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Algorithm and Human Creativity: Threats or Opportunity? A Literature Review

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ABSTRACT

We explore the move from a mechanical vision of Artificial Intelligence (AI) to a systemic vision of Intelligence Augmentation (IA) (Barile et al., 2018, 2019, 2020, 2021; Navarrini, 2020; Chiriatti, 2019). AI assumes the role of empowered intelligence (IA) as it is capable of expressing a capacity for modeling integration of experiences, knowledge and emotions in conditions of strong uncertainty (Barile et al., 2021; Hagel, 2021). But in a world where the nature of machine learning is changing so rapidly, does technology empower or annihilate creativity? The aim of the paper is to draw attention to the impact that disruptive technology has on human creative processes. How might progress in AI affect Human Creativity (HC)? We propose a literature review to better understand both trends and gaps.

Keywords: AI, Human creativity, Viable systems approach (VSA)

INTRODUCTION

Creativity is one of the intellectual hallmarks of Homo Sapiens (Boden, 1990; Cristofori et al., 2018; De Bono, 1970; Eysenck, 1995; Kaufman and Sternberg (eds.), 2019). Human creative processes are being amplified and enhanced via Artificial Intelligence (AI) progress. The dream of reproducing the characteristics of the human mind is very ancient, and is a goal that appears ever closer (Getzels and Csikszentmihalyi, 1976; Flores and Korsten, 2016). However, will AI progress ultimately flatten and/or atrophy the creativity, imagination and humanism of life itself? (Gobet and Sala, 2019; Bassano et al., 2020; 2021).

The paper is organized as follows: first we clarify the virtuous circular process linking creativity and innovation and the role of AI. Second, we illustrate our methodological approach for the literature review and use of the interpretative perspective of the Viable Systems Approach (VSA)'s Information Variety Model (IVM), highlighting the shift from Artificial Intelligence (AI) to Intelligence Augmentation (IA) (Barile et al., 2018, 2019, 2020, 2021; Navarrini, 2020; Chiriatti, 2019). Finally, we discuss future implications.

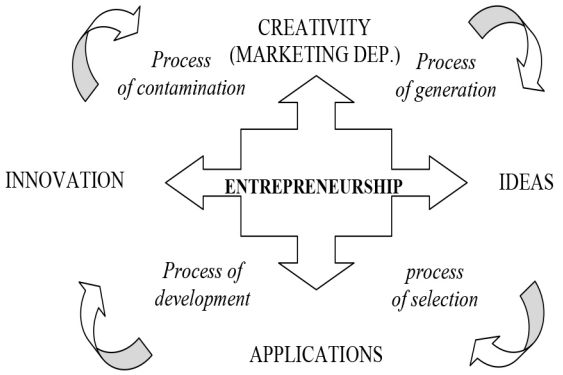

Figure 1: The virtuous circular process between creativity and innovation (Adapted from Piciocchi et al., 2009).

INNOVATION, HUMAN CREATIVITY AND THE SHIFT FROM ARTIFICIAL INTELLIGENCE (AI) TO INTELLIGENCE AUGEMENTATION (IA)

Today business sustainability implies a "cognitive differential" with *innovation* and *creativity* as the engines for reaching viability and competitiveness. As previous studies state (Piciocchi et al., 2011; Bassano et al., 2017; Piciocchi and Bassano, 2021):

- "innovation" expresses the entrepreneurial capability to "exploit routines"; such routines have in itself the characters of innovation because their modification produces an "intelligent" recombination of existing practices;
- "creativity", instead, allows the entrepreneur to renew routines to obtain, in a planned way, more consonance with the variety and the variability of the context. In this sense, creativity is the capability to join existing elements in new connections, that could be useful (Poincarè, 1905).

According to our perspective, "creativity" and "innovation" are closely related. Creativity would represent the input and the innovation the output (Vicari, 1998). The following Fig. 1 shows the virtuous circular process linking creativity and innovation. If the technological environment "suggests" the activation of the innovation process, then, within the firm, the creativity induces innovative methods in routine and in output (Bassano and Piciocchi, 2021; Piciocchi et al., 2011).

