.

These five ontological elements were originally interpreted as nodes, as illustrated in Fig. 3. Because the I^5 *System* is intended as a synthesis of systemic approaches, *Integration* is, in a sense, its final dimension (in Fig. 3 all arrows converge to *Integration* interpreted as a node; links without arrows denote the possibility of impact in both directions). The beginning node is *Intervention,* where problems or issues perceived by the individual or the group motivate their further analysis and the entire creative process. The node *Intelligence* corresponds to various types of knowledge, the node *Involvement* represents social aspects. The creative aspects are represented mostly in the node *Imagination.*

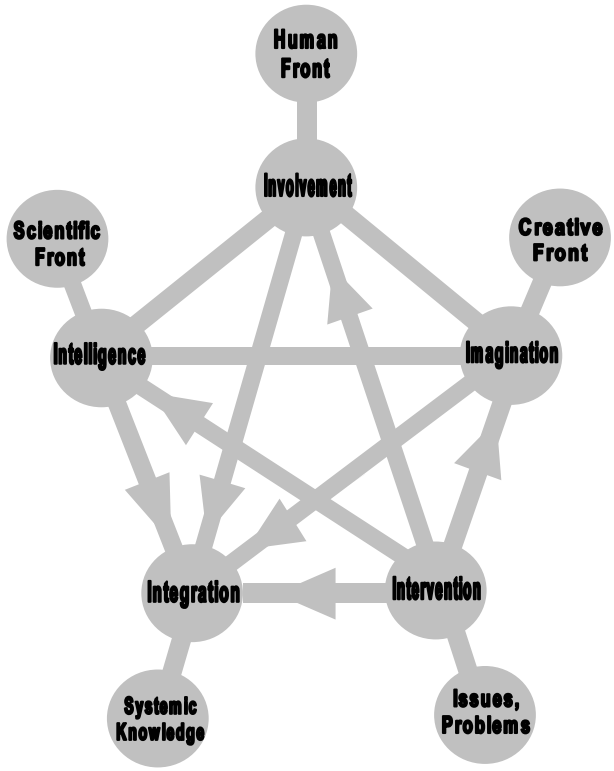

Fig. 3. The I^5 or *Knowledge Pentagram System*

Observe, however, that the node *Intelligence* – together with all existing scientific knowledge – corresponds roughly to the basic *epistemological dimension* (*Emotive – Intuitive – Rational knowledge*) of *Creative Space.* The node *Involvement* stresses the social motivation and corresponds roughly to the basic *social dimension* (*Individual – Group – Humanity Heritage*) of the *Creative Space.* When analyzing these dimensions we have found that binary logic is inadequate and even rough, three-valued logic barely sufficient for a detailed analysis. For example, it is not only necessary to distinguish between the knowledge on the level of individual, group and humanity heritage; it is also important to distinguish motivation related to the *interests* of the individual, the group and humanity. While an organization operating in the commercial market rightly stresses the interests of the group of people employed by it (or of its shareholders), educational research activity at universities might be best

promoted when stressing the individual interests of students and young researchers; on the other hand, the interests of humanity must be protected when facing the prospect of privatization of basic knowledge.

However, other nodes presented in Fig. 3 indicate the need to consider other dimensions of *Creative Space,* and additional dimensions result in additional complexity. The dimension *Imagination* seems to be an essential element of only individual intuition. All creative processes can be related, on the other hand, to three levels of *Imagination: Routine – Diversity – Fantasy;* we shall discuss the importance of this distinction in the next section.

2. DIMENSIONS OF *IMAGINATION, INTERVENTION,* AND *INTEGRATION* IN CREATIVE SPACE

We start with the dimension *Imagination.* We utilize imagination in diverse degrees depending on the character of a creative process. The lowest level is *Routine* – that involves imagination, but in a standard, well-trained fashion. We are able to use imagination more strongly, to involve an element of *Diversity* – but we must be motivated to do this by professional pride, pure curiosity, monetary rewards etc. Finally, we have also the highest level of imagination, which might be called *Fantasy.* The 20th Century tradition of not speaking about metaphysics (started by Wittgenstein [7]) relegated fantasy to the arts and the emotions. However, fantasy is an essential element of any highly creative process, including the construction of technological devices and systems (see Fig. 4).