Obviously, the model is simplified; the relationship between creativity and innovation must be considered in terms of circular causality and not simply in terms of linear causality (Piciocchi et al, 2011; Pantano et al., 2018). The problem is the ability of the organization to exploit the virtuous circle of creativity-innovation to reach sustainable differential performance consistent with the competitive strategy, business model, product, service and

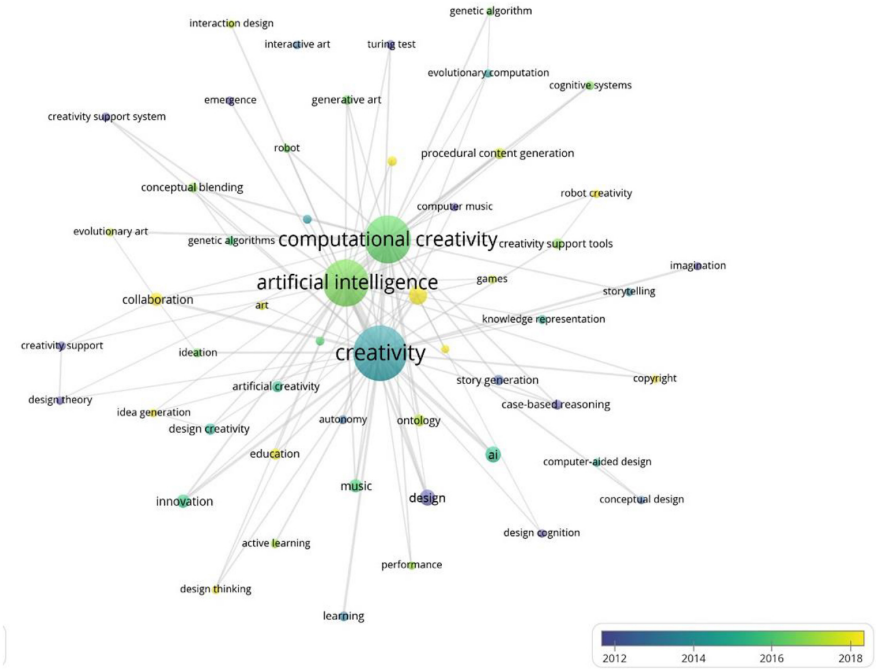

Figure 2: Author Keywords co-occurrence (Adapted from Vosviewer, developed by van Eck and Waltman, 2010).

processes. To this end, we want to draw the attention on the positive effect of technology in itself (as shown in Figure 1), helping the exploitation of the virtuous circular process between creativity and innovation (Bassano et al., 2018).

According to recent studies (Barile et al., 2018, 2019, 2020, 2021; Bassano et al., 2020; Navarrini, 2020; Chiriatti, 2019), AI assumes the meaning and role of autonomous and empowered intelligence (IA) as it is capable of expressing a capacity for modeling integration of experiences, knowledge and emotions that produce further knowledge and enhanced cognitive variety: data, interpretative schemes and value categories enhanced for the search for optimizing solutions in conditions of strong uncertainty (Barile et al., 2021; Hagel, 2021).

In other words, from the VSA perspective, the firm is viable when it is able to build and improve its own creative cognitive capital. Thanks to the application of AI to decision-making processes, the so-called IA effect is capable of generating sustainable differential value, difficult to reproduce and imitate (Barile et al., 2021).

METHODS AND MATERIALS

The VOSviewer Software for the Literature Review

We used a bibliometric approach to carry out our analysis. Following the guidelines of established protocols (Donthu et al., 2021; Paul et al., 2021), we have defined the search mechanism to be used to source the references

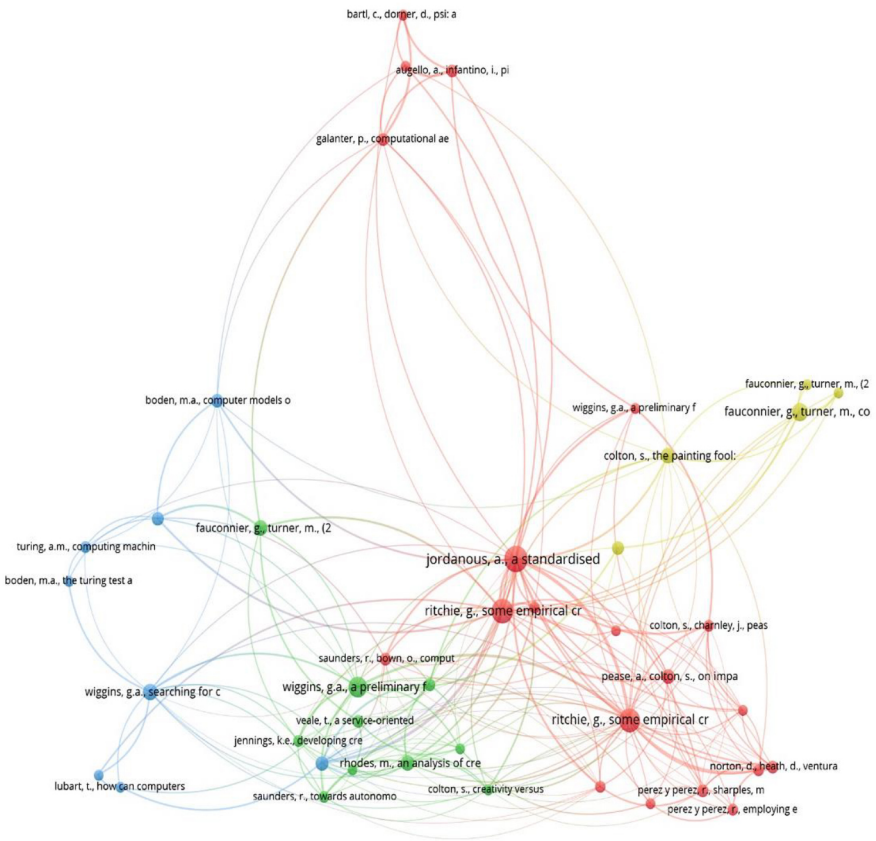

Figure 3: Co-citation analysis (Adapted from Vosviewer, developed by van Eck and Waltman, 2010).

responding to our Research questions: How may AI affect Human Creativity (HC)? Does technology empower or annihilate creativity? To achieve this, we have first examined the results obtained from Scopus through the query: (KEY ("creativity") AND KEY ("artificial intelligence" OR ai)) AND (LIMIT-TO (LANGUAGE, "English")). We obtained 850 documents (up until February 2022).

After exporting the references data, we have conducted a preliminary bibliometric analysis through VOSviewer, developed by van Eck and Waltman (2010). To study the development of the field, we have evaluated the co-occurrence of author keywords in our database, presented in Figure 2 in chronological visualization, ranging from blue (older keywords in the field) to yellow (more recent fields).

From this preliminary analysis, we could observe how the older concepts (e.g., computer generated music, story generation, design and autonomy, etc.) give way to newer concepts (e.g., machine learning, human-AI collaboration, deep learning, procedural generated content, and robot creativity). Starting from these results, we have then carried out a second review through the co-citation analysis technique to reconstruct the "ancestry", in terms of cited references, of the field (Figure 3).

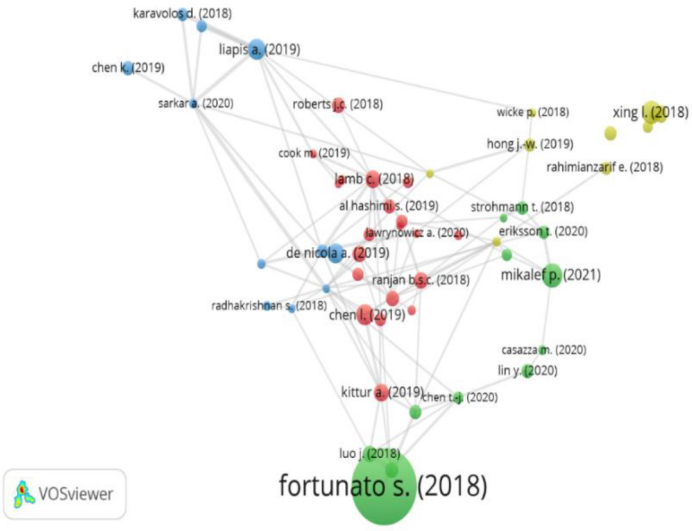

Figure 4: Bibliographic coupling (Adapted from Vosviewer, developed by van Eck and Waltman, 2010).