Fig. 4. Levels of dimension *Imagination*

Here we encounter a difficulty in the graphic representation of *Creative Space:* to represent its three or more dimensions on paper, on a two-dimensional plane, might be difficult. As we well know, it is possible to represent three-dimensional objects, while for the representation of four-dimensional objects there are only some inadequate tricks. Consider the possibility of three-dimensional representation of *Creative Space*, in which, say, the additional dimension *Imagination* would be indicated by three layers of nodes of the space. Already this representation is would be too complex and such an idea serves only to illustrate an obvious conclusion:

> Knowledge and technology creation are essentially very complex processes; all models of creative processes are just simplifications, necessary for a better understanding but far from fully representing reality.

The dimension *Intervention* is difficult to consider separately in Oriental philosophy and culture, with their concepts of unity of mind and body and unity of man and nature: the will to do something is not considered as a separate phenomenon, it is simply a part of being, and being should be such as not to destroy the unity of man and nature. In a culture seeking consensus and harmony, such an explanation and such principles are sufficient. Occidental or Western culture pays more attention to the problems related to human intervention and will. Western culture has a long history of philosophic debate of the issues of will and freedom of intervention. The seminal points of this debate start just after the Enlightenment era, in German pre-romanticism, first with the concept of self-realization, then in the *Kritik der praktischen Vernunft* (I. Kant [8]) with its radical concept of freedom: a man is free in a radical, transcendental sense, self-determining not as a natural being, but as pure moral will:

> This unity of self-determination, moral life, autonomy and freedom, expressed best by Kant's statement *the starlight sky over me and the moral law in me,* was exhilarating for his contemporaries and still remains a powerful motivation for the representatives of Western culture.

The concept of will, of freedom to act and intervene, has been for many centuries and still remains one of the central ideas of Western or Occidental culture. Concerning any creative activity, it is clear that the role of motivation, of the will to create new ideas, objects of art, technological devices, etc. is a central condition of success. Without *Drive, Determination, Dedication* no creative process will be completed (see Fig. 5).

Fig. 5. Levels of dimension *Intervention*

By *Drive* we understand here the basic fact that *creativity is one of the most fundamental components of self-realization of man. Determination* is the concentrated Nietzschean will to overcome obstacles in realizing the creative process. *Dedication* is a conviction that completing a creative process is right in terms of Kantian transcendental moral law.

The dimension of *Integration* in the original I^5 *System* (see Fig. 3) is a node intended to represent the final stage, the systemic synthesis of the creative process. Thus, in this stage we should use all systemic knowledge; applying systemic concepts to newly created knowledge is certainly the only explicit, rational knowledge tool that can be used in order to achieve integration. Thus, any teaching of creative abilities must include a strong component of systems science (see Fig. 6).

Fig. 6. Levels of dimension *Integration*

The apparently simplest is *Specialized Integration,* when the task consists of integrating several elements of knowledge in some specialized field. But even this task can be very difficult as, for example, the task of integrating knowledge about the diverse functions of contemporary computer networks. It becomes more complex when its character is *Interdisciplinary,* as in the case of the analysis of environmental policy models. However, the contemporary trends of globalization result today in new, even more complex challenges related to *Intercultural Integration,* as in the case of integration of diverse theories of knowledge and technology creation. In fact, the *Intercultural Integration* of knowledge might be considered a defining feature of a new interpretation of systems science.