We find Turing's seminal and revolutionary work "Computing Machinery and Intelligence" (1950) (opening with the paragraph famously titled *The Imitation Game*), which introduced to the general public the concept of the Turing test, a test to measure a machine's ability to exhibit intelligent behaviour equivalent to that of a human. The Author assess the topic of creativity in an effort to invalidate the objections affirming that a machine can never 'take by surprise', concluding that "appreciation of something as surprising requires as much of a 'creative mental act' whether the surprising event originates from a man, a book, a machine or anything else". We also find Rhodes' "An Analysis of Creativity" (1961), in which the Author investigates the nature of the creative process and how ideas can be distinguished, inviting to always engage to identify the factors associated with the creative process. In their anticipatory work, Bartl et al. (1993) explored the role of emotions in cognitive and motivational processes and interactions, proposing a formalized computational architecture of human psychological processes, while Fauconnier and Turner (1998) argue that creativity is possible by virtue of the competition of optimality principles (integration, topology, web of appropriate connections and good reason) and the power of blending to accommodate them. Ritchie (2007) approached computational creativity taking into account the artefacts produced through computational means, mainly novelty, quality and typicality. Jordanous (2012) proposes a three-step Standardised Procedure for Evaluating Creative Systems demonstrated through a comparative case study. More recently some extra considerations were revisited as part of the older four Ps framework for creativity evaluation (Jordanous, 2016). According to the four Ps, the creative producer (i.e., the computer software or indeed the human programmer) and the press (i.e., the environment in which a creative act takes place) should also be added to the product and process criteria for a more comprehensive assessment of

CLUSTER 1.

KÖBIS N. (2021)	ARTIFICIAL INTELLIGENCE VERSUS MAYA ANGELOU: EXPERIMENTAL EVIDENCE THAT PEOPLE CANNOT DIFFERENTIATE AI-GENERATED FROM HUMAN-WRITTEN POETRY
YANG L.-C. (2020)	ON THE EVALUATION OF GENERATIVE MODELS IN MUSIC
RAGOT M. (2020)	AI-GENERATED VS. HUMAN ARTWORKS. A PERCEPTION BIAS TOWARDS ARTIFICIAL INTELLIGENCE?
SEKIGUCHI K. (2020)	ORGANIC AND DYNAMIC TOOL FOR USE WITH KNOWLEDGE BASE OF AI ETHICS FOR PROMOTING ENGINEERS' PRACTICE OF ETHICAL AI DESIGN
ŁAWRYNOWICZ A. (2020)	CREATIVE AI: A NEW AVENUE FOR THE SEMANTIC WEB?
PINI A. (2019)	AI INSPIRED RECIPES: DESIGNING COMPUTATIONALLY CREATIVE FOOD COMBOS
CHEN L. (2019)	AN ARTIFICIAL INTELLIGENCE BASED DATA-DRIVEN APPROACH FOR DESIGN IDEATION
GÓMEZ DE SILVA GARZA A. (2019)	AN INTRODUCTION TO AND COMPARISON OF COMPUTATIONAL CREATIVITY AND DESIGN COMPUTING
AL HASHIMI S. (2019)	THE EFFECTIVENESS OF SOCIAL MEDIA AND MULTIMEDIA-BASED PEDAGOGY IN ENHANCING CREATIVITY AMONG ART, DESIGN, AND DIGITAL MEDIA STUDENTS
COOK M. (2019)	FRAMING IN COMPUTATIONAL CREATIVITY - A SURVEY AND TAXONOMY
HÄMÄLÄINEN M. (2019)	MODELLING THE SOCIALIZATION OF CREATIVE AGENTS IN A MASTER-APPRENTICE SETTING: THE CASE OF MOVIE TITLE PUNS
VARSHNEY L.R. (2019)	A BIG DATA APPROACH TO COMPUTATIONAL CREATIVITY: THE CURIOUS CASE OF CHEF WATSON
KITTUR A. (2019)	SCALING UP ANALOGICAL INNOVATION WITH CROWDS AND AI
TATAR K. (2019)	MUSICAL AGENTS: A TYPOLOGY AND STATE OF THE ART TOWARDS MUSICAL METACREATION
RANJAN B.S.C. (2018)	A SYSTEMATIC APPROACH TO ASSESSING NOVELTY, REQUIREMENT SATISFACTION, AND CREATIVITY
LAMB C. (2018)	EVALUATING COMPUTATIONAL CREATIVITY: AN INTERDISCIPLINARY TUTORIAL
MCCAFFREY T. (2018)	AN APPROACH TO HUMAN-MACHINE COLLABORATION IN INNOVATION
PÉREZ Y PÉREZ R. (2018)	THE COMPUTATIONAL CREATIVITY CONTINUUM
KARIMI P. (2018)	EVALUATING CREATIVITY IN COMPUTATIONAL CO-CREATIVE SYSTEMS
ROBERTS J.C. (2018)	THE EXPLANATORY VISUALIZATION FRAMEWORK: AN ACTIVE LEARNING FRAMEWORK FOR TEACHING CREATIVE COMPUTING USING EXPLANATORY VISUALIZATIONS