3. *PENTAGRAM SYSTEM, SHINAYAKANA SYSTEMS APPROACH* AND *CRITICAL SYSTEMS THINKING*

In summary, the knowledge creation system called *Knowledge Pentagram System* or I^5 *System* is comprised of five elements – dimensions, nodes or subsystems:

1. *Intervention:* Taking action on a problem situation which has not been dealt with before. First we ask: what kind of knowledge is necessary to solve the new problem? Then the following three subsystems are called on to collect that knowledge.
2. *Intelligence:* Raises our capability to understand and learn things. The necessary data and information are collected, scientifically analyzed, and then a model is built to achieve simulation and optimization.
3. *Imagination:* Creating our own ideas on new or existing things. Complex phenomena are simulated based on partial information, by exploiting information technology.
4. *Involvement:* Raising the interest and passion of ourselves and other people. Sponsoring conferences and gathering people's opinions using techniques like interview surveys.
5. *Integration:* Integrating heterogeneous types of knowledge so they are tightly related. Validating the reliability and correctness of the output from the above three subsystems.

We can interpret these elements variously – either as nodes, or dimensions of *Creative Space,* or subsystems. In the last interpretation, while the 1-st and the 5-th subsystems are, in a sense, autonomous, the 2nd, 3rd and 4th subsystems are dependent on others; it is generally difficult for them to complete their missions themselves, and thus we can interpret them as a lower level system with similar structure to the overall system.

Even if I^5 *System* stresses that the creative process begins in the *Intervention* dimension or subsystem and ends in the *Integration* dimension or subsystem, it gives no prescription how to move in between. There is no algorithmic recipe how to move between these ontological nodes or dimensions: all transitions are equally advisable, according to individual needs. This is true to the *Shinayakana Systems Approach* tradition that is in a sense further developed by the I^5 *System.* Thus, for a better understanding of I^5 *System* it is useful to comment also on *Shinayakana Systems Approach.*

Shinayakana is a systemic approach developed by Sawaragi and Nakamori for several years prior to its publication [9]. The approach proposes a synthesis, an integration of hard and soft systemic methods, integration from the perspective of Japanese philosophy and culture. In *Shinayakana Systems Approach,* Sawaragi and Nakamori tried to resolve the controversy between hard and soft systems traditions by using Far East philosophy: both hard and soft sides are necessary, we must use them in harmony and seeking consensus. Most important is the principle of openness to diverse soft systems approaches while preserving the strength and variety of hard systems approaches, the principle of being hard and soft at the same time.

In fact, *Shinayakana* means both soft and hard – elastic like a willow and sharp as a sword. Because of their synthesis of soft systems thinking with Oriental philosophy, the authors of *Shinayakana Systems Approach* did not formulate any spirals, any algorithmic processes, only a general description of principles – although both authors are also specialists in hard systems practice and could propose algorithmic processes. The I^5 *or Pentagram System* of Nakamori is in fact a continuation of *Shinayakana Systems Approach* with slightly more algorithmic tendency – although, as we already observed, I^5 *System* gives no precise prescription

how to move between ontological nodes or dimensions, true to the *Shinayakana* tradition.

On the other hand, *Shinayakana* and *Pentagram System* give a different way to the synthesis of soft and hard systemic approaches than *Critical Systems Methodology (CSM)* or *Critical Systems Thinking,* see, e.g., [10]. *CSM* tries to broaden the approach of *Soft Systems Methodology (SSM)* [11], but preserves the assumption of the superiority of soft systemic approaches made by *SSM.*[1] *Shinayakana* and *Pentagram System* treat both hard and soft systemic approaches as equally important, following Far Eastern philosophical principles of harmony, integration and methodological simplicity.

4. FURTHER DIMENSIONS OF *CREATIVE SPACE*

4.1 Basic versus Applied Research

The dyad of hard versus soft systems approaches does not stress another dyad of much relevance for modern science: that of *basic* versus *applied research.* We should stress that *technology and applied research is not, as some theoreticians suggest, just an application of basic research results, it is just the opposite: seeking solution of relevant practical problems*, *even if basic research did not yet supply sufficient results.* Basic and theoretical research is extremely important, but it is often motivated by applied research; and applied research is often more difficult and certainly more onerous than basic research – because it is aimed at the solution of practical problems with all complications resulting from this fact.

On the other hand, if universities did not conduct basic research, the quality of education would deteriorate even further. The value of basic research is thus not that it produces world-shaking results; it is known that world-shaking results are produced rarely and in unexpected places, such as the Swiss patent office. The value of basic research is that it keeps up the quality of university education. But uncontested concentration on basic research results in producing graduates who can perform only abstract or quasi-abstract functions, who are not prepared for practical tasks. Students should be also educated in practical tasks, including industrial internships; *uniting* basic and applied research. We shall call this dimension of creative processes *Abstraction dimension* and consider its three levels: *Applied, Basic, United* (see Fig. 7).

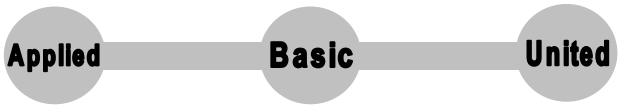

Fig. 7. Levels of dimension *Abstraction*

4.2 Constructivist versus Objectivist View of Reality

The postmodern critique is only one of several trends towards the end of 20th century that deny the concept of objectivity. In postmodernist thinking, there is no objectivity; the question of veridicality, of truth is futile and should be replaced by *critical reflectiveness* – that is actually equivalent to purely *subjective,* though critical, selection by the individual – and *intersubjective* discussion. Stronger grounds for abandoning the concept of objectivity were given before postmodernism in the *constructivist* vision of reality. After V.W. Quine showed [13] that logical empiricism is illogical in its foundation, that all human knowledge is a human construction touching reality only at its edges, the turn to constructivism in epistemology was inevitable. Radical constructivism, limited to the *biological vision of evolution,* see, e.g., [14], [15], [16], went much further and maintained that the concept of truth is unnecessary, since all functions of the mind can be explained by eigen-behavior. But the perspective of *civilization evolution,* as opposed to *biological evolution,* leads to opposite conclusions:

> *Objectivity and truth are necessary not as absolute concepts, but as useful ideals, conditions of human evolutionary cooperation and of the development of science and technology.*

Consider, between various advancements of the industrial civilization era, electricity. It is clear that without electricity we would not have today's informational and knowledge civilization. The development of electrical networks required *objective knowledge,* shared by many people constructing such networks, although this knowledge needed not to be absolute nor absolutely true, approximate but reasonably objective knowledge sufficed. Thus, we have three levels of the dimension *Objectivity* (see Fig. 8):

Fig. 8. Levels of dimension *Objectivity*

[1] The assumption of superiority of *soft* over *hard* is very clearly made in [11] and repeated in [10], although it is inconsistent with the conclusions of *SSM* that advise to give equal attention to different *Weltanschaungen.* Since *soft* and *hard* correspond to distinct *Weltanschaungen* (moreover, they even belong to *different cultures*, see [1], [12]), they should be treated equally, if *SSM* wants to be internally consistent.

We agree that *knowledge is power,* whether in times of geographic discoveries or of electrification, and that claims of objectivity might be used politically. However, any civilization device – print, electrification etc. – also can be and has been used politically, while without reasonable objectivity we cannot advance technology and civilization. We also agree that technology might be used wrongly, even to enslave people; but historically, so was iron used, and nobody could reasonably wrong iron for that fact.

In the *Creative Space,* we can discern two spirals related to the opposition *Intersubjectivity – Objectivity.* Both rely on the transition *Enlightenment (illumination, aha, eureka,* simply having a bigger or smaller idea) between individual intuition and individual rationality. But the one related to *Objectivity,* called *EEIS Spiral (Enlightenment-Experiment-Interpretation-Selection)* assumes that the verification of a new idea occurs through *Experiment,* followed by *Interpretation* of raw experimental data and intuitive *Selection* of new ideas resulting from interpreted data. The *EEIS Spiral* is an elementary process in *normal* (in the sense of T. Kuhn [17]) knowledge creation in research institutions.