computational creativity. In a similar but different fashion, Boden vastly contributes to the literature on the different types and definitions of creativity and novelty, recognizing the existence of a 'psychological novelty' when the idea is new for the person who generated it (Boden, 2009). Differently, the Author acknowledges an idea as 'historically novel' if it never appeared in history before (Boden, 2009); as well as in her breakdown of creativity in its two components of "exploratory creativity", which searches within the

CLUSTER 2.

MIKALEF P. (2021)	ARTIFICIAL INTELLIGENCE CAPABILITY: CONCEPTUALIZATION, MEASUREMENT CALIBRATION, AND EMPIRICAL STUDY ON ITS IMPACT ON ORGANIZATIONAL CREATIVITY AND FIRM PERFORMANCE
CHEN T.-J. (2020)	INVESTIGATING A MIXED-INITIATIVE WORKFLOW FOR DIGITAL MIND-MAPPING
ERIKSSON T. (2020)	THINK WITH ME, OR THINK FOR ME? ON THE FUTURE ROLE OF ARTIFICIAL INTELLIGENCE IN MARKETING STRATEGY FORMULATION
LIN Y. (2020)	IT IS YOUR TURN: COLLABORATIVE IDEATION WITH A CO-CREATIVE ROBOT THROUGH SKETCH
CASAZZA M. (2020)	A PLAYWRITING TECHNIQUE TO ENGAGE ON A SHARED REFLECTIVE ENQUIRY ABOUT THE SOCIAL SUSTAINABILITY OF ROBOTIZATION AND ARTIFICIAL INTELLIGENCE
CAMBURN B. (2020)	MACHINE LEARNING-BASED DESIGN CONCEPT EVALUATION
HE Y. (2019)	MINING AND REPRESENTING THE CONCEPT SPACE OF EXISTING IDEAS FOR DIRECTED IDEATION
XU X. (2019)	ARE EMOTIONALLY INTELLIGENT PEOPLE MORE CREATIVE? A META-ANALYSIS OF THE EMOTIONAL INTELLIGENCE-CREATIVITY LINK
CAUTELA C. (2019)	THE IMPACT OF ARTIFICIAL INTELLIGENCE ON DESIGN THINKING PRACTICE: INSIGHTS FROM THE ECOSYSTEM OF STARTUPS
LUO J. (2018)	DESIGN OPPORTUNITY CONCEPTION USING THE TOTAL TECHNOLOGY SPACE MAP
FORTUNATO S. (2018)	SCIENCE OF SCIENCE
STROHMANN T. (2018)	VIRTUAL MODERATION ASSISTANCE: CREATING DESIGN GUIDELINES FOR VIRTUAL ASSISTANTS SUPPORTING CREATIVE WORKSHOPS

space, and "transformational creativity", which involves expanding the space by breaking one or more of the defining characteristics and creating a new conceptual space (Boden, 1990).

We have conducted a third analysis employing the bibliographic coupling technique to the references published in the last five years (2018-onward). The results of the analysis are presented in Figure 4.

We were able to distinguish four different clusters, each pertaining to a different stream of research on the topic: cluster 1 (red) focuses on AI-generated art, poetry, music and even cooking recipes, and whether they differ or not from human generated ones; cluster 2 (green) focuses on the impact of machine learning in the field of creativity of AI; cluster 3 (blue) focuses on game and scenario design and simulation; cluster 4 (yellow) on labor solutions and research.

We reconnect to the interpretative perspective of the Viable Systems Approach (VSA), and in particular the Information Variety Model (IVM), as a possible bridge to fill the gap explaining the transition from a mechanical

CLUSTER 3.