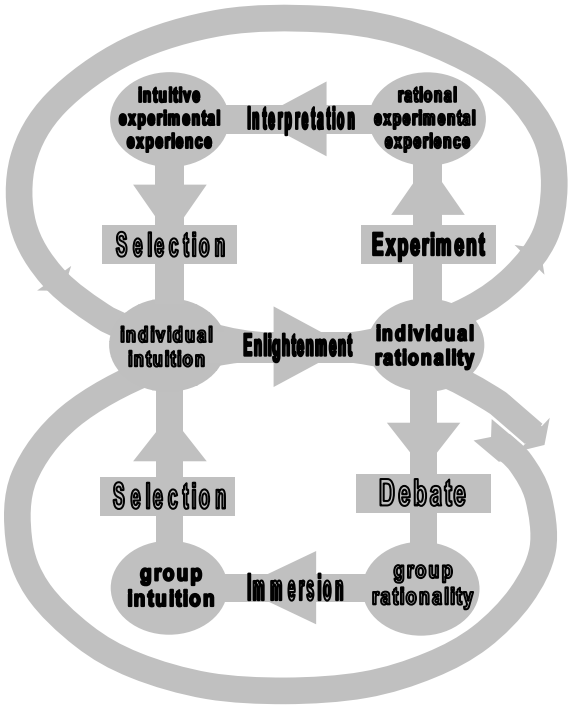

Fig. 9. The *Double EDIS-EEIS Spiral* of itersubjective and objective knowledge creation and verification

Equally elementary and frequent in *normal* knowledge creation processes is the spiral related to *Intersubjectivity,* called *EDIS Spiral (Enlightenment-Debate-Immersion-Selection),* with verification of a new idea occurring through *Debate,* followed by *Immersion* of the results of the discussion in group intuition (possibly and profitably resulting in a second *Debate,* which we call the *principle of Double Debate*) and again an individual, intuitive *Selection* of the results of debating for the generation of new ideas.

Both *EDIS* and *EEIS Spiral* can be represented together as in Fig. 9. By combining them, we can actually achieve a synthesis of intersubjective and objective knowledge creation and verification, which might be a direction to take for a contemporary social science.

4.3 Hermeneutic *Reflection* and *Triple Helix* of Normal Knowledge Creation

However, the seven dimensions of *Creative Space* described above are not exhaustive. As an example, we consider here (very briefly, for much more detailed analysis see [18]) the dimension *Reflection,* with three levels: *Basic, Integrated, Critical* (see Fig. 10)*:*

Fig. 10. The levels of dimension *Reflection*

The *Reflection* level *Basic* represents typical human reflection, used by any responsible researcher. Further levels of *Reflection* are related to the *hermeneutic circle* – see [18]. Without describing it in detail, we only note here that hermeneutics, though not usually discussed in relation to intuition, relies on holistic reflection about tradition and thus involves both emotions (myths, ideology, etc.) and intuition (based on accumulated professional experience and internalized knowledge).

The hermeneutic circle describes the relation of a researcher – a knowing subject – to the object of her/his study represented by historical or literary texts, objects of art, etc. In this relation, the researcher must immerse her/himself in the time and culture represented by the objects of the study and use empathic reflection based on the traditions of her/his discipline. However, there are two types of this hermeneutic, empathic reflection. One is *Critical:* the researcher must remain critical even while empathically immersing her/himself in the objects of study. Another is *Integrated:* the researcher must become united with the objects of her/his study, must feel for them, be integrated with them. This type of integration corresponds actually to the development of intuition, of forming *hermeneutic horizon* [19], a kind of intuitive perspective of perceiving the object of study.

Thus, *we can close the hermeneutic circle by individual intuition.* Therefore, we propose to represent the hermeneutic circle as another creative spiral, called the *EAIR Spir l* (see Fig. 11)*:*