SARKAR A. (2020)	TOWARDS GAME DESIGN VIA CREATIVE MACHINE LEARNING (GDCML)
TANG Y.-C. (2019)	A REVIEW OF DESIGN INTELLIGENCE: PROGRESS, PROBLEMS, AND CHALLENGES
CHEN K. (2019)	THE EFFECT OF EXPLICIT STRUCTURE ENCODING OF DEEP NEURAL NETWORKS FOR SYMBOLIC MUSIC GENERATION
LIAPIS A. (2019)	ORCHESTRATING GAME GENERATION
DE NICOLA A. (2019)	CREATIVE DESIGN OF EMERGENCY MANAGEMENT SCENARIOS DRIVEN BY SEMANTICS: AN APPLICATION TO SMART CITIES
XIAO P. (2019)	CONCEPTUAL REPRESENTATIONS FOR COMPUTATIONAL CONCEPT CREATION
BLAIR A. (2019)	ADVERSARIAL EVOLUTION AND DEEP LEARNING – HOW DOES AN ARTIST PLAY WITH OUR VISUAL SYSTEM?
KARAVOLOS D. (2018)	USING A SURROGATE MODEL OF GAMEPLAY FOR AUTOMATED LEVEL DESIGN
CHERTI M. (2018)	OUT-OF-CLASS NOVELTY GENERATION: AN EXPERIMENTAL FOUNDATION
COOK M. (2018)	REDESIGNING COMPUTATIONALLY CREATIVE SYSTEMS FOR CONTINUOUS CREATION
RADHAKRISHNAN S. (2018)	CREATIVE INTELLIGENCE – AUTOMATING CAR DESIGN STUDIO WITH GENERATIVE ADVERSARIAL NETWORKS (GAN)

CLUSTER 4.

OGBEIBU S. (2021)	LEVERAGING STARA COMPETENCIES AND GREEN CREATIVITY TO BOOST GREEN ORGANISATIONAL INNOVATIVE EVIDENCE: A PRAXIS FOR SUSTAINABLE DEVELOPMENT
LOFTUS T.J. (2020)	INTELLIGENT, AUTONOMOUS MACHINES IN SURGERY
CHA Y. (2020)	COMPENSATING FOR THE LOSS OF HUMAN DISTINCTIVENESS: THE USE OF SOCIAL CREATIVITY UNDER HUMAN–MACHINE COMPARISONS
HAMMERSHØJ L.G. (2019)	THE NEW DIVISION OF LABOR BETWEEN HUMAN AND MACHINE AND ITS EDUCATIONAL IMPLICATIONS
HONG J.-W. (2019)	ARTIFICIAL INTELLIGENCE, ARTISTS, AND ART: ATTITUDES TOWARD ARTWORK PRODUCED BY HUMANS VS. ARTIFICIAL INTELLIGENCE
TOWNSEND D.M. (2019)	ENTREPRENEURIAL ACTION, CREATIVITY, & JUDGMENT IN THE AGE OF ARTIFICIAL INTELLIGENCE
DANIELE A. (2019)	AI + ART = HUMAN
SÄÄKSJÄRVI M. (2018)	CREATIVITY AND MEANING: INCLUDING MEANING AS A COMPONENT OF CREATIVE SOLUTIONS
XING L. (2018)	ARTIFICIAL INTELLIGENCE WILL SOON CHANGE THE LANDSCAPE OF MEDICAL PHYSICS RESEARCH AND PRACTICE
RAHIMIANZARIF E. (2018)	DESIGNING INTEGRATED MANAGEMENT CRITERIA OF CREATIVE IDEATION BASED ON FUZZY DELPHI ANALYTICAL HIERARCHY PROCESS
WICKE P. (2018)	STORYTELLING BY A SHOW OF HANDS: A FRAMEWORK FOR INTERACTIVE EMBODIED STORYTELLING IN ROBOTIC AGENTS

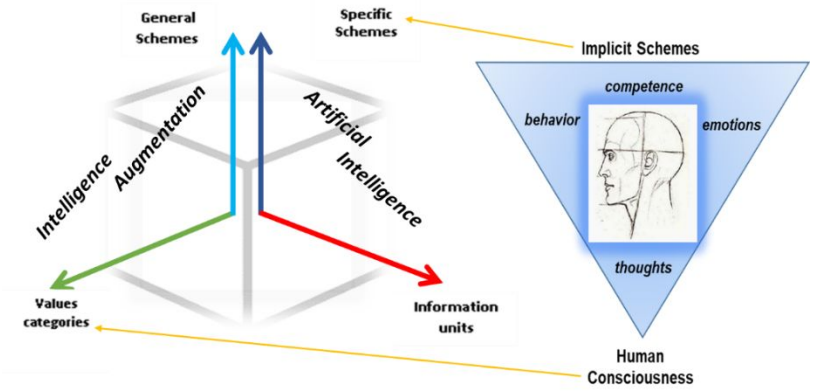

Figure 5: Implicit vs specific vs general schemes - authors' elaboration from Barile, Di Nauta and Iandolo 2016. www.asvsa.org.