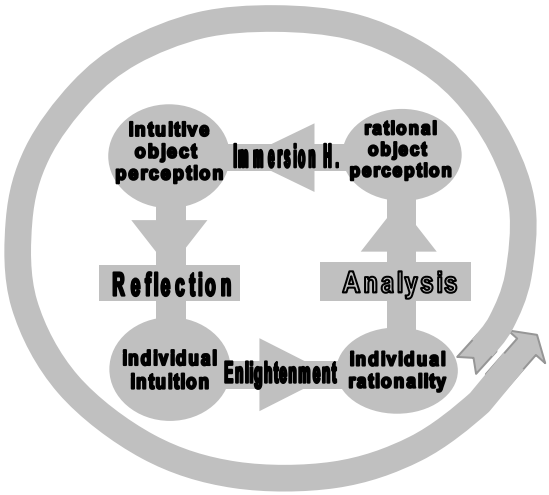

Fig. 11. The hermeneutic *EAIR Spiral*

In this spiral, we consider four nodes: *individual intuition, individual rationality, rational object perception* and *intuitive object perception.* The transition *Analysis* might be treated as an initial and very important one: it means actually searching the entire rational heritage of humanity for materials relevant to a given object of study, using libraries, archives, www, scientific conferences etc. for a never fully complete but as adequate as possible *Analysis* and a rational perception of this object. However, this perception is not sufficient for a full understanding. The researcher must immerse this perception in an intuitive understanding of tradition, to attain an intuitive perception of the objects of study. This transition, indicated by *Immersion H (Hermeneutic Immersion),* might be one of two types: *Critical* (of the object of study) or *Integrated* (with the object of study). This immersion helps to achieve a deep *Reflection,* enriching individual intuition and leading to *Enlightenment* – new ideas about the object of study. There is a danger in becoming too *Integrated:* though it helps to achieve an empathic reflection, it might hinder criticism. Therefore, a methodological advice is to switch between *Integrated* and *Critical,* in order to achieve a truly deep *Reflection.*

Though originally devised as a tool of humanistic studies, the hermeneutic circle – or rather *Hermeneutic EAIR Spiral* – can be recommended for a deep study of any type, including technology development. Therefore, if we reflect on the normal processes of academic knowledge creation – such as happen in any discipline at universities and in research institutes, between rarely occurring periods of revolutionary knowledge creation – we conclude that most typically they use three spirals, perhaps in the following order:

1) The Hermeneutic EAIR Spiral – of searching through rational heritage of humanity and reflecting on the object of study;

2) The Experimental EEIS Spiral – of verification and objectification of ideas through experiments;

3) The Intersubjective EDIS Spiral – of debating on ideas obtained from other spirals or through any other source of Enlightenment.

These three spirals can be represented together as a *Triple Helix of Normal Knowledge Creation,* shown in Fig. 12.

The purpose of such illustration is to stress how the three spirals of normal knowledge creation are actually intertwined, inseparable, although naturally in diverse disciplines one or another spiral might be more or less important.

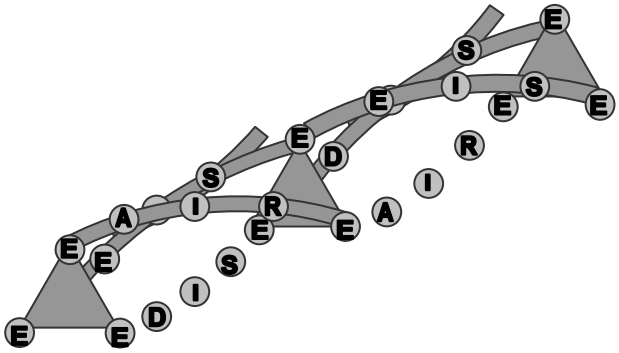

Fig. 12. *Triple Helix* of normal knowledge creation

Triangles in the *Triple Helix* indicate a selection of a future path after *Enlightenment,* a switch between spirals; while having an idea might result from sources in any of the three spirals, the idea can also be used in any other spiral. We use here a different convention than in the illustrations of *Creative Space:* stages or transitions, not nodes, are indicated here by small circles. Clearly, the *Triple Helix* might be repeated as many times as necessary. The usefulness of such a representation is only illustrative: it might help, for example, the dean of a faculty to reflect whether all transitions in the *Triple Helix* are supported well enough at his institution.

4.4 Cross-Cultural and Organizational Knowledge Creation

Finally, we should stress some other aspects or dimensions in *Creative Space* that are very important in applications of creativity theory. These aspects are related to two dimensions: *cross-cultural* and *organizational*. In a sense, they are both organizational aspects: the *cross-cultural* refers to diverse cultural perceptions of how a knowledge creation process should be organized, while *organizational* refers more to organizational learning processes and to the problem of activating knowledge dispersed in an organization.