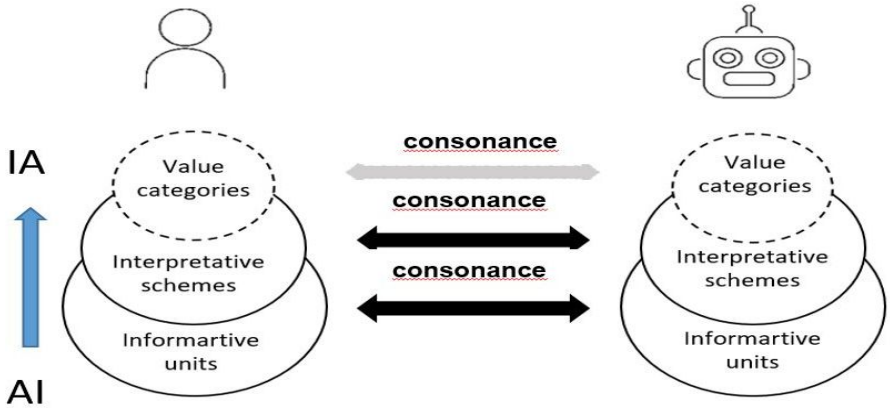

Figure 6: Interactions between consonant viable system entity interpreted as information variety (Adapted from Bassano et al., 2020).

vision of Artificial Intelligence (AI) – to a systemic complementary vision consistent with an interpretation of the new concept of Intelligence Augmentation (IA) (Barile et al., 2019; 2020; 2021; Bassano et al. 2020, 2021).

The VSA Interpretative Model

Today, creativity is mandatory. The creative moment does not correspond to the simple intuition, but to a process of abduction (Pierce et al., 1965), that emerges from the variety of knowledge owned by an individual and/or organization (Barile, 2006). According to the Viable System Approach (VSA) the firm is viable when it is able to build and improve its creative cognitive capital (Piciocchi et al, 2011). The competitiveness of the firm increasingly depends on (AI) and its application to the cognitive and decisional processes to generate (IA).

The moment of creative generation is significantly fueled by internal processes of self-reflection, autonomous recombining of what we call *viable*

system variety…"most striking at first is this appearance of sudden illumination, a manifest sign of long, unconscious prior work" (Poincarè, 1929:388). The peculiarity of the creative process that we would like to underline is the nature of the activation of the creative moment, which can be defined not as "intuition or insight" in the common sense of the terms, but as abduction, in the sense defined by Barile in line with Aristotelian thought: a creative moment emerges not "ex novo", but from previous sets of knowledge – i.e. variety – embedded in the organization (Johnson-Laird, 1993; Barile, 2009). These conceptual elements are stratified at several levels of depth: the *information units* are to be found at the most superficial level, while what we call *value categories* are the deepest level and the *interpretative schemes* (*implicit, specific, general)* are somewhere in the middle (Barile et al., 2019; 2020; 2021; Bassano et al. 2020, 2021).

The framing of these elementes at three levels defines the variety of the viable system. Considering that the application of (AI) to the decisional making processes leads to the (IA) of the system, the assessment of the degree of consonance implies comparing the respective sets of varieties of interacting entities as represented in Figure 6.

To explore the relationship between AI and Human Creativity, we assume that:

1) AI can empower the interpretative schemes' understanding potential.
2) IA enriches value categories (re-humanization process of intelligence).
3) Intuition enriches cognitive variety and variability.
4) Abduction refers to machines and so to technology in itself (AI).

CONCLUSION

The integration of advancing AI capabilities in business and societal systems cannot be ignored (Pakkala and Spohrer, 2019; Spohrer, 2020). Ultimately, we must answer the question: in a world where the nature of machine learning for AI is changing so rapidly, does technology empower or annihilate creativity? Does progress in subtle ways sacrifice human imagination (Plucker, and Makel, 2010; Zeng, Proctor, and Salvendy, 2011). This paper combined a bibliographic analysis with a Viable Systems Approach (VSA) to explore trends and gaps. Much work remains to be done.

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