We underline here some aspects actually stressed by one of the very first contemporary micro-theories of knowledge creation, by *The Knowledge Creating Organization* [2]. The particular knowledge conversions or transitions in the *SECI Spiral* (see Fig. 1) express the cross-cultural experience of knowledge creation in global market-oriented organizations, but the order and character of these transitions (*Socialization-Externalization-Combination-Internalization*) has a distinctly Oriental, even specifically Japanese origin. This is stressed also in [20]. On the other hand, the transitions in the *OPEC Spiral* (*Objectives-Process-Expansion-Closure*) of S. Gasson, see [21], [1], have a more Occidental, but also cross-cultural, purposeful character: they start by defining objectives and goals and end with a summary of achieved results. Both these processes are motivated by the interests of market-oriented organizations, both are different from normal knowledge creation processes (occurring mostly in academia, but also in industrial research laboratories) modeled by the three spirals of *Triple Helix* that are motivated more by the interests of an individual researcher.

For a good understanding of similarities and differences between different types of organizations, it might be useful to reflect further on a comparison of these different spirals and processes. Many research questions arise then that might go beyond the scope of this paper. For example: we have shown that such seemingly opposite aspects as *intersubjectivity* and *objectivity* can be integrated by combining two *EDIS* and *EEIS Spirals* into the *Double EDISEIS Spiral*. Can we similarly combine the *SECI* and *OPEC Spirals* into a double spiral? Can we combine, say, the SECI Spiral with Triple Helix Spirals in order to overcome the differences between academia and market-oriented organizations, to enable a better cooperation between them?

There exists, however, another cross-cultural approach to knowledge creation, actually not often used in universities, sometimes used at research institutes but mostly found in market-oriented organizations, though it was originally used in a different purpose-oriented organization, NASA. This is *brainstorming,* introduced by A.F. Osborn [22], now a traditional process of generating new ideas by a group devoted to a given purpose or to solving a problem. The essence of brainstorming consists of *promoting diversity* of generated ideas (by prohibiting criticism, accepting the wildest ideas, etc.) in the first *expanding phase* and of *organizing integration* of the ideas listed from the first phase in the second *contracting phase.* However, diverse methods of organizing this process can be found in the broad literature of this field. An important contribution to the field of brainstorming comes from S. Kunifuji, see [23]. Kunifuji rightly argues that a creative process involving brainstorming should include at least four phases, which we can identify with following transitions: *Divergence, Convergence, Crystallization, Verification* and represent also as a *Brainstorming DCCV Spiral* (see Fig. 13):

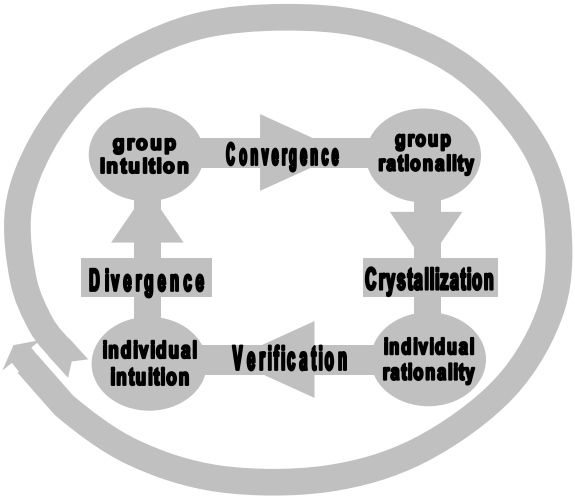

Fig. 13. Brainstorming *DCCV Spiral*

Although the *DCCV Spiral* is in some sense very similar to the *SECI Spiral* – it goes in the same direction through practically the same nodes – it is, however, essentially different: it describes much older process, the transition *Divergence* is quite different than *Socialization,* and the transitions *Convergence* and *Crystallization* are also somewhat different than *Externalization* and *Combination*. There are, however, some useful analogies resulting from such a comparison: for example, when interpreting *Externalization* as a transition similar to *Convergence,* we can use for *Externalization* many existing computer tools designed for supporting *Convergence* (see Fig. 14).

Fig. 14. The levels of dimension *Cross-cultural*

This conclusion can be generalized: the analogies resulting from such abstract analysis of diverse creative processes can stimulate the development of computer software to support creativity, see [1].

The purely *organizational* dimension of *Creative Space* represents other concerns: harnessing the power of *knowledge networks of distributed knowledge in organizations,* see, e.g., [23] in order to *activate distributed knowledge.* This is a challenging problem, also addressed from a somewhat different perspective by other researchers [24], [22].

Fig. 15. The levels of dimension *Organizational*

Keen and Sheffield [23] justly stress that another, organizational dimension should take into account three different types of knowledge, represented in Fig. 15: *Accountable, Discretionary* and *Autonomous*. *Accountable* means knowledge related to public identity, in a sense a contribution to rational heritage. *Discretionary* means private, individual rational knowledge; *Autonomous* is interpreted as a part of private identity, probably closely related to individual tacit knowledge, individual intuition and emotions.

4.5. Summary of Dimensions of *Creative Space*

Creative Space is a network-like model of relevant *nodes* and possible *transitions* between those nodes; sequences of such transitions form *knowledge creation processes.* Particularly interesting are sequences forming loops that we call *creative spirals* or *spiral models of creative processes.*

As discussed here, *Creative Space* has at least ten dimensions: *epistemological (Intelligence), social (Involvement), creative (Imagination), motivational (Intervention), systemic (Integration), abstractive (Abstraction), veridical (Objectivity), hermeneutic (Reflection), cross-cultural, organizational.* The levels along these ten dimensions are summarized in Table 1 that stresses the complexity of possible knowledge creation processes.

We could thus consider at least 3^{10} = 59,049 nodes and 59,049x59,048 = 3,486,725,352 possible transitions in the *Creative Space;* these numbers illustrate only that creative processes can be extremely diversified and the spiral models of them presented here are only rough models or ideal approximations.

Dimension of *Creative Space*	Level 1	Level 2	Level 3
Epistemological (Intelligence)	*Rationality*	*Intuition*	*Emotion*
Social (Involvement)	*Individual*	*Group*	*Humanity heritage*
Imagination	*Routine*	*Diversity*	*Fantasy*
Intervention	*Drive*	*Dedication*	*Determination*
Systemic (Integration)	*Specialized*	*Interdisciplinary*	*Intercultural*
Abstraction	*Applied*	*Basic*	*United*
Objectivity	*Subjective*	*Intersubjective*	*Objective*
Hermeneutic (Reflection)	*Basic*	*Integrated*	*Critical*
Cross-cultural	*Oriental*	*Occidental*	*Brainstorming*
Organizational	*Accountable*	*Discretionary*	*Autonomous*

Table 1. Possible levels of the ten dimensions of *Creative Space*

5. CONCLUSIONS

Instead of conclusions, we list the spirals of knowledge creation and other knowledge creation processes identified and discussed due to the concept of *Creative Space:*

1) Three spirals of organizational knowledge creation, typical for market-oriented organizations: *Oriental SECI Spiral* (Nonaka and Takeuchi), *Occidental OPEC Spiral* (Gasson), and *Brainstorming DCCV Spiral* (Kunifuji);

2) Three spirals of normal academic knowledge creation, typical for normal scientific activities at universities and research institutes: *Hermeneutic EAIR Spiral, Experimental EEIS Spiral, Intersubjective EDIS Spiral;* these spirals can be represented together in the *Triple Helix of Normal Knowledge Creation,* all proposed in this book;

3) One spiral of revolutionary scientific creation processes: *ARME Spiral* (Motycka);

4) Two general systemic models of knowledge creation and integration: *Shinayakana Systems Approach* (Sawaragi and Nakamori) and I^5 *(Pentagram) System* (Nakamori).

Reflection on all these models and spirals helps us to understand the diversity and heterogeneity of knowledge creation processes – including technology creation and even artistic creation. The great challenge, however, is to use these reflection to help in the construction of computer software to support creativity, of *Creative Environments,* in a sense similar to the concept of *Ba* [24].

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